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Flawed Nature Cosmology

A Dissertation Submitted by

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ABSTRACT

This thesis presents a new cosmological model based on a blank-slate reconsideration of the issue of the first cause in cosmology. It is proposed that a pre-Big Bang evolution of nature occurred that removes the need for postulating the existence of matter, energy and time. This new approach leads to an underlying conceptualisation of nature consistent with quantum mechanics.

The problems of first cause and initial conditions in cosmology are reconsidered. It is proposed that the initial conditions were *flawed* and evolved to produce the Big Bang as a natural response to these flaws. This contrasts with the traditional approach of postulating a homogeneous initial state requiring perturbation by an additional first cause.

In flawed nature cosmology the origin of time occurs as a natural response to the flawed set of initial conditions, and removes the need to postulate time. The development of causality remains an ongoing process rather than being fully determined by the first cause. Ongoing development of causality provides a conceptual understanding of the probabilistic nature of quantum mechanics and its relationship with classical physics.

Flawed nature cosmology is used to examine pre-Big Bang evolution, in order to justify rather than postulate a set of conditions leading to the Big Bang. This examination of pre-Big Bang evolution also introduces a structured method to start addressing the question of the origin of matter and the forces of nature.

Flawed nature cosmology reconsiders the issues that introduced the many-universes concept into physics such as spontaneous first causes, the many-worlds interpretation of quantum mechanics, brane cosmology's use of the extra dimensions in string theory, and parallel universes to solve the fine tuning problem. The many-universes concept has found favour, as much of the puzzling behaviour of the universe can be avoided by simply stating that if there are many universes, one could match our experience. In contrast, flawed nature cosmology demonstrates that the universe we experience is the unique product of its evolutionary history.

CERTIFICATION OF DISSERTATION

I certify that the ideas, experimental work, results, analysis, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

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ENDORSEMENT

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A Note Regarding the *Afterword* to this Thesis

The subject matter of this thesis naturally lends itself to a discussion of theological issues. Given the author's familiarity with the details of the thesis, it is considered appropriate to provide a theological interpretation as an *Afterword* to the thesis, instead of leaving interpretation entirely to the reader. This *Afterword* is included for completeness of debate only and should not be considered part of the examinable material.

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The current big bang model simply presupposes the existence of matter, along with a temporal environment that allows action and the laws of physics that controls the results of interactions. By contrast this dissertation provides an initial discussion of how the origin of these fundamental aspects of nature might be modelled within physics. This necessitates the introduction of some new concepts and terms as listed below.

Nature

In this dissertation the term 'nature' is used to encompass all aspects of the natural world, both the universe of our normal experience and the pre-big bang environments under consideration.

Postulate

In this dissertation the term 'postulate' is used in its normal sense and means to assume without proof.

Initial condition

In this dissertation the term 'initial conditions' is used in its normal sense, meaning the state of the system before any action has occurred.

Flawed Nature

The initial postulate of this cosmology is that: *The lack of a first cause represents a flaw that nature must take action to overcome*. The term 'flawed nature' is then used to distinguish this conceptualisation of nature.

Evolutionary epoch

The cosmology of this dissertation is broken up into three 'evolutionary epochs,' the last of which is the current universe. In this context an 'evolutionary epoch' is a distinct section of the evolutionary timeline.

Residue

In this dissertation the term 'residue' refers to all the components of the previous evolutionary epoch that are carried forward into a new evolutionary epoch.

Do over

In this dissertation the laws of nature are not presumed, instead the evolution of constraints on the unlimited potential inherent in an initial state devoid of a first cause are considered. The term ‘do over’ describes the situation where a newly evolved constraint does not only apply to future events, but is applied to the current evolutionary epoch as if it had always been applicable.

Since this dissertation seeks to discuss whether some of the fundamental attributes of quantum mechanics can be given a cosmological basis, it is necessary to initially distinguish between new concepts introduced as part of this cosmology and current concepts within quantum mechanics with which they are associated. This distinction is necessary because not all of the attributes of the associated components of quantum mechanics are introduced at the same time; instead this dissertation suggests a series of evolutionary events that may have given rise to these attributes. Below are listed some of the new cosmological terms and the quantum concepts with which they are associated.

Pre-asserted representation

In this dissertation the cosmological equivalent of the wavefunction is simply termed a ‘pre-asserted representation.’

Assertion

In this dissertation the terms ‘assertion’ is used in the same context as the terms ‘measurement’ in quantum mechanics. In quantum mechanics measurement implies deriving a real value from the abstract representation of the wavefunction. In this dissertation assertion implies deriving a real value from the pre-asserted representation. The term ‘assertion’ was chosen because, unlike the terms ‘measurement,’ it does not imply the presence of a conscious observer. This is important since ‘assertion’ is treated as a naturally occurring process.

Since this dissertation seeks to discuss the origin of the matter of this universe, it is necessary to start this discussion with a more abstract entity from which matter evolves. Below are some of the terms used in this discussion.

Minimum entity

The terms ‘minimum entity’ is used in this dissertation in the same way it is used in string theory, to state that there is a minimum component from which all matter is derived. In string theory this is a ‘string,’ a postulated minimum entity that has some spatial extent, as distinct from particles that are spatial points.

Potentia

In this dissertation the minimum entity is the ‘potentia,’ a term used by Heisenberg, who borrowed it from Aristotle. Heisenberg used the term ‘potentia’ in the context of elementary particles because he felt that, “*…the atoms and the elementary particles themselves are not as real; they form a world of potentialities or possibilities rather than one of things and facts…* (resulting in) *a strange kind of physical reality just in the middle between possibility and reality.*” Strings, even though they are conceived as one-dimensional objects within a multi-dimensional space, are essentially classical objects with well-defined intrinsic properties. The ‘potentia’ of this dissertation by contrast evolve from the broad concept of potential, with their properties introduced by specific evolutionary events.

Reference frame

The initial potentia are visualised a being like reference frames, such as colour, by which the entire initial state can be defined.

Over-specification

In this dissertation the term ‘over-specification’ refers to the situation where many potentia provide different, and perhaps contradictory, definitions for the same initial state.

Intermediate potentia

An ‘intermediate potentia’ is a potentia whose pre-asserted representation is defined between two boundary conditions.

Coexistent unit

A ‘coexistent unit’ is the first instance of a potentia that is a discrete, and therefore particle like, entity rather than having the character of a reference frame. It represents the further evolutionary development of the intermediate potentia.

Difference schema

In this dissertation a ‘difference schema’ is a method by which individual potentia are distinguished. The specific example used is a property common to all the individual potentia, with a different value of this property taken by each.

Orbital

The common property of the difference schema can be used to produce a configuration space that provides a visual representation of orthogonal potentia as a series of concentric circles termed ‘orbitals.’

Residual orbital

The dissertation models how the orbital space collapses to leave a single orbital called the ‘residual orbital,’ which is associated with the ground state energy of the current universe.

Chapter One:

Introduction -

A Physics Beyond *How?*

Philosophy is the art of vision, simply the capacity to see.

1. Introduction

The purpose of this dissertation is not to calculate how a particular aspect of nature works, but to understand in broad terms why nature behaves in the manner we experience in this universe. This is part of the natural evolution of science as Gross pointed out, *" Now that we understand how it works, we are beginning to ask why are there quarks and leptons, why is the pattern of matter replicated in three generations of quarks and leptons, why are all forces due to gauge symmetries? Why, why, why?* [1]*"* However Feynman said that to gain such a fundamental understanding was impossible, lamenting that, *"…while I am describing to you* how *Nature works* (using quantum electrodynamics), *you won't understand* why *nature works that way. But you see, nobody understands that. I can't explain why Nature behaves in this peculiar way* [2]*."* To understand why nature works in a particular way it is necessary to return to physics something it has lack for more than one hundred years, since Planck, on 19th October, 1900, presented his results implying the quantisation of energy [3], an event which is taken as the birth of quantum mechanics – the capacity to say that it provides humanity's best direct description of nature. This is neither an easy nor safe task, since it will require setting aside all the postulates of physics and the comfort of mathematical certainty, to undertake a blank slate reconsideration of nature's origin and evolution. This is what is done in this dissertation, a task in keeping with Einstein's aspirations, *" I want to know how God created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element. I want to know His thoughts; the rest is detail* [4]*."*

A blank slate reconsideration of fundamental issues in cosmology is considered necessary because too many problems of fundamental importance to cosmology have been allowed to accumulate in the *'Too hard'* basket. However the preliminary reconsideration of this dissertation does not presume to be able to resolve these outstanding issues, but is undertaken simply with the intent of introducing some new approaches, which might serve to reinvigorate debate and recommence research. The most fundamental issues to be considered are the nature of the initial state from which all things originated and the first cause that set evolution on its course. In doing this the existence of time will not be assumed as an additional initial postulate, instead its origin and nature will be reconsidered. It is felt necessary at this time to reconsider such fundamental issues, since it is clear that the initial conditions for the big bang are too complex to be accepted solely as initial assumptions or postulates. To do so can provide no clear insight into why the universe functions as it does, so too many fundamental questions are left unanswered. What is the origin of the matter of the universe? Why are there four forces with the specific characteristics evidenced by physics? It is hoped that the blank slate reconsideration of nature's pre-big bang evolution can provide a set of pre-conditions for the big bang that are not simply postulated, but that can therefore give new insights into resolving these as well as other problems. This approach accepts that there are no simple, single-instance solutions to profound problems, but that they must be considered in the context of nature's entire evolutionary history.

In order to apply this approach it is necessary to outline a cosmological model both as a framework for the expression of new general concepts and to allow the presentation of some specific solutions to outstanding problems. But what must be kept in mind is that what is of most significance is not the specific cosmology outlined, but the individual new concepts around which it is built. An elaborate consideration is often necessary for the development of new ideas, even if in consequence of this only key concepts are retained. It is to be expected that other researchers once exposed to the key ideas introduced by this dissertation may utilise these key concepts in different ways, to come up with quite different cosmological models. As for the outstanding problems addressed, no problem can be considered unsolvable until we have run out of new ideas to apply to its resolution. What this dissertation seeks to demonstrate is that this point has clearly not been reached. To do this it is necessary to offer specific solutions. They are offered because it is believed that they are correct, but you, the reader, may disagree. Good! What is of primary importance is not whether the solutions offered in this dissertation prove to be the final ones, but that they exist as a starting point to re-invigorate debate and that their derivation demonstrates a method by which these questions can be addressed. What is sought, either by your agreement with the proposals outlined in this dissertation or by your disagreement with them, is to remove these issues from the *'Too hard'* basket and place them in the *'Work in progress'* basket, where they can again be addressed by the entire scientific community.

This preliminary work cannot be considered to be a cosmological model as such; rather it is the necessary precursor to a formal model, the simple reconsideration of fundamental problems long placed in the *'Too hard'* basket. But this reflects the main recommendation of this dissertation, simply not to rush, agreeing with Saint Augustine that, *" Patience is the companion of wisdom* [5]*."* In order to deal with truly fundamental questions we must start where physics started, with natural philosophy, since as we have argued for many years philosophy "*…births the ideas that the other sciences test and apply* [6]*."* F. David Peat agrees concluding his book *Superstrings and the Search for the Theory of Everything* with the statement, *" If these ideas seem to be verging on the philosophical, then this is exactly where physics may have to go. Either postmodern physics can continue to be guided by its mathematics, or at some point much deeper insights will be needed. When Einstein was trying to formulate his theory of relativity, he did not study mathematics, nor did he supplement his scientific training by looking at the latest experiments on the speed of light; he read philosophers like Ernst Mach, Immanuel Kant, and David Hume. His essential thought was philosophical, thinking deeply about the meaning of science, the problem of knowledge, and the philosophical implications of space-time. In this way, he was brought to ask some fundamental questions. Many of the great revolutions in physics have had at their roots difficult philosophical considerations* [7]*."* But such an approach is not merely justified by past precedents it is necessitated by recent experimental outcomes, just as Heisenberg predicted, *" Many of the abstractions that are characteristic of modern theoretical physics are to be found discussed in the philosophy of past centuries. At that time these abstractions could be disregarded as mere mental exercises by those scientists whose only concern was with reality, but today we are compelled by the refinements of experimental art to consider them seriously* [8]*."*

2. Physics or Metaphysics?

Figure 1

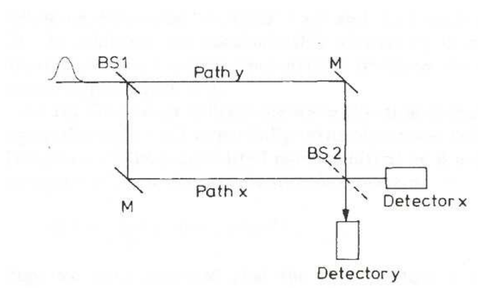

Fig. 1: Wheeler's diagram of his proposed delayed-choice experiment.

The experimental arts are now capable of bringing into question our most fundamental beliefs about the nature of time and causality. One example of this is the delayed choice experiment proposed by John Wheeler [9] in 1978. The experiment involved sending a single photon pulse through an interferometer via a beam splitter BS1. In the absence of the second beam splitter, BS2, Detector *x* and Detector *y* determine the path the light quanta took, either Path *x* or Path *y*. With BS2 inserted the path information is lost and an interference pattern is detected. The delayed-choice aspect is introduced, according to Wheeler, since we only choose *"…whether to put in the second beam splitter or take it out at the very last minute. Thus one decides whether the photon shall have come by one route, or by both routes after it has already done its travel* [10]*."* A physical realisation of Wheeler's *gedankenexperiment* was later performed at the Max Planck Institute for Quantum Optics outside Munich by Hellmuth, *et al* [10], who concluded their paper on this experiment, *"…by noting that the delayed choice experiment thus has far-reaching consequences for our picture of the past. As Wheeler has frequently pointed out, the strangeness of the delayed-choice experiment reminds us more explicitly than ever that 'the past has no existence except as it is recorded in the present.'* [10]*."*

An entirely different type of delayed-choice experiment was conducted by Wang, Zou and Mandel [11] using signal and idler photons produced by parametric down-conversion in two non-linear crystals. During the process of down-conversion in a non-linear crystal, incident pump photons interact parametrically with the medium and split into signal and idler photons [12]. The down-conversion can be stimulated by a strong external field and is coherent with the field. If the external field is weak, the down-conversion occurs spontaneously and at random, and the spontaneously emitted light is then not expected to exhibit induced coherence. However, Wang, *et al* were able to verify experimentally that it is possible to induce coherence in down-conversion without induced emission. The analogy of Greenstein and Zajonc clarifies what is happening, *" In this case, first the final photon is emitted, and only later is the initial photon absorbed. No ball game we know of has the player throw the ball before catching it. If interpreted literally, the process represented by the second* (Feynman) *diagram says precisely this, and so does violence to our ideas of a well-running, causally ordered universe.*

" We might ask if we really need the perverse second quantum amplitude? The answer turns out to be a clear 'yes.' One can calculate the cross section for Compton scattering in two ways: first by using only the straightforward first Feynman diagram…, and second by using both. The result is that the two calculations differ from each other. Furthermore, experiment has clearly shown that the second calculation agrees with the data and the first does not. We conclude that the Feynman diagram…, in which the normal flow of time is scrambled, must be included in the analysis [13]*."* Wang, *et al* concluded that, *"…the state not only*

reflects what is known about the photon (from an actual measurement) *but to some extent also what is knowable, in principal, under the given circumstances, whether it is actually known or not* [11].*"*

These are experimental results and cannot be ignored by any science claiming to be empirically based. The need to explain them is as urgent as for the experiments that led to the introduction of quantum mechanics. Nor can we rely for their explanation on philosophical concepts already absorbed into physics, since as Murray Gell-Mann stated, *" The fact that an adequate philosophical presentation* (of quantum mechanics) *has been so long delayed is no doubt caused by the fact that Niels Bohr brainwashed a whole generation of theorists into thinking the job was done 50 years ago* [14].*"* The brainwashing, if this is what it was, concerned the introduction of the concept of complementarity. This concept was introduced by Niels Bohr in a lecture at the 1927 conference at Como, Italy which was reprinted in *Nature* [15], " …(the quantum of action) *forces us to adopt a new mode of description designated as complementarity in the sense that any given application of classical concepts precludes the simultaneous use of other classical concepts which in a different connection are equally necessary for the elucidation of the phenomena* [16].*"* These comments were prompted by both the wave particle duality and Heisenberg's uncertainty principle [8]. However, Bohr's lecture did not immediately convince his peers, as evidenced by Eugene Wigner's comment to Leon Rosenfeld, *" This lecture will not induce any one of us to change his own opinion about quantum mechanics* [17].*"* Undeterred, Bohr continued to express his opinions regarding wave particle duality stating, *" In fact, here again we are not dealing with contradictory but with complementary pictures of the phenomena, which only together offer a natural generalisation of the classical mode of description* [18].*"* One month later at the fifth Solvay meeting, after extensive debate with Einstein, Ehrenfest came to the conclusion that Bohr *"… towered over everybody. At first not understood at all…then step by step defeating everybody* [19].*"* But not convincing everyone; Einstein wrote to Schrödinger of complementarity, *" The soothing philosophy – or religion? – of Heisenberg-Bohr is so clearly concocted that for the present it offers the believers a soft resting pillow from which they are not easily chased away. Let us therefore let them rest. …This religion does damned little for me* [20].*"* Schrödinger agreed, *" Bohr wants to 'complement away' all difficulties* [21].*"*

Einstein, as part of his debate with Bohr about complementarity, suggested a version of the double-slit experiments that could potentially observe both particle and wave properties. Such an experiment has been conducted by Wootters and Zurek's [22]. While their results agree with complementarity in that when there is full path information there is no interference pattern and when there is no path information there is a full interference pattern, the partial interference pattern evidenced between these extremes is an entirely new concept. Clearly, mutual exclusion by degree is not what Bohr had in mind. Yet it cannot be claimed in reference to this experiment that the two states, wave and particle, do not simultaneously exist as both attributes are evidenced in the same experiment where there is partial path knowledge. As expressed by Greenstein and Zajonc, *" While valuing the principle* (Bohr's complementarity) *for the light it throws on the perversity of the quantum world, we do not agree with him that it resolves the unrest caused by modern experiments in quantum mechanics. Rather, we believe that the complementarity principle forcefully illustrates the scope of the dilemma they pose. If, as Einstein expressed it, Bohr hoped complementarity would prove a soft pillow to lull scientific thinking to sleep, Bohr failed. The challenges to thinking have only intensified and broadened* [13].*"*

But the philosophical consideration must run even deeper than this, simply because it is unreasonable to expect to be able to address previously insurmountable problems without a re-examination of the tools used to work on them. Bohr, commenting on a lecture by the philosopher Philipp Frank [23] who he noted had used, *"…'metaphysics' simply as a swearword or, at least, as a euphemism for unscientific thought* [24]*,"* retorted, *" I began by pointing out that I could see no reason why the prefix 'meta' should be reserved for logic and mathematics – Frank had spoken of metalogic and metamathematics – and why it was anathema in physics. The prefix, after all, merely suggests that we are asking further questions, i.e., questions bearing on the fundamental concepts of a particular discipline, and why ever should we not be able to ask such questions in physics* [24]*."* We have no choice but to ask *questions bearing on the fundamental concepts* of physics, in order to determine why it has failed to resolve crucial issues, and where possible suggest extensions to these concepts that may make addressing these issues possible. Therefore in this sense this is a work of metaphysics. Cosmology is a useful tool in this endeavour since in examining the origin of the universe from nothing cosmology also examines the origin of physics. Cosmology in its most fundamental form cannot merely apply physics, but instead must derive it.

As Jennifer Trusted states, *"…metaphysical theories are not only not irrelevant, they are absolutely essential to scientific inquiry* [25]*."* This is because, as Dudley Shapere [26] points out, observation can never be freed of theory. This is reinforced by Immanuel Kant's consideration of *a priori* concepts [27], whereby we must depend on some presuppositions in order to establish empirical facts [25]. It is these presuppositions, derived from metaphysical considerations, which establish the postulates on which physics is based. Some postulates are what Bertrand Russell called *instinctive beliefs* [28] and would be readily accepted by most people, while others like Newton's law of inertia [29] or Einstein's definition of simultaneity [30] are more abstract and obscure. In these cases as Kant states, *" Metaphysics, even if we look upon it as having hitherto failed in all its endeavours, is yet, owing to the nature of human reason, a quite indispensable science, and ought to contain a priori synthetic knowledge. For its business is not merely to analyse concepts which we make for ourselves a priori of things, and thereby to clarify them analytically, but to extend our a priori knowledge* [31]*."* We must continually re-evaluate *a priori* concepts if we are to sharpen Ockham's razor. The fourteenth century philosopher William of Ockham [32] advocated that if two theories equally explain some aspect of the universe, the one that begins with the fewest assumptions is to be preferred [33]. It is this test that is most often applied to scientific theories in the absence of experimental results. However, as we shall see below, many cosmological models rather than striving to reduce the number or scope of their initial postulates, instead strive to increase the speed with which they progress from an unfamiliar initial state to a more familiar and comfortable environment. But the test of Ockham's razor is not concerned with our comfort, but purely with the number of assumptions required as a basis for a theory. By taking the time to reconsider the *a priori* concepts to be included in the model, we contend that the resultant cosmology will contain fewer assumptions and therefore be preferred in terms of the criteria of Ockham's razor.

However we still cannot ignore the crisis cosmology currently faces, a crisis not caused by the diversity, or even the absurdity, of the ideas introduced, but by the inability to conceive any means for experimental scrutiny. Aristotle considered metaphysics to mean *"…beyond physics* [34]*."* Karl Popper [35] formalized the distinction between theories belonging to metaphysics or physics by the test of falsifiability, that is, a theory that could not be falsified by experiment is considered part of metaphysics, while a theory that can be falsified by experiment is part of physics. Many of the cosmological models current in the literature, for example Brane theory [36-38] with its reliance on unseen dimensions and even universes, could not pass this test and therefore would be considered by Popper to belong to metaphysics. It is not good enough to simply claim that the initial states of these models are lost to the past and unverifiable [39]. We offer a cosmology where nothing of the initial conditions is lost, where it can be seen that the way this universe functions is clearly based of precedents established by its earliest evolution. In this way prediction about the current working of nature derived from the cosmology will allow experiments to be conducted that scrutinise the earliest parts of this model. In this way we seek to satisfy Popper's criterion for the acceptance of this cosmology as a theory in physics and thereby make a contribution to progressing cosmology beyond the infancy of wild speculation, to the maturity of a fully empirical science.

The need to revisit metaphysical considerations may seem a little strange, since the Renaissance [40] is generally considered to have marked the end of this approach, as the brilliant minds of that age decided that more understanding could be gained by going out and observing the world, than by contemplating its nature. As Leonardo da Vinci forcefully stated, " *All our knowledge has its origin in our perceptions* [41]." This approach, together with Galileo's emphasis on experimentation [42], marked the advent of the scientific method and has proved of great benefit to humanity. The problem is that physics has progressed to the point where the things to be studied can no longer be easily seen. For example, it is doubtful that any government will provide the billions of dollars necessary to build a supercollider [43] generating sufficient energies to test string theory. It has therefore become necessary once more to look at the universe with the mind's eye. But unlike pre-Renaissance times, with a view to developing models that can be subjected to experimental scrutiny and thereby make the transition from metaphysics to physics.

However, this does not mean that the current work is not speculative, speculation is necessary in order to overcome stagnation. But there are two types of speculation. Firstly, speculation that cannot be experimentally tested, which Popper would classify as metaphysics. Secondly, speculation for which timely experimental disproof is offered, this Popper would classify as physics. We attempt the latter by simply following Heisenberg's advice that, "*…it is found advisable to introduce a great wealth of concepts into a physical theory, without attempting to justify them rigorously, and then to allow experiment to decide at what points a revision is necessary* [8]."

3. Mathematics

Lord Rutherford stated that, " *We haven't the money so we've got to think* [44]." Equally there comes a point where we have not got the mathematics and therefore have to think independently of it, since there are questions that run deeper than the axioms of our mathematics, questions that Quine referred to as "*…perennially present* [45]," the determination of the origin of the universe from nothing is one such question. But this introduces no new dilemma, since as part of the process of re-evaluating the fundamental concepts of physics we must reconsider its use of mathematics.

Bobbitt commented to Weinberg that, *" When I say to a child who asks why an apple falls to earth, 'It's because of gravity, dear,' I am not explaining anything. The mathematical description of the physical world that physics provides are not explanations…*[46]*"* David Böhm goes further, expressing the view that, *" …physics has relied excessively on mathematics during the last half-century, to the point where physicists are ignoring the philosophical and physical underpinnings of their theories and concentrating on the mathematics* [47]*."* For Bohm, mathematics is a relatively limited language in which to understand the universe. As Sir James Jeans said of the mathematical models of physics, *" Most scientists would agree that they are nothing more than pictures – fictions, if you like, if by fiction you mean that science is not yet in contact with ultimate reality* [48]*."* What we seek in this dissertation is to take the first steps to be *in contact with ultimate reality*, a contact not blurred or prejudiced by the axioms of any specific formalism.

Bohr lamented that, *"… even the mathematical scheme does not help. I want first to understand how nature avoids contradictions…* [13]*."* To do this, as we shall see, requires more than the application of mathematics, it will necessitate its re-conceptualisation to be more in keeping with how nature actually works. But such a process is necessary if we are to resolve Wigner's dilemma regarding *"…the unreasonable effectiveness of mathematics* [49]*."* Einstein's solution to this problem was to consider that, *" As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality* [50]*."* It is only through considering how nature itself experiences mathematics that this gap can at least partially be closed. However, even though the key mathematical concepts required will be introduced in this dissertation, we recognise that the task of developing a complete formalism for this cosmology is beyond any individual, and therefore it is necessary first for these new concepts to be introduced to, and assimilated by, the broader cosmological community so that they can participate in this development.

A complete mathematical framework is essential for the full development of any cosmological model, however there is some preliminary work that must be done *without a safety net*, so to speak, before this can be achieved. Therefore we must take Rutherford's advice and simply think.

4. Positivism

But before we can begin to think through outstanding problems in physics, we must determine if the terms of our consideration should be dictated by the requirement of positivism. This, like the reconsideration of mathematics, is simply part of the process of re-evaluating the fundamental concepts of physics.

The quickest way to understand the effect of positivism on physics, and the opposing opinions regarding it, is by considering Heisenberg's recollection of a conversation he had with Einstein, *" I pointed out* (to Einstein) *that we cannot, in fact, observe such a path* (of an electron in an atom)*; what we actually record are frequencies of the light radiated by the atom, intensities and transition probabilities, but no actual path. And since it is but rational to introduce into a theory only such quantities as can be directly observed, the concept of electron paths ought not, in fact, to figure in the theory. To my astonishment, Einstein was not at all satisfied with this argument. He thought that every theory in fact contains unobservable quantities. The principle of employing only observable quantities simply cannot be consistently carried out. And when I objected that in this I had only been applying the type of* *philosophy that he, too, had made the basis of his special theory of relativity, he answered simply: 'Perhaps I did use such philosophy earlier, and also wrote it, but it is nonsense all the same.'* [51]*"*

While other disciplines may claim to still adhere to the dictates of positivism, that is, to only consider observable quantities in their theories, cosmology certainly can not. Cosmology is already littered with *unobservable quantities* – strings [52], extra dimensions [53-55], even whole parallel universes [56, 57]. While advocating an initially philosophical approach to constructing a cosmological model, we contend that this exercise will not increase the number of unobservable quantities but reduce them.

Weinberg, who is certainly not a supporter of the benefits of collaboration between philosophy and physics [58], nonetheless admits that, *" In the hunt for the final theory, physicists are more like hounds than hawks; we have become good at sniffing around on the ground for traces of the beauty we expect in the laws of nature, but we do not seem to be able to see the path to the truth from the heights of philosophy* [46]*."* However, Weinberg complains that, *"…I have tried to read current works on the philosophy of science. Some of it I found to be written in a jargon so impenetrable that I can only think that it is aimed at impressing those who confound obscurity with profundity* [46]*."* While we agree with Weinberg that philosophy has become lost in rhetoric and needlessly complicated debate, this is not the nature of the consideration to follow. As for rhetoric we defer to Aristotle, *" The modes of persuasion are the only true constituents of the art: everything else is merely accessory* [59]*."* We submit that the best way to win the debate is to speak simply and be understood. Even Saint Augustine, once professor of rhetoric at Milan, acknowledged that, *" Our use of words is generally inaccurate and seldom completely correct, but our meaning is recognizable none the less* [60]*."* It should not be surprising if in defining the origin of the universe from nothing we confront concepts never perceived before and therefore never encapsulated by humanity into words. In attempting to make such new concepts understood we have no choice but to use inadequate terminology in order to make contact with concepts already defined by language. Over time these analogies will fade to recover the original insights, by then familiar enough to be encapsulated by their own unique words. Until then we must simply do the best we can to be understood, preferring to speak poorly than become so entangled in debate about the proper use of words that nothing can be said at all; *"…positivists will object that you are making obscure and meaningless noises, whereas they themselves are models of analytic clarity,"* Pauli complained to Heisenberg, *" But where must we seek for the truth, in obscurity or in clarity? Niels* (Bohr) *has quoted Schiller's 'Truth dwells in the deeps.' Are there such deeps and is there any truth? And may these deeps perhaps hold the meaning of life and death?* [24]*"* The *deeps* we would explore are the initial state from which the universe arose and this should be explored by whatever means possible, either *in obscurity or in clarity*. In doing so we simply take heed of Wigner's warning that, *"…we have no right to expect that our intellect can formulate perfect concepts for the full understanding of inanimate nature's phenomena* [61]*,"* a warning positivism would ignore. Bohr's final comment on positivism to Heisenberg and Pauli when they discussed the subject in Copenhagen in 1952 was that, *" Positivist insistence on conceptual clarity is, of course, something I fully endorse, but their prohibition of any discussion of the wider issues, simply because we lack clear-cut enough concepts in this realm, does not seem very useful to me – this same ban would prevent our understanding of quantum theory* [24]*."* Applied rigidly the dictates of positivism would reduce science to irrelevance before the human thrust for knowledge, since it would disallow questions humanity cannot abandon.

As Alfvén stated, " *To try to let knowledge substitute ignorance in increasingly large regions of space and time is science* [62]*.*" The part of Einstein's 1905 paper [63] that dealt with the photoelectric effect and introduced the concept of the photon contained barely any mathematics, but as Martinus Veltman commented, " *…it was nevertheless really a wonderful piece of physics. Great physics does not automatically imply complicated mathematics* [64]*!*" This sentiment is reinforced by Sirag, " *The essential point in science is not a complicated mathematical formalism or a ritualized experimentation. Rather the heart of science is a kind of shrewd honesty that springs from really wanting to know what the hell is going on* [65]*!*" After eighty years of the strict mathematical formalism of quantum mechanics that denied reality rather than giving insight into it, in the presentation of a new cosmology we must first seek to understand *what the hell is going on*. What is sought from philosophy is simply a deeper consideration of the problems associated with defining the origin of the universe from nothing, which may lead to new concepts that can be applied to their resolution. As for formalism, we simply recommend that we first take the time to understand what it is we wish to describe, since as von Neumann put it, " *There's no sense being precise when you don't even know what you're talking about* [5]*.*" Quantum mechanics provides a strict mathematical formalism [66], elevated to the status of a logic by Birkhoff and von Newman [67] yet still, as Penrose pointed out, "*…it makes absolutely no sense* [68]*!*" We would have cosmology make sense and from this understanding build an appropriate formalism. To achieve this we simply offer a slight correction to the zeal of the Renaissance that says we should think a problem through thoroughly and come to an understanding of the solution we would propose before seeking formalisation. Physicists too often wish mathematics to create their thoughts rather than simply express them.

5. Cosmology and the Process of Learning

It is easy to construct a cosmological model that is correct, even ones that claim to model creation from nothing. Postulate a set of initial conditions and then proceed from there in conformity with mathematics or logic, concluding at a point in agreement with some observational data. But being correct in these terms has proved to be a pointless approach to the problem, since there are too many fundamentally incompatible models that can be constructed in this manner. This approach presumes too much of nature, in fact as we shall see, more than it could do. But worst of all this approach ignores what we are trying to achieve. Make no mistake; what we seek is not the truth as nature experienced it, but human comprehension. The truth of the origin of the universe, if it were revealed before you, would be so subtle, so small a thing, that you could have no understanding of it. There can be no comprehension without a process of learning, which we deny ourselves by starting with postulates that are by definition unquestionably true. Instead, we must start with a scenario that far exceeds the truth in terms of its claim to make these events comprehensible, even though it can be deemed wrong because of this, and slowly strip away over time what becomes unnecessary as we grow familiar with the underlying concepts, working back to the truth in all its sparseness and subtlety, but grasping onto this process of reduction and learning in order to finally understand.

Were we to describe the story of nature's evolution accurately, that is, in accordance with how nature experienced it, then every sentence written would have to replace the previous one, until all that could be recorded is a description of what lies outside your window. There would be no explanation of where it came from, just a description of what it now is. This is the truth, if by the truth you mean a record of nature's experiences. Nature has no memory of specific events; it is merely the accumulated consequences of them. Nature has no capacity to do what cosmologists are tasked to do, describe the sequence of events that lead to this moment and this universe. The universe itself cannot know from whence it sprang, this secret is for human eyes alone to see. But nature's lack of memory does not exclude human comprehension since we possess a liar's eyes that can see even that which is not true. From a philosophical and epistemological point of view, this approach states that human comprehension may exceed the state's self-definition. That as human beings we are not restricted by physical truth, but may introduce concepts of structure not actually present in the physical system in order to provide an explanation for the state's eventual nature. The task of cosmology is not the retelling of nature's story, but the filling in of blanks in nature's memory. Cosmology has never succeeded at its task for the simple reason that it has never truly understood it.

We must utilise more than the senses that allow us to observe the external world in order to come to a full understanding of nature's evolution, we must draw also on our own experience of existence. But this is a reasonable approach since to deny that the human experience reflects the evolutionary process is to say that humanity arose independently of natural evolution. This would place human existence beyond the domain of science. Evolution is a cumulative process whereby each new epoch is built upon the consequences of its predecessor, therefore there is no point where earlier evolutionary epochs cease to be evidenced in the nature of the current system. If this were not true, science would be restricted to a study of the present physical system and cosmology would be impossible. While humanity is a recent addition to the evolutionary timeline, it is the cumulative result of the totality of it and as such it is valid to look to human experience to gain an understanding of all that lead to it. Make no mistake about what is sought, it is not the stones or the trees that wish to understand the events of nature's evolution, it is human beings. In this context, there can be no true understanding that does not relate to human experience, or in fact give credence to its origin and evolution. But even if nature could remember these events, it would not define them in this humanistic way, but simply as physical interactions. We however can understand what is happening at the earliest evolutionary epochs in terms of its contribution to later evolutionary developments, including the experience of sentient life.

But it is inadequate simply to write down an extended description of nature's evolution to despoil a piece of paper, which is then left undisturbed on some library shelf. Knowledge is not, nor should it be made, so passive a thing. The best place to store knowledge is not in a library but in humanity's perception of itself. Humanity has experience of several types of evolution, including biological and technological evolution, but to this list we must add perceptual evolution. Humanity can acquire a level of knowledge of the true nature of existence, sufficient to alter how we classify ourselves and how we interact with nature. This can be achieved if we assimilate an awareness of our origin into our very consciousness such that it need not be remembered, but instead affects our self-definition and thereby our actions, and through them the evolution of the environment around us.

No matter that we see our motivation for seeking knowledge of the origin and evolution of the universe as a personal quest, we as part of nature are a component of the physical apparatus of its learning process. Therefore a cosmologist's role is not merely to record past events as they occurred, but to use all the attributes of our humanity to instil in nature an understanding of them in terms that did not then exist. We are not retelling an old story but creating a new one. What must be understood is that, curiosity aside, there is no need to retell this story as it occurred, since that it happened and has had this consequence is enough. We must retell the story in such a way that it achieves new consequences. Specifically, pushing back the dawn of consciousness from when evolution first realised it, all the way back to the initial state. This is much to ask from a poor collection of words, but every journey must start somewhere and can be hastened if a map is provided to guide the way. Alfonso the Wise, King of Castile (1221-1284) boasted that, " *Had I been present at the Creation, I would have given some useful hints for the better ordering of the universe* [69]." Nature indeed seeks such advice, such hindsight.

6. A Brief Review of Quantum Cosmologies and the Problems of Defining the Initial State and First Cause

The Roman philosopher Lucretius' asserted that, " *Nothing can ever be created by divine power out of nothing* [70]." This remains the central dilemma of cosmology, how to create something from nothing in a manner acceptable to science. As Gott stated, " *The question of first-cause has troubled philosophers and cosmologists alike. Now that it is apparent that our universe began in a big bang explosion, the question of what happened before the big bang arises. Inflation seems like a very promising answer, but as Borde and Vilenkin* [71] *have shown, the inflationary state preceding the big bang could not have been infinite in duration – it must have had a beginning also. Where did it come from? Ultimately, the difficult question seems to be how to make something out of nothing* [72]."

There are many examples in the literature of cosmological models claiming to define the origin of the universe from nothing, with a vacuum fluctuation model being proposed by Edward Tryon [73] as early as 1973. More recently Atkatz and Pagels proposed a quantum tunnelling model in which, "*Massive, expanding matter has been 'created' from the vacuum* [74]." Vilenkin [75] also proposes a quantum tunnelling model, extending on the earlier work of Starobinski [76, 77], in which he claims that, "*…the Universe is spontaneously created from nothing…*[75]." All of these models follow the same basic formula – take a quantum phenomenon such as wavefunction fluctuations [78], vacuum pair production [79] or quantum tunnelling [75] and use this as a pseudo first cause for a cosmology. However there are several problems with this basic approach.

The first problem is that it is clear from a review of existing models in the literature that any number of cosmologies can be written using this basic approach that are either unrelated or incompatible, but that nonetheless all give agreement with the currently available data and are therefore indistinguishable. Having an unlimited number of solutions to the problem of the first cause is only slightly better than having none if we cannot determine which is in fact correct.

The second problem arises because of these models' reliance on quantum mechanics, which provides predictions of experimental results not explanations, as Penrose pointed out, " *The theory has, indeed, two powerful bodies of fact in its favour, and only one thing against it. Firstly, in its favour are all the marvellous* *agreements that the theory has had with every experimental result to date. Secondly, and to me almost as important, it is a theory of astonishing and profound mathematical beauty. The only thing that can be said against it is that it makes absolutely no sense!* [68]*"* Feynman agrees, lamenting that, *"…while I am describing to you* how *Nature works* (using quantum electrodynamics), *you won't understand* why *nature works that way. But you see, nobody understands that. I can't explain why Nature behaves in this peculiar way* [2]*."* The most that can be claimed by these quantum cosmologies is that we do not need to understand the first cause, because we have experienced such quantum events occurring in our current physical environment, but if we are simply to presume that the structures and interactions that we experience now also exist at the very beginning of the evolutionary timeline, we can only construct cosmologies that include no true evolution at all. This is far less than the ideal of knowledge philosophers and physicists have sought for so long. It would be a sad end to this long quest to simply say that we ultimately do not know how the universe came into existence, but that this is acceptable because we do not know how it currently works either. If in cosmology we start from an initial state that presupposes quantum mechanics, we deny ourselves any opportunity to fundamentally make sense, or to directly describe nature. In so doing we forgo any opportunity to address the most fundamental problem in physics – that the only means we have to get the right answer, quantum mechanics, makes absolutely no sense in terms of a description of nature. Only by examining a cosmology that does not presume quantum mechanics but demonstrates how its fundamental attributes arise as a consequence of nature's evolution can this problem be addressed. To assume that everything has remained the same and then try and do cosmology is a self-defeating and pointless exercise.

Quantum cosmologies that use vacuum pair production as a pseudo-first cause immediately introduce particles that already possess all the properties encountered in our current universe, allowing no opportunity to consider how these complex states evolved or how properties such a mass, charge, etc. originated. Ultimately these states and properties can only be understood in terms of their evolutionary history and without such understanding physics provides no more than an observation of the relationships between such states and properties. As difficult as it may seem we must start with states more fundamental than the elementary particles and attempt to discover how the elementary particles and their properties arose.

The various quantum cosmologies because of their reliance on spontaneous events as a pseudo-first cause share a common feature, the prediction that our universe is just one of an infinite number of other inaccessible, parallel universes. But there is a high price to be paid for this result – if our universe is merely one of an infinite ensemble then physics is reduced to the examination of an infinitesimally small fraction of the totality of nature that despite our self-interest, since it is the universe we inhabit, may be totally insignificant. The laws of physics that we have spent centuries unravelling may be repeated nowhere else and have no deeper basis than – '*Why not?*' This is too high a price to pay for a quick solution to the problem of the first cause, instead cosmology must persist in seeking a conceptualisation of nature's evolution that results solely in the one universe we can empirically examine thereby providing an explanation of its laws.

However the most fundamental problem with quantum cosmology is that it takes its starting point from an assumption that is known to be unjustified. Quantum cosmologies presume the existence of an initial state wavefunction even though no boundary conditions are given by which this wavefunction could be defined. This results in cosmologies that must rely on secondary quantum effects and new postulated processes rather than the more usual process of defining and then measuring a wavefunction. For example those quantum cosmologies that like Tryon [73] focus on perturbations in the wavefunction, having them act as focal points for significant effect as if they were the sole disturbance within an homogenous state, in this way ignore what the initial state wavefunction actually represents, so that the very definition of the initial state has no role to play in the progress of evolution. Paul Davies summarised the evolution proposed by the most popular quantum cosmology in this way: " *A tiny bubble of space pops spontaneously and ghostlike into fleeting existence as a result of quantum fluctuations, whereupon inflation seizes it and swells it to macroscopic dimensions. Freeze-out then occurs and the expansion rate drops amid a burst of heat. The heat and gravitational energy of expanding space then produce matter and the whole assemblage gradually cools and decelerates. Presto, a universe!* [78]*"* This process, according to Michio Kaku, does not violate conservation laws because, *"…it takes no energy to create a universe. If the universe is closed like a bubble, then the energy content of its matter is positive, while the energy of its gravity is negative: The sum is exactly zero (because it requires positive energy to lift an object out of a gravitational well, the object's gravitational energy is negative). Thus it takes no new energy to create new bubbles, which are constantly being created in the sea of nothing. Universes are for free* [80].*"*

Quantum cosmology relies on the quantum postulate that everything can be described by a wavefunction, and that such wavefunctions exhibit random fluctuations, to provide its initial conditions. But the information the initial wavefunction is presumed to include is neither specified nor used, since no measurement to extract it from the wavefunction is ever performed. Instead a totally new process is introduced whereby we must postulate repulsive gravity and have it act on perturbations in the wavefunction to inflate them into new universes. But there is in fact no reason to use the initial state wavefunction for this process rather than any other wavefunction, since perturbations are present in all wavefunctions. There is no inherent reason not to believe that universes should not spontaneously spring from any wavefunction at all, for example, from the one describing the surface of a desk. Of course quantum cosmology can postulate that there is an initial state wavefunction and that repulsive gravity only acts on its perturbations, but then this is no longer standard quantum mechanics but a unique variation of it. This variant quantum mechanics does not conform to the Copenhagen interpretation - there is no reality here dependent on measurement, since there is no measurement performed.

But ignoring the full specification of the initial state wavefunction and avoiding measurement is not an oversight but necessary since as Davies pointed out, " *If you are one of the people who believe that the observer matters, then you have a problem with quantum cosmology, because if you apply quantum physics to the whole universe you can't get outside the universe to observe it* [81].*"* This is why quantum cosmology postulates repulsive gravity rather than using measurement, because in order to do a measurement the initial state wavefunction must be an ensemble average of possible universes, which implies that there is some pre-existing knowledge of them that could be reduced to our universe by measurement. This would represent a more standard interpretation and application of an initial state wavefunction, but the question of who could have such foreknowledge and do such a measurement would then present somewhat of a problem. Science would have to rely on God to do this, with cosmology merely changing the Bible's account from, *"…God said* [82]*…"* to *"…God measured…"*

But in its postulation of repulsive gravity quantum cosmology ignores the fact that the object and the wavefunction describing it are not the same thing. The wavefunction representing all that can be known about a state does not exist in real space, but in a complex configuration space, with only the measured values extracted from it being considered real. A perturbation, no matter how large, is not a measurement and is therefore still restricted to the complex space. Gravity has no role in this environment, which is devoid of mass or spatial curvature, containing instead only complex numbers. Of course a role for gravity in this environment and a means for transition from the complex environment to a real one, independent of measurement, can be postulated. But this has even less of a relationship with standard quantum mechanics. Given this, the term 'quantum' cosmology becomes somewhat misleading, since all it relies on from quantum mechanics is the provision of a perturbation to act as a focal point for repulsive gravity in an otherwise homogeneous state. But if how this wavefunction is derived is never specified, if no information it is presumed to contain is ever extracted by measurement, if it must be a unique wavefunction, the only one on which repulsive gravity acts, and which can make a transition from complex to real space without ever being measured, why call it a wavefunction at all? A more honest postulate would be: *There is an initial state in which spontaneous perturbations occur, which are acted upon by repulsive gravity to create universes.* This is cheaper in terms of weight of postulates than to assume all the postulates required to establish quantum mechanics, augmented by the unique postulates mentioned above, in order to have these perturbations appear to occur naturally. We agree that because quantum mechanics works there is a certain credibility to utilising its postulates, but we would argue that quantum cosmology in altering them negates this. It is of no use relying on quantum mechanics to provide credibility if it cannot be used in its standard form. But if we are left with just the above postulate, we could just as easily postulate that the universe pops out of the hat with the rabbit. If we are simply to use all encompassing postulates, it is doubtful that any one postulate is more scientific than another. There are no simple solutions to a problem as complex as the origin of the universe, no quick fixes. It is necessary to truly understand the constituents of the initial state and how they drive evolution.

Much has been written about the capacity, or lack thereof, to know the initial conditions for any cosmological model. Valchurin *et al* [83] seek to avoid this difficulty by arguing that a theory of the initial conditions is not required since inflation is self-sustaining into the future. Similarly, Guth [84] has suggested that all information about the initial conditions would be lost because of the huge scale of inflation. However, it is recognized that inflation is not usually justified, but rather arbitrarily postulated by inflationary theorists [85]. Surely what is desirable is to understand why inflation occurs and what mechanism drives it. Simply postulating inflation and then saying that its presence either removes the need or capacity to understand the initial conditions cannot achieve this. Hawking and Turok stated that, *"…whether inflation actually occurs within a given inflationary model is known to depend very strongly on the pre-inflationary initial conditions. In the absence of a measure of the set of initial conditions inflationary theory inevitably rests on ill-defined foundations* [86]*."* However, Max Born [87] and Feynman *et al* [88] argue that the knowledge of the initial conditions required to model a system's development are absolutely unreasonable. Perhaps they are, but we cannot accept on the arguments of either Valchurin *et al* [83] or Guth [84] that any credible cosmology can be presented that ignores a description of the initial conditions. Nor do we accept that evidence of these initial conditions will be lost due to the effects of inflation. For cosmology to be an empirical science we must understand the initial conditions sufficiently to be able to find residual evidence of them within the current experimentally accessible environment.

a. A Reconsideration of the Problems of Defining the Initial State and First Cause

Our consideration must start with a problem that has confounded philosophers for millennia – *What is the first cause?* This problem can most simply be represented by the *Tower of Turtles* whereby Atlas holds up the world and is himself supported by standing on the back of a turtle, which stands on another turtle, which stand on another, *ad infinitum*. Is this truly an infinite regression or can we find a lowest turtle that stands on nothing at all and thereby represents the first cause? The solutions so far presented by physics can be characterised as simply replacing the vertical infinity of turtles with a horizontal one, an infinite number of parallel universes spontaneously springing forth from the same, usually quantum, phenomena. The vertical infinity of turtles states that the problem of determining the first cause is so difficult that it has not been solved. The horizontal infinity of turtles states that the first cause is so trivial that it occurs spontaneously and therefore an infinite number of times. We would suggest that neither of these alternatives is correct, but that instead we must accept that no state that can truly be termed the *initial state* can have a cause at all. The question: *What is the first cause?* has not been solved because it is invalid.

Such an initial state, devoid of cause, would equally be devoid of constraint – it is a state of unlimited potential but unspecified definition. But it is a state that is familiar to physicists, an environment where anything that can happen will. Tryon notes that in quantum field theory, *"…every phenomenon that could happen in principle actually does happen occasionally in practice, on a statistically random basis* [73].*"* And Steven Weinberg that, *"…we generally find that any complication in our theories that is not forbidden by some symmetry or other fundamental consideration actually occurs* [46].*"* Physics merely defines the constraints on the underlying reality that *anything that can happen will*, therefore it is on this basis that we must approach cosmology.

Saint Augustine asked, *" How did it occur to God to create something, when he had never created anything before?* [60]*"* This may seem to be a purely theological, or at best philosophical, question but it is science's failure to address it that has lead to the inclusion in our cosmology of an infinite number of universes. Science has taken the impossible, the act of creation, and replaced it with the spontaneous, an action so trivial that if assumed must constantly be repeated. Saint Augustine's concern has found its way into physics, expressed in contemporary, scientific terms by Tryon who states that the creation problem has two aspects, *" One is that the conservation laws of physics forbid the creation of something from nothing. The other is that even if the conservation laws were inapplicable at the moment of creation, there is no apparent reason for such an event to occur* [73].*"* The problem remains that no solution has been found as to why there should be a first event at all. But this is because the presumption incorporated into both of these considerations is that there was first an acceptable initial state, to which some motivation must be applied for it to become something totally different. The error here is to consider that the initial state was ever acceptable. In consequence of the lack of cause and thereby constraint, that initial state could have any number of contradictory definitions, becoming so hopelessly over-specified that it can have no meaningful definition at all. We perceive the initial state as nothing not because it is too empty, but because it is too full. Evolution is not about creating something from nothing, but rather it must involve the provision of constraints that can limit the over-specification that is an unavoidable consequence of a flawed set of initial conditions, so that there is some non-contradictory net definition.

The main impediment to understanding the origin of the universe is that it is seen as an immense and perplexing event - something goes bang resulting in the existence of space, time, galaxies and people. We have had to resort to considering this as either fundamentally a consequence of a spontaneous or random quantum event, or of divine whim, in order to explain why such a strange thing should occur. The gulf between science and religion, their presumed irreconcilability, is most sharply focused around this difference in the conceptualisation of the origin of the universe. But the truth, as is always the case, lies somewhere in between seemingly irreconcilable extreme views. The reason no resolution of the first cause has been found is that our most fundamental presumption concerning nature is wrong - *nature is not perfect*. The first cause is neither a wilful act nor a spontaneous event, but simply a response to the fact that the initial state is flawed.

The perfection of nature whether justified on the basis of its being God's creation; or simply on our experience of the beauty and complexity of earth's ecosystem; or on the consistency and mathematical beauty of the physical laws, is humanity's most fundamental presumptions about nature. But this has not lead to a satisfactory understanding of nature. Weinberg lamented that, *"…the more the universe seems comprehensible, the more it seems pointless* [89]*."* He later called this statement rash and clarifying it, *" I did not mean that science teaches us that the universe is pointless, but rather that the universe itself suggests no point* [46]*."* We would disagree. The initial state is not perfect, but flawed in having no cause that could necessitate a single existent expression. Nature does not arise from a set of perfect initial conditions. However this does not represent a crisis for physics, but an opportunity to determine purpose through the examination of physical processes. It is not true that *"…the universe itself suggests no point* [46]*,"* it is just that the presumption that nature is perfect has made us incapable of discovering the evidence of purpose. Purpose is determinable in terms of flaws that can be addressed. We can therefore determine the purpose of an evolutionary progression if we can see the flaw it would overcome. Such flaws are a determinable part of the physical makeup of the system, as open to empirical examination as any other aspect of it. The flaw inherent in the initial state is that it can have no cause. Evolution's journey commences not in consequence of there being a first cause, but because a cause must be found in order to resolve the flaw of over-specification.

7. A Physics Beyond *How?*

For countless millennia people have stared into the night sky, wondering how this empty blackness could give rise to the world around them. They sought a cause, a reason why nature should seek to progress beyond the calm serenity of oblivion to the calamity and strife of the current universe. More than anything else what they wanted to know was: *Why does the universe exist, what purpose does it serve?* In a supposedly more enlightened age science abandoned this question as either too difficult or beyond the domain of physics, instead concerning itself with *how* the universe works, in an attempt to predict and harness the outcomes of its interactions. But as Quine pointed out, *" Many of the problems of philosophy are of such broad relevance to human concerns, and so complex in their ramifications, that they are, in one form or another, perennially present. Though in the course of time they yield in part to philosophical inquiry, they may need to be rethought by each age in the light of broader scientific knowledge and deepened ethical and religious experience. Better solutions are found by more refined and rigorous methods. Thus, one who approaches philosophy in the hope of understanding the best of what it affords will look for both fundamental issues and contemporary achievements* [45].*"* Therefore it is not surprising that as humanity's scientific knowledge has broadened our thinking has come full circle, as Gross pointed out, *" Now that we understand how it works, we are beginning to ask why are there quarks and leptons, why is the pattern of matter replicated in three generations of quarks and leptons, why are all forces due to gauge symmetries? Why, why, why?* [1]*"* Physics has matured to the point where its next challenge is addressing the question: *Why?*

In response to Weinberg's original comment that, *"…the more the universe seems comprehensible, the more it seems pointless* [89],*"* the astronomer Margaret Geller asked, *"…Why should it have a point? What point? It's just a physical system, what point is there?* [90]*"* That there is a point to evolution and the universe that arrises from it, is unavoidable given that there are flaws yet to be overcome. A physics incapable of addressing the question *Why?* cannot hope to comprehend what set evolution on the path leading to the universe we experience. Nor will we truly understand this universe, until we are able to see it as just one incremental step in a consistent evolutionary progression with a clear and comprehensible purpose.

8. Concluding Comments on Chapter One

In this chapter we have considered the questions: *What is the first cause?* and: *What is the initial state?* concluding that there is no first cause and in consequence of this no clearly defined initial state, but that this situation does not represent a lack of human knowledge but a real flaw that nature must strive to overcome. What sets evolution on its path is not the presence of a cause but the search for it. Cause is not the instigator but the goal.

But if the initial conditions are unresolved and the first cause yet to be determined, it might seem that cosmology is impossible since these, its most fundamental questions, have not yet been answered. But this does not make cosmology impossible, but rather it is this fact that will allow cosmology to take its place as an empirical science. Cosmology is not a purely theoretical discipline speculating about an unreachable past, the resolutions of its most fundamental dilemmas are still being acted out in the physical environment around us, where they are clearly within the reach of empirical science. The origin of the universe is not something that happened, *" A long time ago in a galaxy far, far away…*[91],*"* it is something happening right here, right now.

What we shall attempt to do over the following chapters is trace the evolution of the universe in terms of nature's attempts to overcome the flaw of having no first cause. By doing so we automatically model the consequential physical structure and its interactions in these terms, thereby revealing how this concept can be experimentally scrutinized. This approach no doubt leaves us on unfamiliar ground, but this is as it must be. If you choose a starting point for a cosmological model that is recognisably part of physics, then the exercise engaged in can not be an attempt to understand the origin of physics. In developing this new *Flawed Nature Cosmology* we cannot apply the same methods as previous researchers and achieve significantly different results, instead we must look behind the physics, beyond structure itself, and see what nature still has to reveal. We apologise if this makes this presentation difficult or confronting, but please keep in mind Voltaire's advice that, "*If we do not find anything pleasant, at least we shall find something new* [92]." However we shall balance the introduction of new ideas, as far as possible, by showing that precedents for these ideas exist or by demonstrating how they can overcome outstanding problems in a simpler manner than has previously been suggested. We are fortunate enough to live in an age when scientists like Michio Kaku can say, "*Today, we will discuss what probably happened before creation. Analysing this question is what I do for a living* [80]." We would join him in this profession.

Chapter Two:

The Origin of the Future

“ There is a theory which states that if ever anybody discovers exactly what the Universe is for and why it is here, it will instantly disappear and be replaced by something even more bizarre and inexplicable.

“ There is another theory which states that this has already happened [93]*.”*

Physicists named this *something even more bizarre and inexplicable* quantum mechanics.

9. Introduction - Time and Cosmology

The current approach to constructing cosmological models is to postulate some initial state and then *'run the clock forward'* to evaluate its evolution over time. But this leaves time as merely the ticking of some universal clock, an additional initial condition that must also simply be postulated. This approach presumes physical evolution rather than explaining it. For cosmology to progress to a new level of insight we must commence our consideration in an environment where time neither pre-exists nor has a predetermined structure. Time itself must originate in a comprehensible manner as a consequence of the inherent nature of the initial state.

But can we deal with time in a more fundamental way than simply in terms of the motion of material objects? Most cosmologists would say no and therefore wish to constrain cosmologies to commence with the big bang, when material particles first moved in space. Gott cites Hawking's analogy [94] that the beginning of the universe *"…is pictured as being like the south pole of the Earth and it is usually said that asking what happened before that is like asking what is south of the south pole* [72]*,"* as a way of avoiding looking at anything preceding the big bang. Paul Davies [78], in his popular writings on quantum cosmology, goes even further quoting Saint Augustine, *" The world was made, not in time, but simultaneously with time. …There is no time before the world* [60]*,"* as justification for the statement that if time is created with the universe, then it makes no sense to talk of what happened before the big bang. Weinberg stated that, *" …An important implication* (of quantum cosmology) *is that there wasn't a beginning; …one doesn't have to grapple with the question of it before the* (big) *bang. The multiverse has just been here all along…*[80]*."* But it is not sufficient to claim that a question you cannot answer cannot be asked. Saint Augustine was willing to confess ignorance, *" What, then, is time? I know well enough what it is, provided that nobody asks me; but if I am asked and try to explain, I am baffled* [60]*."* Physicists such as Baggott are equally honest, stating with regard to the debate as to whether quantum mechanics represents a complete picture of nature, *" …my personal view is that we still do not yet know enough about the physical world to make a sound judgment about its* (quantum mechanics') *meaning. The positivists say that the theory is all there is, but the realist says: Look again, we do not yet have the whole story. As to where we might look, my recommendation is to watch* ***time*** *closely: we do not yet seem to have a good explanation of it* [95]*."* Saint Augustine stated clearly that, *" My problem is to discover the fundamental nature of time and what power it has* [60]*."* This remains a crucial problem even for today's physicists, as Penrose emphasised, *" It is my opinion that our present picture of physical reality, particularly in relation to the nature of* time, *is due for a grand shake up – even greater, perhaps, than that which has already been provided by present-day relativity and quantum mechanics* [96]*."*

It is the advent of quantum mechanics more than anything else that should have compelled physicists to undertake a reconsideration of the nature of time, since it removes the causal determinism whereby the next instant of time can be considered to be determined by the current physical circumstances. Even though the classical conceptualisation of a causal timeline does not agree with the results of quantum experiments, it still dominates our visualization of time to the point where it is simply assumed as an initial condition in cosmological models. We submit that the presumption that such a causally deterministic, sequential timeline exists is not one to which cosmologists are entitled. Instead what we shall consider here is a more primitive initial state that provides the motivation and the mechanism to at least attempt to establish a sequential timeline. Such a fundamental reassessment is possible because the nature of time remains an open debate within physics [97-99], philosophy [100-102] and the general community [103]. To undertake this consideration is an essential exercise if we are to reconcile our conceptualisation of time with the facts quantum experiments have revealed to us.

Without understanding what motivates evolution to commence there was no hope of gaining a more fundamental insight into the nature of time; however this consideration states that evolution is motivated by the need to overcome the flaw of there being no first cause. At its most fundamental then, time is a specific approach to establishing causality and thereby overcoming this flaw. Time is not the ticking of a clock but the specification of a causal schema. We shall therefore treat time not as an amorphous thing without structure, but in terms of specific causal schemas. The origin of time shall not be dealt with simply in terms of a single initial event, as is the case for cosmologies that would have time originates with the big bang, but instead we shall consider the incremental evolution of time over several distinct evolutionary epochs. This concept leads us to deal with a subject not dreamt of by Saint Augustine [60] in his contemplations, let alone evident in the literature of physics – the evolution of time, that the structure of time itself must adapt to meet nature's changing needs. This is a truly revolutionary concept but one, as we shall see, that arises quite naturally out of this cosmology.

Essentially what is to follow is an initial blank slate reconsideration of all the fundamental questions in cosmology. This approach is necessary because current cosmologies seem too often to be putting the cart before the horse, so to speak, by seeking a formal mathematical representation before thoroughly thinking through all the issues a truly fundamental cosmological model should address, with the need to reconsider the nature of time being one example of this. We shall present this work in a quite informal narrative manner, because this gives us an opportunity to deal with subjects quite beyond any capacity for formal analysis. What is sought is a physics that not only provides calculations but explanations. Calculation has been emphasised in physics for nearly two hundred years, but this approach has lead us to a quantum mechanics that has no clear relationship with a real description of nature and must therefore too often characterise the results of its calculations as *'non-intuitive.'* Compared to this vast extent of time and scientific endeavour we feel that the emphasis this dissertation places on explanation is a small redress.

Wigner was concerned with what he described as *"…the unreasonable effectiveness of mathematics. Again and again, abstract and beautiful mathematical relationships, explored for their own aesthetic sake, are later discovered to have exact correspondences with the real world – a coincidence that is quite remarkable* [49]*."* With physics' growing reliance on more and more abstract mathematics the inability to address Wigner's concerns puts all developments in theoretical physics at risk. Where there is not the constraint of timely experimental support but instead only reliance on the mathematics itself, a clear understanding of the relationship between the mathematics and nature itself, particularly with respect to any limitations in the applicability of the mathematics, is essential since without this we run the risk of wasting enormous amounts of time and effort on abstract mathematical models that may have no relevance to how nature actually works. The problem is that currently physics does not possess a clear enough conceptualisation of nature to address Wigner's concern at all. However, since what we are engaged in here is a more preliminary but more fundamental consideration of cosmology, instead of seeking a mathematical representation of the initial state so that its evolution can be modelled, we shall reverse the roles of cosmology and mathematics so that the initial environment and its evolution defines the mathematics. By doing this we hope to emphasise that there are two distinct types of mathematics, pure mathematics whose components are conceptual and need refer to no material states, and the mathematics of physics that must, by the very nature of this science, refer to real constituents of nature. This distinction has become lost as the mathematics used by physicists has become more complicated and abstract. The physical states and situations the mathematics was originally supposed to model have become lost amidst mathematical representations that no longer seem to have any association with real objects. The cost of this is that it deprives physicists of the use of intuition in seeking solutions to the problems they are working on. They are left solely with mathematical operations that may or may not have anything to do with how nature actually works. This cosmology represents a blank slate reconsideration of nature's evolution and therefore provides an unprecedented opportunity to form connections between mathematical representations and the objects of nature at a fundamental level. Even though this process can only be begun here, we hope it will inspire others to the same endeavour, thereby giving an understanding of the mathematics of physics distinct from that of pure mathematics, which will allow the intuition of physicists a greater role in providing solutions to their equations.

However since this work will not present a formal cosmological model you might reasonably ask: *What immediate benefit does this dissertation provide?* Apart from new concepts we hope will reinvigorate the debate on cosmology and lead it to address more fundamental issues, the most significant immediate benefit this dissertation offers is a totally new conceptualisation of nature and its evolution consistent with all that has been learned since the introduction of quantum mechanics. This can be achieved because this cosmology provides a general comprehension of nature's actions, that the lack of a first cause is a flaw that must be resolved, something we contend that science requires. Many scientists would disagree with this statement because it is not the current state of physics, which instead provide precise calculations of properties such as the magnetic moment of the electron, while having abandoned any attempt to maintain a consistent conceptualisation of nature and thereby any general comprehension. However what this dissertation seeks to make clear is that this state of affairs is not necessitated, that it is possible to have a conceptualisation of nature and its evolution consistent with all that physics has learned. It has been more than one hundred years since Planck, on 19th October, 1900, presented his results implying the quantisation of energy [3], an event which is taken as the birth of quantum mechanics. It is long past time for physics to once again be able to claim that it provides humanity's best direct description of nature and thereby encapsulates a general comprehension of " …*what the hell is going on* [65]*!*" The journey before us through the initial consideration of this new cosmology is not an easy one, but the potential rewards are worth any effort. So as the narrator once said, " *I would like, if I may, to take you on a strange journey* [104]*.*"

10. The Origin of the Future

The cosmologist’s task is to stare into the heart of oblivion and understand. Lucretius’ assertion that, “ *Nothing can ever be created by divine power out of nothing* [70],” may or may not prove to be correct given the total extent of nature’s evolution, however what is important to us here is that nature certainly did not know this to be correct at the beginning of all things.

The initial postulate of this cosmology is that: *The lack of a first cause represents a flaw that nature must take action to overcome*. The obvious question therefore is: *How does nature know that the lack of a first cause represents a flaw?* It does not. Nature has no knowledge independent of the physical consequences of events and no event has yet occurred. It is simply true that no first cause is evident. Therefore nature’s first action assumes that none is required, it simply realises any random potential as the definition of the initial state. The lack of a first cause does not mean that nothing can happen, but that nothing causally deterministic can happen. The lack of a cause is equally a lack of constraint such that anything is possible. The realisation of any random potential represents the establishment of the future, that is, the realisation of a definition of the entire initial state independent of any causal justification, any past at all.

The first level of time, as defined by the causal schema of random realisation of potential, is the future. This approach to overcoming the flaw of there being no first cause defines nature’s first evolutionary epoch. It is interesting to note that we have not found the past at the beginning of all things but the future.

Can we have the future realised before the provision of a cause as part of a cosmological model? We already do. Hawking’s [94] cosmology[1] is also based on a non-standard concept of time with the goal that, *“…in imaginary time there need not be any singularity which forms a beginning or end to time…*[105]*.”* The implications of such a time, as Isham pointed out, are that, *“…when you come to imaginary time you have this rather peculiar possibility of having a now, as it were, without necessarily having a chain of past moments…*[105]*.”* Whether we are dealing with the cosmology of this consideration or Hawking’s imaginary time cosmology, physics is confronted with a conception of time where the future can be realised independent of a preceding causal sequence.

a. The Principle of Sufficient Reason

It is commonly believed that there must be some reason for action so that the past provides a definite cause for the current state of the world. This concept is embodied in Gottfreid Leibniz’s *principle of sufficient reason* [106], whereby for something to exist there must be sufficient reason to justify it. But in terms of cosmology Leibniz rejected the concept that the state of the world a moment before now and the physical laws of motion are sufficient to explain the existence of the world now, *“…however far you go back to earlier states, you will never find in those states a full reason why there should be any world rather than none, and why it should be as it is* [107]*.”* This was taken to be so because it was believed that the earliest state must be nothing itself and that the principle of sufficient reason dictates that something can not come from nothing, *ex nihilo, nihilo fit*, since nothing can not

[1] See also Chapter Three: 28a. *Comparison with Hawking’s Flexiverse.*

provide sufficient reason. We contend that adherents of the principle of sufficient reason are correct in saying that nothing can not provide sufficient cause for the existence of the world as it is, but incorrect in presuming that progression must await a cause. The commencement of nature's evolution can be understood precisely because it is a consequence of the lack of cause. While humanity, seeking certainty in the world, may wish time to progress according to a linear sequence of sufficient causes from past to future, nature itself is not so fussy, if a cause proves to be required nature is as content for it to be provided by the future as by the past. It is not the initial state that provides causal resolution, but rather the evolution of the physical system over all of time. The physical system is not the consequence of a first cause, but is rather the catalyst by which sufficient reason is sought. Scientists and philosophers still seek a first cause in the initial state, but nature has already passed beyond this course of action. It is of no use seeking an answer in terms nature itself does not pursue.

b. Retrocausality in Physics

The concept that *if a cause proves to be required nature is as content for it to be provided by the future as by the past* is not unfamiliar to physics, since general relativity contains the idea of a *block universe*[2] where the past, present and future all exist seamlessly and where, as David Miller of the Centre for Time at the University of Sydney, Australia put it, *" If you have the block universe view, the future and the past are not very different, so there's no reason why you can't have causes from the future just as you have causes from the past* [108].*"* Quantum electrodynamics, as developed by Feynman and Wheeler, is *"…based on waves travelling forward and backwards in time* [108].*"* In fact, as Caslav Brukner pointed out, *" Real temporal order in general, for quantum mechanics, is not important* [108].*"* Physics has incorporated nature's solution to the lack of a first cause into the framework of both general relativity and quantum mechanics, without having a clear cosmological justification for it, at least prior to the Flawed Nature Cosmology of this dissertation. By explaining this temporal aspect of both theories within one consistent cosmological framework, their perceived incompatibility can at least in part be redressed. As Avshalom Elitzer stated, *" …I believe that when we finally find the theory we've been looking for, a theory that unified quantum mechanics and relativity, it will involve retrocausality* [108].*"*

c. Creation verses Physical Process

The assertion of one possible definition of the initial state independent of causal justification can be considered as an act of creation. But what could not be understood before the introduction of the concept that nature could be flawed, is that even if creation occurs it can only form part of the total process, since the assertion must be tested to see if it overcomes the flaw that motivated it by negating the need for a first cause, or if some causal justification is still necessary. The gulf between science and religion, their presumed irreconcilability, is most sharply focused around this difference in the conceptualisation of the origin of the universe, whether it is an act of creation or the consequence of a physical process. But what we are examining here is not the human debate of science versus religion; we are simply describing

[2] We shall examine the cosmological bases for the *block universe* concept in Chapter Two: 34d. *The Further Evolution of Time – Epoch II.*

what nature is doing, quite independent of human involvement or prejudices. Nature is determining for its own reasons if there can be creation purely by assertion or if causal justification is required. That the first and most fundamental of nature's actions is reflected in a human debate, simply demonstrates that humanity is more in tune with nature than is consciously realised. But since this is fundamentally nature's dilemma not humanity's, this issue need not be endlessly debated, but can be resolved by a more detailed understanding of the evolutionary process.

11. Nothing and Evolution

Because there is a definition in our dictionaries we tend to think of nothing as a clearly defined concept and therefore an initial state that is nothing as a clearly defined state. But the nothing that we find in cosmology has no cause and therefore has no necessitated definition. It is perhaps tempting therefore to think of it as the absence of definition, but this is not correct either, since having no first cause means that it can potentially take any definition at all. Nothing in this cosmological context is the absence of definition but the presence of potential. It is this unresolved state that is the *Well of Creation* from which all things are drawn. Nothing is not pre-defined at the beginning of all things but must instead be defined by some process. It is the examination of this process that provides physics with its most fundamental cosmology. We have called the nothing that we examine in this consideration *the initial state* to save confusion arising from ingrained prejudices. However periodically we will point out that this initial state retains equivalence with nothing, despite its evolving complexity.

If the initial state is unconstrained such that anything that can happen will, can its realised potential, like the fluctuations of quantum cosmology, immediately establish entire universes? No, the limiting factor is knowledge. Even the most primitive constituents of a universe, energy and space, are complex states beyond the initial state's experience. While the lack of restraint inherent in an initial state devoid of a first cause ensures that anything that can happen will, only knowledge provides complexity in the application of this potential. Such knowledge only comes from the actual occurrence of events, not from an overabundance of untested potential.

Let us consider nature to be a sculptor and the initial state its lump of rock. When nature chips away from the rock all that is excluded by constraints, the universe is what is left. Is the universe then the work of a blind sculptor who does not know what he seeks to make? It is the presumption that foreknowledge is either required or desirable that is in error here. The sculptor need not know in advance what statue lies hidden within the rock, he is a questioner and the refinement of the sculpture no more than the refinement of the question, until the question is so precisely phrased that there can be no other answer but the resultant sculpture. The universe arises as a consequence of its own processes, that one event influences what is to follow in terms of the refinement of constraints. Physics could not deal with creation from nothing, but defining constraints that can be placed upon potential in order to elicit a specific result is a problem physics can address.

12. This Cosmology and Vacuum Pair Production

Sir Arthur Eddington commented on Heisenberg's uncertainty principle that, "*Something unknown is doing we don't know what* [109]." It is easy to project any imaginable concept into such a vague environment. But by far the most bizarre consequence of the uncertainty principle is the one for which we actually have empirical evidence, the spontaneous appearance and disappearance of virtual particle pairs from the vacuum. Such vacuum pair production forms the basis for many cosmologies [79]. But these particle pairs, no matter the fleeting nature of their existence, are exactly as complex as the elementary particles that make up the universe. The virtual particles pop into existence with perfectly defined mass, charge, spin, etc. and exhibit spatial separation. No wonder cosmologists favour using vacuum pair production as the first event in their models, since it leaves them with little left to do. But a cosmology that simply accepts that the constituents of the initial state automatically possess all of these complex properties can give no further insight into the origin of those aspects of nature that physics is most concerned with. If nature from its inception possesses such complexity, then perhaps those that denote it *'Nature'* are correct in deifying it.

But this is not what the current consideration suggests. Instead the initial state is only defined by what it does not possess, a first cause. The lack of constraint that is an unavoidable consequence of this ensures that anything that can happen will, but it provides no knowledge that would allow this potential to result in the spontaneous appearance of complex structures. The initial states of most cosmologies are either short lived, like the pre-conditions for the big bang [110], or soon departed from, such as the primitive spaces of tunnelling cosmologies [74, 111]. These are all linear models that soon progress beyond their initial conditions. However the initial state of this consideration cannot be influenced by any causal past and therefore its evolution must involve self-exploration rather than progression. If as a cosmologist you are handed a box of nothing and asked to make the universe from it without adding anything, you must do what the initial state itself needed to do, look in the box. If we are to understand the origin of our universe starting from nothing and adding nothing, we must look inside the initial state rather than beyond it. The vacuum, including the spontaneous manifestation of virtual particle pairs, is the current evolutionary epoch's realisation of the initial state. However, the complexity involved in this realisation requires a long and arduous evolutionary journey. It is only by accepting that the current properties of the vacuum, like the galaxies of this universe, are evolutionary developments applicable only to this epoch that we can come to understand what virtual particle pairs are and how they came to possess the complex properties that physics models.

13. A New Minimum Entity

The unprecedented success of quantum mechanics means that it is generally accepted that everything can be defined in terms of quantum wavefunctions, that we have reached a point where ' *One model fits all*.' However if we look at this statement in the context of cosmology it clearly cannot be true, since if a wavefunction requires boundary conditions for its definition these cannot themselves be wavefunctions. Therefore cosmology compels us to do the unthinkable, introduce a state more fundamental than the wavefunction. But in doing this we shall not shatter the uniformity of physics' model of nature but make the statement that *'One model fits all'* true, where previously it had been a claim too easily refuted by cosmology. This requires that both the initial boundary conditions and the wavefunction itself be special cases of the same underlying state. We shall do this by introducing a new minimum entity, but first let us briefly review physics' current dominant minimum entity model - string theory [1].

a. A Brief Review of String Theory

Minimum entity models start by postulating a minimum constituent from which the universe is presumed to be composed, and then seek to build up a consistent picture of nature from this. String theory [1] is the most well known of these models. Later when considering the origin of space, we shall also review Penrose's [112] *spinor* and *twistor* minimum entities.

The description of elementary particles as spatial points represents a significant problem for physicists, since there is no mathematical model for examining such singularities. One approach to this problem was to remove singularities from the physical model altogether, by postulating a spatially extended minimum entity, a *string*. As Michael Green put it, *" In a nutshell, string theory is a generalisation of all earlier particle theories in which the fundamental particles are no longer described as points but arise as different modes of excitation of an extended, string-like, object* [113]*."* Such a string theory describing bosons was proposed by Yoichiro Nambu [114] in 1970. As Peat pointed out, *" To overcome the objection that such objects had not been detected in elementary particle experiments, Nambu set their length at 10^{-13} cm, about the experimental size of an elementary particle. The other fundamental parameter was the tension, which Nambu set at 15 tons. These parameters determined the string's vibration and rotation and therefore a corresponding spectrum of masses* [7]*."* But there was still a fundamental problem which was pointed out by Claude Lovelace [7], in order for the equations describing these one dimensional strings to be relativistically covariant they had to be written in an unimaginable 26-dimensional space. Since most physicists were unwilling to take seriously a theory that had as its basis a one-dimensional object, rotating and vibrating in a twenty-six-dimensional space, Nambu's string theory was unsuccessful.

Building on the earlier work of Pierre Ramond [115], as well as André Neveu and John Schwarz [116], aimed at extending Nambu's string theory so that it could describe both fermionic and bosonic particles, string theory was revived in the 1980s through the work of Joel Scherk [117, 118], John Schwarz [119-121], Michael Green [113, 122, 123] as superstring theory [124]. Nambu's strings had been designed to deal only with the properties of bosons, whereas superstring theory was to deal with all the elementary particles and all the forces of nature. But if superstrings were to represent gravitons, then their size must be set at 10^{-33} cm, the scale of the Planck length at which space-time begins to break down. Superstring theory did not manage to remove the extra dimensions that plagued Nambu's theory, but it did reduce the number of dimensions required to ten, which made it somewhat more palatable. This new string theory proved popular, so much so that several variations of string theory were proposed, none of which could be shown to be better than any other. As Michael Duff commented, *" If String Theory was this so-called Theory of Everything five theories of everything seemed like an embarrassment of riches* [125]*."*

The solution to the over abundance of string theories turns out to be the introduction of a new theory, M-theory, which was formulated in eleven rather than ten dimensions. As Burt Ovrut [126] put it, *" The answer turned out to be – and it really was absolutely remarkable …that they were all the same. These five String Theories turned out to be simply different manifestations of a more fundamental theory, precisely this theory we had discarded back in the early 1980s* [125]*."* Kaku

[124] continues, *" In 11 dimensions looking from the mountain top, looking down you could see String Theory as being part of a much larger reality, reality of the eleventh dimension* [125]*."* M-theory does not deal just with one-dimensional strings, but with a range of objects called *branes,* which are *"…extended objects with p spatial dimensions (p = 0 for particles, p = 1 for strings, p = 2 for membranes etc.) Note that a 0-brane sweeps out a worldline in spacetime* (which gives a history of the particle in terms of its positions at all times). *A string sweeps out a worldsheet and in general a p-brane sweeps out a p + 1-dimensional 'worldvolume' in spacetime* [127]*."* Peat describes the origin of a world surface, or worldsheet, in these terms, *" In our conventional space, a string is a one-dimensional object. But in spacetime it acquires the additional dimension of time. As a result, the string becomes a one-dimensional line that becomes swept out in the forth dimension of time. In other words, a string becomes a two-dimensional surface* [7]*."*

b. A Brief Review of Brane Cosmology

String theory did not originate as a cosmology, since strings as minimum entities are postulated fully developed rather than derived in any cosmological sense. However it has been suggested that superstrings existed and underwent significant interactions prior to the big bang [52, 128-130]. Eventually, from M-theory, string theory spawned its own cosmological models - brane cosmology [38, 131]. One version of brane cosmology postulates that there are an infinite number of universes existing in the extra dimension branes of M-theory. As Michael Duff put it, *" The other universes are parallel to ours and may be quite close to ours, but of which we'd never be aware. They may be completely different with completely different laws of nature operating* [125]*."* Burt Ovrut took this concept even further, *" These things can move. They are not static, they're, you know, like everything else in the world they can move around and there's not much room for them to move in. In fact if they move they're very likely to bang into each other, and one thing that had occurred to me very early on is what happens if they do?* [125]*"* In a conversation between Ovrut, Neil Turok and Paul Steinhardt [132] it was suggested that collisions between these moving universes might explain the big bang that created our universe. As Ovrut recalls, *" And as we went along, at least I learned more and more about how it might be possible to have these brane collisions produce all of the effects of the early Universe and in particular it's just easy to do with my hands, when they collide you might have a Big Bang* [125]*."* It is therefore the contention of this brane cosmology that the big bang that created our universe was the result of the collision of two universes moving along the extra dimensional branes of M-theory. As simplistic, or even absurd, as this proposal may seem there has been an enormous amount of effort expended in its development [38].

But this explanation of the big bang is just one extreme example of an overall cosmological schema *"…where our four-dimensional world is a hypersurface (three-brane) embedded in a higher dimensional spacetime…*[133]*."* Therefore, *" In brane cosmologies, the observed universe is a brane in a higher-dimensional bulk* [134]*."* These higher dimensions can be postulated to contain all sorts of things to solve all sorts of problems. For example some brane cosmologies *"…depict dark matter* (matter only evidenced by its gravitational effect) *as being placed on another brane, a sort of parallel world, in the bulk; others address in a novel way the cosmological constant problem* (which relates to both the use of repulsive gravity in quantum cosmology and current evidence that the universe is presently undergoing accelerated expansion [135-139]) *by considering the effects of a scalar field in the bulk…*[38].*"* In this dark matter model it is assumed that gravitational effects cross the dimensional barriers, while other effects are isolated on their respective branes, thereby seeking to explain why dark matter is non-interactive except in terms of gravity. Other brane cosmologies redefine gravity all together, with some having gravity act differently at small length scales [140-143], while others have it act differently a large length scales [144]. The extra dimensions of brane cosmology are considered not to be evidenced either because they are compact [145] or if non-compact their gravitational effect is localized [143], thereby being evidenced only as an extra dimensional graviton. As for how these situations evolved, one approach is to consider that originally all dimensions were compact and that while some grew to be the familiar dimensions of our universe, others were prevented from doing so [55].

Given the basic scenario of brane cosmologies you are free to postulate anything you like to create any number of varying, even contradictory, models. It is then a matter of determining if any of these cosmologies are useful in resolving real problems in physics. But should we not ask ourselves whether these solutions to problems in physics, if they must be placed in extra dimensions that are not experimentally accessible, are truly part of physics at all? Eighty-five years ago Einstein asked, *" How does it come about that alongside of the idea of ponderable matter, which is derived by abstraction from everyday life, the physicists set the idea of the existence of another kind of matter, the ether? The explanation is probably to be sought in those phenomena which have given rise to action at a distance…*[146].*"* Science is now dealing with different problems, but in framing their solutions we must be careful not to make the extra dimensions of string theory the ether [147, 148] of a new millennium.

c. Potentia

It is not our intention to construct a cosmology from the postulation of a minimum entity, since no truly fundamental cosmology can presume the presence of any such state. In the initial state of this consideration nothing is present, not even a first cause. If we are to introduce a minimum entity it must be derived from the cosmology, not the cosmology from its postulation.

While we are used to thinking of states in terms of material objects such as stones and trees, where they are defined by definite properties that distinguish them from an external environment, this is simply a macroscopic illusion. When we dissect these things into their smallest constituent parts, we find that they are composed of elementary particles that are more ethereal, less resolved. As Heisenberg put it, *" In the experiments about atomic events we have to deal with things and facts, with phenomena that are just as real as any phenomena in daily life. But the atoms and the elementary particles themselves are not as real; they form a world of potentialities or possibilities rather than one of things and facts… The probability wave… means a tendency for something. It's a quantitative version of the old concept of potentia in Aristotle's philosophy. It introduces something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality* [8].*"* Quantum mechanics is a formalism that describes the evolution of unresolved states, states of potential. Because of this it has long been assumed tha*, a strange kind of physical reality just in the middle between possibility and reality* t quantum mechanics cannot be providing a direct description of nature. However nature's initial state does not have the benefit of a first cause and therefore ultimate authority rests not with power but with an absolute lack of restraint so that anything that can happen will. But this is an authority devoid of knowledge. There could be no specific consequence of the lack of constraint just a vague awareness of the potential it allowed, that any possibility could and inevitably would find expression. The initial state is truly *a strange kind of physical reality just in the middle between possibility and reality,* it possesses no resolved definition only potential ones. The minimum entity we shall introduce simply encapsulates a discrete element of this potential and therefore in keeping with Heisenberg we shall apply to it Aristotle's term - *potentia*. In this way we have taken the general concept of potential and elevated it to the status of an objective minimum entity called a potentia so that its evolution can be modelled in more specific terms. In order to retain the clarity of the distinction between the minimum entity and potential as a general concept, we shall use the word potentia to represent either one or multiple such minimum entities. It must be noted that the term potentia must be taken to be a *primitive* that remains undefined within our language, in the same sense that the terms *set* and *element* are taken to be primitives in set theory. Cantor considered a set as *"…a collection of definite distinguishable objects, called elements, thought of as a whole* [149]." However this definition is now considered to be too naïve, leading David Kurtz to assert that, *"…in any language there must be terms which are undefined within that language. This is also true of mathematics and we will take both set and element of a set to be primitive, undefined terms* [149]." Note that this approach is quite different from postulating a representation for the potentia, since while it allows them to become included in a narrative we do not presume to know the details of their structure. But what is important to evolution is not if humanity can find a precise definition for the potentia, but if there is any requirement for nature itself to do so.

At the beginning of all things there is only the potential inherent in the lack of constraint, with no realisation at all. The initial state has no constituents prior to the realisation of some potential in the form of a specific definition of the initial state. The potentia are not pre-existing elements of the initial state but become discrete states because no specific definition can encapsulate all the potential of an initial state devoid of the constraint of a first cause, so that there must be further definitions added. There are multiple potentia because as soon as any potential is made at all specific, it becomes non-inclusive of all possibilities so that no matter how many attempts are made to give the potential of the initial state a specific realisation, this can never represent everything that is possible. The potentia therefore arise as discrete states because of a limit on the effectiveness of the realisation of potential. The initial state is not composed of multiple, pre-existent potentia it is simply that the well of potential can never be emptied. If there is one specific potential realised, there must be another to compensate for the fact that the first cannot possibly give expression to everything that is possible. Note however that we must be careful at this point not to consider the second realised potentia to be a refinement determined by the first, it is just a different guess. Still the realisation of subsequent potentia is not truly a spontaneous event, but the consequence of previous realisations that represent a flawed definition of a state of unlimited potential.

How then should we define the first realised potentia? Let us imagine that the property by which it defines the initial state is *red*. This asserts that the entire initial state is *red*, it has always been *red*, will always be *red* and there is therefore nothing to compare *red* to. In our current evolutionary epoch *red* is a quite specific property, however in the environment of epoch I even though a specific property has been realised, in isolation what that property actually is cannot be understood. We shall therefore simply label the first realised potentia *a*, since not even nature itself possessed a clearer understanding of it. But this is not to say that it cannot possess a more detailed specification. It is simply that the realised potentia can only be more precisely defined by their relationships with other similar states. The property *red* can only truly be defined by comparison with another colour. The reason that we can consider such a primitive and abstract evolutionary epoch in the context of physics is that nature learns nothing independent of process, and there has as yet been no process whereby the full details of the definitions of the realised potentia could be established. But it must be stressed that while *a* represents a specific property, as it is compared to various other states the range of distinctions can become more complex, requiring any number of different degrees of freedom for their expression. There is simply as yet no circumstance that makes them evident. It is therefore inappropriate to attempt to postulate the properties of the potentia; instead we must trace their development as the evolutionary process unfolds. But even given this and the previous statement that the term potentia must be taken as a primitive without further definition, all potentia nonetheless share one defining characteristic - that there is a potential that may or may not be realised does not constitute the basis for a potentia, a potentia represents as a discrete minimum entity a potential that must at some point be realised.

d. A Simple Visualization of the Potentia

We can visualize the initial state as a canvas, and the potentia as coats of paint. Each colour covers the entire canvas, representing that each potentia seeks to independently define the entire initial state. The canvas is considered undefined except for the property of colour, with the various coloured potentia providing all the values this property can take. Each colour is totally independent so that multiple colours either as a patchwork or as a single blended colour can never define the canvas. But even though there are multiple colours there are not multiple things here, the thing is the canvas, the colours are what defines it, what makes it vibrant, existent.

With no colour applied the canvas is white and undefined. But with all colours applied, from an external view that sees not just the topcoat but all colours at once, the canvas is still white and undefined. The colours are only distinct when viewed individually as discrete states, the internal degrees of freedom of the canvas itself. The external view simultaneously examines all possible values for a property *colour* at once, and only reveal a specific value if there is a net consequence of this overview. From this external view the initial state remains white, an undefined nothing.

Note that this is different from how we would interpret the initial state of quantum cosmology using the same visualization. Quantum cosmology’s canvas would have many tiny dots of colour representing random fluctuations in the initial state wavefunction constantly appearing and disappearing, while the majority of the canvas would remain blank, since these quantum fluctuations do not provide a definition as such, merely points of variation from the homogeneous blank canvas. Quantum cosmology takes each of these points of variation and blows them up using the postulate of repulsive gravity, so that each forms it own macroscopic universe, its own new canvas. In contrast the cosmology of this consideration is concerned with how an adequate definition can emerge for the single canvas representing an initial state of unlimited potential.

As for quantum cosmologies that utilise vacuum pair production, the first manifest state of this consideration is in every sense different from a vacuum particle pair. Where the particle pair is composed of two discrete, spatially separated states with well defined properties that are insignificantly small in comparison with the vastness of the vacuum, the realised potentia is a singular state that need not require the existence of space; has no clearly defined properties and seeks to define the entire initial state.

e. Concluding Comments on A New Minimum Entity

String theory's attempt to postulate a minimum entity that could explain all of the elementary particles eventually led to the heterotic string [120], which has a ten dimensional component circulating in one direction and a twenty-six dimensional component in the other. Such a string can no longer be justified in terms of being a simple component from which more complex elementary particles can be constructed, since it is more complex than any constituent of normal matter. Yet this incredibly complex object is merely postulated devoid of any evolutionary history to provide it with any theoretical justification via cosmology. The cosmology that has arisen out of string theory, brane cosmology, presupposes the existence of entire galaxies floating on the extra-dimensional membranes of M-theory rather than giving a more fundamental basis for the existence of strings themselves. This would seem crucial, since at this time there is no experimental evidence for the existence of strings. It is not the function of physicists to try to dictate the structure of the universe by their postulates, but rather to patiently observe and try to come to an understanding that will allow them to describe nature as it truly exists. The potentia are not postulated to solve a problem, as strings were, but appear here because they are a determinable aspect of nature's evolution.

With regard to selecting a representation for the potentia, we would sound a word of caution about rushing too quickly into formalisation. When Lovelace pointed out that string theory needed to be formulated in a twenty-six dimensional space this came as a shock to string theory's founders [7]. While the number of extra dimensions was reduced to eleven through the development of M-theory, what is important here is that these extra dimensions were never part of the original conceptualisation of string theory but arose unexpectedly out of the mathematics. The whole point of doing this detailed consideration prior to the formalisation of this cosmology is so that it will not be driven by the mathematics, but rather the mathematics will have to conform to a pre-determined model of nature's evolution. It is hoped that the conceptualisation of nature developed here will be strong enough, so that it can be recognized when the mathematical model has gone wrong and needs to be revised. This has not been the case for other cosmologies, which have principally been driven by their mathematical development.

Now that we have introduced the potentia we shall examine their evolution and how both the boundary conditions and the first wavefunction can be derived from them.

14. The Origin of Time

We stated above that there will be more than one potentia because - *If there is one specific potential realised, there must be another to compensate for the fact that the first cannot possibly give expression to everything that is possible* and that in this way - *The potentia arise because of a limit on the effectiveness of the realisation of potential*. It is this process that represents the origin of time, that is, that a first event will necessitate a second and so on. Time does not pre-exist but is the manifestation of the flaw of over-specification. Time evidences nature's imperfection. In the first evolutionary epoch this is achieved by the perpetuation of the random realisation of potential, the repeated application of the causal schema characterised as the future.

Those physicists, like Davies and Gott, who want to have time commence with the big bang treat time as evidenced by the motion of physical objects. However in final analysis, this is a classical approach to time whereby the physical circumstances necessitate further motion and therefore the perpetuation of time. But if quantum mechanics has taught us anything it is that there is no strict causal relationship between the physical composition of a system and its consequence, as evidenced by the fact that the same physical circumstances can have a range of possible outcomes. Time therefore must have a motivation other than the classically determined consequences of physical situations - time itself must flow independent of any specific physical constraints. So it does in this cosmology, time flows because no realised potentia, no specific definition, even one as complex as this physical universe, can fully express all of the potential of an initial state that is not constrained by a first cause. Time evidences a flaw in the realisation of potential, which ensures that there will always be a next event. Specific physical circumstances that can act as boundary conditions add to the flow of time the capacity to define that the next potential to be realised must be intermediate to these boundary conditions. This establishes a localised event that can limit the included potential. However this does not provide causal determinacy as such, merely a more refined set of constraints on the flow of time which must remain fundamentally characterised as: *Anything that can happen will.*

15. The Initial State Boundary Conditions

As mentioned above quantum cosmologies simply assume the existence of an initial state wavefunction without stating any boundary conditions by which it is derived. This necessitates a situation where the wavefunction is never measured but instead secondary quantum effects, such as fluctuations in the wavefunction, vacuum pair production or quantum tunnelling, and new postulated process such as repulsive gravity acting on fluctuations in the wavefunction, are used to build the cosmology. This is justified by the assumption that no boundary conditions for the entire universe can be found, since as Aharonov *et al* point out, *" …the Copenhagen interpretation cannot be applied to the wave function of the entire Universe because, first, there is no observer outside the Universe, which by definition is everything that exists, and, second, the probabilistic interpretation of the wave function can be given physical meaning only by having an ensemble of large number of identical systems whereas there is only one Universe* [150].*"* While these authors attempt to address this problem by considering an interpretation of the wavefunction based on *protected measurement* [151-154], that is, the capacity to measure a wavefunction without inducing its collapse, in this consideration we are concerned with the evolution of time and therefore must look for boundary conditions in this context.

a. The Significance of Over-specification

The first temporal event is simply the realisation of any potential as a definition of the entire initial state. If a single potentia could be realised to the exclusion of all other potential, remaining eternally unchallenged and unchanged, nature would require no first cause. This however would not establish a basis for the universe as we currently experience it, since there would be no discrete structures or differentiation between regions, instead it would establish the perfectly homogenous initial state presumed by so many cosmologies. But as we have seen above the full potential of the initial state cannot be satisfied by the realisation of any specific potential. There must be the realisation of a second potentia, which we shall denote as *c*. We live in a universe that is a composite state composed of many discrete particles, but this is not the nature of the initial state, which would be a single state with only one defining property. It is not that complexity is sought, but that the lack of a first cause makes it unavoidable.

Quantum cosmology would no doubt apply repulsive gravity to both of these perturbations, inflating them to create new universes. But nature has evolved no capacity or reason to do this. The parallel universes of quantum cosmology have no interactions or shared consequences. But in this consideration we instead have two definitions realised for the one initial state. That the statement *'a defines the entire initial state'* is true is what realisation means. But the statement *'c defines the entire initial state,'* since it is also the realisation of a potentia, is also true. This realisation of nature's potential does not result in two universes just two truths and with that doubts. This more than anything else is what over-specification does, it makes the truth unclear. The realisation of a potential is no longer the final arbiter of truth. That there are two potentia realised introduces the need for more to be done, for the truth to be determined by actions, justified by a cause, not just realised and accepted. Creation is not enough.

Now we can answer the question: *How does nature know that the lack of a first cause represents a flaw?* The answer is: *Because the unavoidable consequence of this is over-specification of the definition of the initial state.* The need for evolution to progress beyond the random realisation of potential arises because of over-specification and the uncertainty this introduces. The initial state cannot be described in terms of a statement of what is true, but must be described in terms of an anomaly that must be resolved, a situation that is not just best represented as a question, but that provides a cosmological basis for questioning.

There is no knowledge here but for the consequence of physical events that must naturally occur. A single state possessing multiple, perhaps mutually exclusive, definitions provides no single truth and is therefore clearly a flaw. Nature had attempted to simply assume that no first cause was required, over-specification provides a physical demonstration that this is not so, that cause is still required in order to reconcile these two definitions of the one initial state.

b. The Evolution of Time

The question describing the initial state is not: *Is a or c true?* It is already determinable that both are true, since this is what it means to be realised. Nor do *a* and *c* represent a choice between two alternatives, since the second assertion need not be another colour such as *green* thereby providing an alternative to *red*, but can be a totally different property such as *sour*. The question then is: *If the initial state is red and sour, how are these two properties related?* Does a universe that is *red* have to be *sour*? Are these mutually determined properties so that if one is know the other can be deduced so that only one need be stated explicitly, thereby avoiding over-specification, or are they independent properties that must be specified separately, thereby leaving the initial state with multiple non-related and perhaps contradictory definitions. Are *a* and *c* two incompatible properties that would make the physical realisation of nature's potential no more than an insane bedlam or could they be causally associated thereby becoming components of a single changing definition that would retain the integrity of the initial state? No answer could be determined by the specification of the asserted potentia, their physical properties if you like, which is inadequate to determine if they are or are not mutually exclusive and therefore to resolve this question more must happen. Over-specification of the definition of the initial state establishes the need to seek a causal link between *a* and *c* that would prove that one definition in the over-specification necessitates the other. In this way over-specification is overcome through a changing definition of the initial state that moves from one potential definition to another. Humanity takes for granted that things change, but in the evolutionary epoch of the initial state this is a revolutionary concept, instead of there being a single definition of the initial state, static and timeless, there could be a changing definition that would sequentially realises all potential, but because of a causal association that proves that each definition could change to be equivalent to the next this would nonetheless remain a single definition of the initial state. In this way all realised potentia would be part of one evolving definition, rather than being independent or conflicting static definitions. This is ultimately what the linear timeline we associate with an evolving system is, a non-static but consistent definition of the initial state. It is this need to establish a relationship between realised potentia that sets the requirement for such a causal timeline. This nature of time was not preordained but arises at a determinable point in nature's evolution in response to a more specific manifestation of the flaw that there is no first cause. If there were only a single definition of the initial state it would not be necessary. This is the first instance where we can clearly see that *the nature of time itself must adapt to meet the changing needs of evolution*. In this instance time must evolve because simply asserting a causally unjustified future has resulted in the over-specification of the definition of the initial state, proving that the lack of a first cause is a flaw that must be overcome. Therefore the very nature of time must evolve to provide the capacity for the causal reconciliation of *a* and *c*. If the future can not be silenced, if there will always be more said, then nature would at least have each new word form part of a coherent story instead of standing alone as a cacophony of unrelated sounds. The timeline is the best that can be made of a bad situation.

The realisation of *a* and *c* does not itself establish a sequential timeline because we cannot characterise it as: *The initial state was nothing and now it is* a, but must express it as: *The initial state's definition was unknown so that it could have always been* a. The potentia *a* is asserted as an unchanging definition of the entire initial state for all of the past and all of the future. The initial state will have always been, and will always be, defined by *a*. But the same is true for the assertion of *c*, so that we cannot say that either assertion occurred before the other since they both occupy the same temporal footprint, which extends without boundary into the past and future. A causal association between *a* and *c* must establish which came first and how it leads to the other.

c. The First Boundary Conditions

But whether the causal association of *a* and *c* is desirable or not nothing of nature's evolution is predetermined, therefore that *a* and *c* can be causally associated is a proposition that must be proven. However nature has no capacity for overt actions no matter the strength of its motivation and therefore in seeking this causal association can only utilise those limited capacities it already possesses - all it can do is seek to realise another potentia. If a causal association between *a* and *c* is to be achieved this must be done by the realisation of all potential intermediate to them. In this way the presence of two already realised potentia establishes a new, more complex environment whereby *a* and *c* act as boundary conditions, since if *a* and *c* have already been realised then they are no longer part of the pool of all potential and therefore the one constraint on the selection of the next potentia to be realised is *'Anything but a or c.'* The boundary conditions introduce constraints on the further realisation of potential. However it must be noted that the intermediate potentia are not something new, but only distinguishable from the potentia which resulted in *a* and *c* in terms of the constraints imposed by having *a* and *c* as boundary conditions. However these constraints do more than simply provide boundary conditions that define intermediate potentia they affect the entire environment. There is a temporal sequence demonstrated by the realisation of potentia such as *a* and *c* that constitutes the environment of epoch I and it is within this environment that the boundary conditions must be set. The initial state boundary conditions of this consideration are not given in terms of a limit on spatial extent (which at any rate would have no meaning since in epoch I space does not yet exist), they merely ensure that the intermediate potentia is realised next after *a* and *c*. The boundary conditions provide a constraint on the sequence in which nature's unlimited potential is realised. The realisation of potential cannot be entirely random, the next potential to be realised must be intermediate to *a* and *c* in order to causally reconcile them. This sets the basis for temporal sequencing, that there is a required order to the occurrence of events, a feature that is usually simply presumed to be an attribute of time. However in this cosmology neither the existence nor the attributes of time need to be presumed or postulated, instead how they are introduced as part of the evolutionary process can be examined.

d. Flawed Boundary Conditions

You might complain that *a* and *c* do not represent the limiting extent of the initial state's evolution, which in somewhat simplistic terms would need to be the first and last potentia to be realised, whereas *a* and *c* are merely two randomly realised possible definitions of the initial state. This is absolutely true. It has been claimed that no boundary conditions representing the extremities of the entire universe can be defined and this remains correct, but while this concept restricted philosophers and cosmologists from suggesting any initial state boundary conditions nature simply does the best that it can, attempting to utilise flawed boundary conditions where no others naturally occur. Unless cosmologists confront the concept that nature can be flawed its evolution will never be understood. Below, when we consider how the first wavefunction is defined by these boundary conditions, the significance of their flawed nature will become apparent.

e. The Boundary Conditions and Many Universes

The realised potentia *a* and *c* act as boundary conditions because nature reacts to the flaw of over-specification, that is, that they introduce multiple definitions of the one initial state, the one universe. If the postulate of many universes were accepted without question, no such boundary conditions could be recognised.

f. Concluding Comments on The Initial State Boundary Conditions

Those engaged in quantum cosmology can no longer claim that no boundary conditions for the initial state can be conceived of and therefore they can not simply assume the existence of an unspecified initial state wavefunction and proceed to examine secondary affects arising from it. Boundary conditions can be specified and therefore the next step in the development of any truly quantum cosmology is to determine how the first wavefunction arises from them.

16. A Brief Review of the Debate Regarding the Reality or Otherwise of the Wavefunction

Before we consider how the initial state boundary conditions might allow the derivation of the first wavefunction, it is necessary to put this endeavour into historical perspective.

a. Copenhagen verses Reality Interpretation

The debate as to whether the wavefunction is a real attribute of nature or just a mathematical convenience, often referred to as the *quantum reality question,* has raged in the literature of physics for more than eighty years [155]. The Copenhagen interpretation of quantum mechanics gives no objective reality to the wavefunction maintaining that it simply represents one's state of knowledge about the system. According to Bohr [156, 157] there is no reality underlying quantum mechanics itself, instead he insisted that, *" There is no quantum world. There is only an abstract quantum description* [65].*"* But as the renowned particle physicist Gerard 't Hooft wrote, *" To this day, many researchers agree with Bohr's pragmatic attitude. The history books say that Bohr has proved Einstein wrong. But others, including myself, suspect that, in the long run, the Einsteinian view might return: that there is something missing in the Copenhagen interpretation* [158].*"* As for the wavefunction itself, Schrödinger in a lecture before the Royal Institution, London on 5th March, 1928, stated that *"It* (the wavefunction) *is merely an adequate mathematical description of what happens* [159].*"* But not everyone agrees that the wavefunction merely represents one's state of knowledge, with Penrose writing that, *" This view I really cannot accept. Quite apart from the question of who the 'one' might be in this statement (and the 'one' is surely not me!)… we conclude that (if the theory is correct) the property of being in state* $|\psi\rangle$ (the ket vector representation of the wavefunction) *is, indeed, completely objective* [160].*"* Weinberg has a similar opinion, *" Those of us who would like to take a more objectivist view of quantum* *mechanics would argue that the wave function really is out there in nature – that it is reality, and evolves whether or not people know anything about it* [161].*"*

b. Bohm's Pilot Wave Interpretation

David Bohm [47, 162, 163], together with many other physicists before [164-166] and since [167], was greatly troubled by the loss of classical causality that accompanied the introduction of quantum mechanics [47, 168, 169] stating that, *"…from the very beginning, it took the form of a set of laws that gave in general only statistical predictions, without even raising the question as to what might be the laws of the individual systems that entered into the statistical aggregates treated by the theory. Moreover …the indeterminacy principle of Heisenberg led physicists to conclude that in investigations carried out to a quantum-mechanical level of accuracy no precise causal laws could ever be found for the detailed behaviour of such individual systems, and thus they were led to renounce causality itself in connection with the atomic domain* [169].*"* Bohm went on to state, *" …there is good reason to assume the existence of a sub-quantum mechanical level that is more fundamental than that at which the present quantum theory holds* [169].*"* Bohm [170, 171] proposed a model that interpreted the wavefunction as more than a mathematical device, building upon de Broglie's [172, 173] *pilot wave* concept suggested in the 1920's. De Broglie himself abandoned this approach when Pauli supported devastating criticism of it [174, 175]. Even Einstein, who was at the time seeking a more reality based interpretation of quantum mechanics, rejected it on the basis that it was *"…too cheap…"* a solution [174, 175]. In Bohm's model there is both a real particle with intrinsic characteristics and a real pilot wave. When you make one kind of measurement, the pilot wave has one form; when you make another kind of measurement, the pilot wave takes another form. It is the alteration in the pilot wave that is given as the explanation for the variation in the attributes of the electron with different measurement methods. As Barry Loewer explains, *" Quantum-mechanical probabilities enter the theory by way of a postulate to the effect that particle positions are distributed in conformity with the usual quantum-mechanical probabilities. These probabilities represent ignorance of the precise values of the quantum state and the particle positions. It follows from the theory that this ignorance is irremediable. BQM* (Bohmian Quantum Mechanics) *has no need for the collapse law since the particles possess determinate positions even when their quantum state fails to assign them determinate positions. So when the state of a cat is a superposition of alive and dead, the positions of the cat's particles 'decide' whether the cat is alive or is dead. BQM is realist and objective in that it describes an unobservable and mind-independent reality that underlies its empirical predictions* [174].*"*

Bohm's theory however ran into conflict with Einstein's theory of relativity [30, 176], in that it required the pilot wave to transfer information using faster-than-light signalling. John Bell, while trying to reconcile Bohm's theory with von Neumann's proof that no ordinary object model of quantum mechanics could be constructed, produced what is now called *Bell's theorem* [65] that showed that any valid model of reality, whether ordinary or contextual, must be non-local since in a local reality signals cannot travel faster than light and in this case information is not transferred fast enough to explain quantum facts. While many physicists considered that Bell's theorem invalidated Bohm's interpretation of quantum mechanics [174], Bell himself was not a critic but rather a supporter of Bohm's work, stating that,

"…in 1952 I saw the impossible done. It was in papers by David Bohm. Bohm showed explicitly how parameters could indeed be introduced into nonrelativistic wave mechanics with the help of which the indeterministic description could be transformed into a deterministic one. More importantly, in my opinion, the subjectivity of the orthodox version, the necessity of reference to the `observer,' could be eliminated. Moreover, the essential idea was one that had been advanced already by de Broglie in 1927 in his `pilot wave' picture. But why then had Born not told me of this `pilot wave'? If only to point out what was wrong with it? ... Should it not be taught ... to show that vagueness, subjectivity, and indeterminism, are not forced on us by experimental facts, but by deliberate theoretical choice? [177]*,"* concluding that, *" …conventional formulations of quantum theory, and of quantum field theory in particular, are unprofessionally vague and ambiguous. Professional theoretical physicists ought to be able to do better. Bohm has shown us a way* [177]*."* Yet even given this endorsement Bohm's interpretation was never broadly accepted, its conflict with general relativity was in the end considered too high a price to pay.

But even though his proposed solution was rejected Bohm has not been forgotten, since his attempt to bridge the gap between the quantum formalism and a reality based interpretation is seen as so important that he is still honoured to this day [178].

c. Is Understanding Necessary to Physics?

Is understanding necessary to physics? Many physicists would answer no. Feynman stated that, *"…the way we have to describe nature is generally incomprehensible to us* [2]*,"* but rather than being dissatisfied with this situation he embraces it stated that, *"…I'm rather delighted that we must resort to such peculiar rules and strange reasoning* (as that used in quantum electrodynamics) *in order to understand Nature, and I enjoy telling people about it. There are no 'wheels and gears' beneath this analysis of Nature; if you want to understand Her, this is what you have to take* [2]*."* This is not just a single physicist's opinion but in keeping with the Copenhagen interpretation of quantum mechanics, which as Loewer described it, states that, *" The right way to understand quantum mechanics is not as a true description of physical reality but rather as an instrument for predicting the outcomes of laboratory experiments. There is no coherent interpretation of the quantum-mechanical formalism as describing an unobservable reality that is responsible for those experimental results. That reality is forever beyond our ken* [174]*."* However this inevitably leads to a situation where, as Feynman pointed out, *"…the more you see how strangely Nature behaves, the harder it is to make a model that explains how even the simplest phenomena actually work. So theoretical physicists have given up on that* [2]*."* However not all cosmologists have yet surrendered to such pessimistic pragmatism. To have found a mathematical recipe that allows accurate prediction does not constitute understanding. This only comes when you can recognise the *wheels and gears,* since it remains their description that is the true basis for physics. As Penrose stated, *" Like Einstein and his hidden-variable followers, I believe strongly that it is the purpose of physics to provide an* objective *description of reality* [160]*."* It is certainly true that such *wheels and gears* cannot be found by seeking a return to classical concepts. Nor can they be found by a reinterpretation of the meaning of the wavefunction. However there is another alternative, cosmology, understanding can be found by seeking that point in the evolutionary timeline where the precursor of the wavefunction first occurred and then tracing its subsequent evolution until it is clear that our mathematical device is merely a reasonable description of this state. This would represent a true understanding since it would allow physicists to recognise that the mathematical methods used in quantum mechanics are not merely recopies but represent an accurate description of how nature truly functions. To do this is not easy, nor can it be done quickly, but at least if this work is begun here, it may inspire others to this pursuit. It must always be kept in mind that this current work is merely a preliminary consideration meant to introduce new concepts and with them new directions that future research can take. The full resolution of such fundamental issues should rightly involve the entire scientific community, since ultimately understanding requires participation in research not just the reading of other physicists' papers.

d. Concluding Comments on the Reality or Otherwise of the Wavefunction

Finding a clear interpretation of the meaning of the wavefunction is an issue that has been pursued for so long that most physicists have given up and accepted that no such understanding can be found. We agree that to revisit previous approaches to solving this problem would clearly be pointless. But this is not what is being done here, instead a new approach is being introduced, an examination of cosmology at a far more fundamental level than has ever previously been attempted. This is undertaken not as an attempt to reintroduce classical determinism, but to understand how indeterminism and probability came to be a real aspect of nature.

17. The Intermediate Potentia and the First Wavefunction

Clearly we cannot simply take the Schrödinger equation combined with the initial state boundary conditions given above to define a wavefunction, since epoch I precedes the establishment of energy and space, the parameters in which the Schrödinger equation is defined. But it must be remembered that the main recommendation of this dissertation is simply not to hurry, but to take the time to understand what is being examined before formalisation is sought. When dealing with events within this universe this may seem unnecessary, since the formal descriptions that we have of several aspects of this universe can be applied to clarify new discoveries. But when seeking to extend cosmology to pre-big bang epochs, this pool of formalisations may simply not apply and so more initial consideration is required in order to generate the sense of familiarity from which new formalisms can be developed or existing ones explained. Simply because we cannot derive the wavefunction from an equation does not mean that we can not understand how the wavefunction originates or what its true nature is.

Dirac, during a talk on quantum electrodynamics at Harvard in 1974, advised students to be concerned only with the beauty of their equations and not with the equations' meaning, this according to Weinberg, *"…was not good advice for students…*[46]*."* However this attitude persists with many physicists more concerned with the mathematics than with reaching a fundamental understanding of how nature works. This attitude is reinforced by the absence of a clear reality interpretation of quantum mechanics, physics' principal mathematical tool. In order to progress from: *This answer is correct* to: *I understand this answer*, more work on the interpretation of quantum mechanics must be undertaken. While many physicists may side with

Dirac in contending that understanding is not essential, we believe that if we do not set explaining nature as the principal goal of physics, we risk loosing relevance with the general public's aspirations. As Hans von Baeyer [179] put it, *"…science writers and physicists have long tried to popularize quantum phenomena, but jargon and a lack of cogent imagery are still slowing the spread of the message. A more aggressive strategy for bringing quantum phenomena into the everyday world and developing an intuitive feel for them is needed – dramatic, in-your-face kinds of arguments that will make people sit up and listen* [180]*."* The greater the understanding communicated to the general public about quantum science the greater the public support that can be raised for research and experiments dealing with quantum phenomena. This is essential since if science is to be funded from the public purse, it is its capacity to maintain public interest that ultimately determines the availability of funding.

It is perfectly true that physicists must strive to frame their discoveries within the discipline of mathematics so that precise predictions can be made based on their theories and then experimental support sought. All that we are saying in this dissertation is that this is not necessarily the first step to be taken when approaching previously intractable problems. It is acceptable for physicists to think. In fact it is necessary to examine difficult issues at a conceptual level before any formalisation can be successfully attempted. Moreover we believe that to do this merely as a private contemplation smacks of arrogance or self-interest, since there may be many issues raised by this consideration that require skills other than those of its author. We do not seek to solve all problems, only to see all problems solved.

a. The Intermediate Potentia and the Wavefunction

What does it mean for a potentia to be intermediate to *a* and *c*? Because *a* and *c* occupy the same temporal footprint the intermediate state cannot sit between *a* and *c* either in terms of the sequence of realisation or its final temporal location. Nor can the intermediate state be thought of as having an intermediate value in terms of a common defining property applicable to all three realised potentia. We simply gave the first asserted potentia the label *a* because, as we stated earlier, *not even nature itself possessed a more specific definition of it*. This precedent was continued by labelling the second asserted potentia *c*, but while both labels are letters, the actual property evidenced by the asserted potentia need not be related in any way, for example *a* might be defined in terms of the property *colour*, whereas *c* might be defined in terms of the property *smell*. We must therefore envision the intermediate potentia as providing a translation between reference frames such as *colour* and *smell*. In this early evolutionary epoch this does not result in two states occupying the *smell* reference frame, since the mechanism whereby a property can have a variety of values has not yet been established. However what causal association will establish, for example, is that an initial state that is *red* must also be *sour*, so that only the property *red* must be explicitly stated. But if *red* causally determines *sour* then it becomes possible to say that *a* must occur before *c*, whereas without such a causal association no such temporal sequence could be recognised. This is in keeping with Wheeler's description of time as that which *"…stops everything happening at once* [181]*."*

If *b* is realised and therefore defines the entire initial state, then *a* and *c* are proven not to be independent but rather the absolute boundary conditions for this entire universe. This provides the basis of their causal association, since if there is a universe defined by *b* with *a* and *c* as its limits then at the beginning of the timeline for this universe it is defined by *a*, for its duration it is defined by *b*, but at its end it will be defined by *c*. This provides a non-static definition of the initial state that can be associated with a sequential timeline. The *ac*-environment is the manifestation of the flaw of over-specification that results from there being no first cause. The introduction of a sequential timeline is how nature would resolve this flaw by ensuring that even if there are two possible definitions of the initial state they simply form the absolute boundaries of an intermediate definition which demonstrates that one must become the other.

The realisation of a potentia intermediate to *a* and *c* establishes which came first and how these two elements of structure are associated. But note that a timeline of this nature does not result in Newton's clockwork universe. It is not that the physical composition of *a* causes *c*, merely that because *a* cannot encapsulate the entire potential of the initial state there must be the realisation of further potential, however this constraint is insufficient to causally determine what this next potential will be, it merely necessitates that there will be another random selection made. Therefore instead of Newton's clockwork universe there is a sequential timeline because when *c* is realised a causal association with *a* must be established in order to resolve the over-specification of the one initial state. Causal association is thereby a retrospective process that can only be sought once the boundary conditions have been set. Evolution will not be stifled by this process because such a subsequent cause only involves the two realised potentia and therefore does not eliminate over-specification, but instead resolves each new instance of it by causally associating each new realised potential with what already exists. This is quite different from a timeline where the current physical circumstance determines the next outcome. There will be a next outcome purely because the current physical circumstance can never define all of nature's potential. The motivation for further evolution is still provided by the lack of constraint whereby anything that can happen will. We can therefore think of this as an evolutionary environment driven by random mutations, such as the assertion of *c*, which must then be reconciled with the pre-existing environment.

We might want to ask what the first potentia associated in this way were, but this is largely irrelevant given that they were so sparsely defined. Instead we can understand the motivation for this process, simply that there is one initial state and therefore there should be one definition of it. Humanity has always presumed that nature's evolution involves a sequential timeline, but here in this consideration for the first time we can examine its establishment. We can see that it involves a process, the assertion of an intermediate potentia, and because this does not only occur once in the distant past but is repeated with every new realisation of potential, we have the capacity to examine the nature of time itself as part of the science of physics.

b. The Consequences of the Boundary Conditions being Flawed

The initial state boundary conditions are flawed in that they do not represent the limits of nature's evolution. Instead they define an intermediate potentia that must be realised as the next event in nature's evolution if a causal association between the boundary states is to be established. This intermediate potentia retains the defining property that it is guaranteed realisation given the full extent of nature's evolution, however since the bounding states *a* and *c* do not represent the limits of this evolutionary process, this introduces a situation where the intermediate potentia can be realised within this restricted extent but is not guaranteed to do so. The attempt to realise the intermediate potentia next may indeed fail, an uncertainty that is unavoidable given the flawed nature of the initial state boundary conditions.

c. The Intermediate Potentia and Quantum Uncertainty

Note that we are as yet only considering a situation where there is one intermediate potentia, so that the uncertainty of realising *b* is in no way dependent on there being an alternative potential that might be realised. Probability does not enter the description of nature because there are multiple possible intermediate potentia but because the realisation of even a single possible outcome is uncertain. However this introduces yet another enhancement to the nature of time, providing for a complex present instant where more than one outcome is possible. The present instant had previously been defined by the random selection of a potentia with the sole possible outcome that it would be realised. The boundary conditions dictate that the intermediate potentia will be the next potentia selected, but now there are two possible outcomes, *b* can be realised or fail to be realised.

Quantum cosmologies start with an initial state wavefunction seething with random fluctuations that arise as a consequence of Heisenberg's uncertainty principle, which Herbert interprets as, "*…ensuring each one* (quon or quantum object) *its own forever irreducible realm of possibilities,"* thus allowing the Heisenberg uncertainty principle to be interpreted as a law stating, " *Thou shalt not decrease a quon's total realm of possibilities below a certain limit* [65]*."* The quantum object of this consideration is the potentia, whose defining property is that the potential it encapsulates must at some point be realised, this provides the limit below which the potentia's *realm of possibilities* cannot be decreased. However, without boundary conditions this is simply expressed as the potentia either having a realised expression or not, with the *realm of possibilities* having no manifestation prior to the actual realisation of the potential. However this situation changes with the introduction of boundary conditions, which introduces a complex present instant where the intermediate potentia may or may not be realised. We shall describe this situation using the terminology of probabilities, not because this is necessarily the best terminology to use but because it is the language of quantum mechanics and this allows any new understanding this consideration offers to be more easily incorporated into the existing body of physics. What is important at this stage of the cosmology's development is not the capacity to tell the absolute truth, but to increase comprehension of issues long considered impenetrable. However the uncertainty of realising the intermediate potentia does not simply result in a 50/50 probability for the realisation of *b*, instead all of the constraints on the realisation of the intermediate potentia must be taken into account. The first set of constraints relate to the temporal sequence made manifest by the realisation of potentia such as *a* and *c*. This sequence itself can be expressed in terms of constraints whereby when *a* is realised: *Anything that can happen will* is refined to include the constraint: *Anything but a that can happen will*. The next potentia is realised because no specific potential such as *a* can fully express all of nature's potential, however this constraint results in a situation where there can be no repetition of *a*. In terms of the intermediate potentia therefore it cannot be realised either as *a* or *c*. The second set of constraints arises because *a* and *c* do not represents the limits of the realisation of nature's potential, thereby removing the certainty that a potentia will be realised intermediate to them. These constraints quantify the uncertainty of the realisation of the intermediate potentia and dictate that this must take a range of values.

Let us consider the probability of realising the intermediate potentia, P_b. The boundary conditions ensure that the already realised potentia *a* and *c* cannot be repeated, therefore since the intermediate potentia cannot be realised as either *a* or *c* we shall represent this as there being no possibility of the intermediate potentia being realised at *a* and *c*, that is, $P_b(a) = P_b(c) = 0$. Given the unconstrained scope of nature's potentia there can definitely be a potentia intermediate to *a* and *c*, which would be represented by there being an intermediate point where $P_b = 1$, however because *a* and *c* do not represent the limits of the realisation of nature's potential this must be interpreted as representing that *b* can be realised within the bounded region rather than representing the certainty of its realisation. This situation is clarified by there being a range of values for the probability of realising the intermediate potentia running from 0 at *a* to 1 at the midpoint between *a* and *c*, to 0 again at *c*. We can draw a smooth, continuous curve between these constrained values simply because this represents the default situation in the absence of further constraints that would provide a reason for a more complex curve. In this way the intermediate potentia's minimum *realm of possibilities* has been stretched so that its spans the boundary conditions in such a way that it can be represented and quantified, thereby providing it with a complex pre-asserted representation, which we shall denote b_j, where *j* takes the value of the probability for *b*'s assertion at different points along the *ac*-axis. In contrast the probability of realising an unbounded potentia could only be said to take two values, 0 evidenced by its non-realisation and 1 evidenced by its realisation. The unbounded potentia *a* and *c* are real components of the potential of the initial state but only have a representation upon realisation. In contrast the intermediate potentia can be seen before it exists. This is a wholly remarkable evolutionary development that dramatically enhances the attributes nature has at its disposal.

Herbert wrote that, *" Once you get down to the quantum randomness level no further explanation is possible. You can't go any deeper down because physics stops here* [65]*."* Physics stops only where human comprehension can no longer penetrate. It is true that both *quantum randomness* and the potentia of this consideration can be associated with Herbert's concept of a *forever irreducible realm of possibilities* [65], however quantum uncertainty is not presumed by this cosmology instead the first realisation of this can be seen to arise because the flawed boundary conditions remove the guarantee of realisation from the intermediate potentia, resulting in a complex present instant where more than one outcome is possible. The pre-asserted representation of the intermediate potentia, which quantifies the uncertainty of its realisation, stretches its minimum realm of possibilities between the boundary conditions. Where previously there had been no expression of the potentia before realisation, now there is both uncertainty and anticipation of realisation, a vague restlessness almost like questioning.

d. The First Wavefunction and Probability

It is the pre-asserted representation of the intermediate potentia that provides the ultimate basis for the wavefunction. With this in mind, even though at this point in nature's evolution b_j could only be drawn as a half sine wave, we can represent it using the equation of a sinusoid, which provides a convenient generalisation of all the constraints imposed by the boundary conditions and the nature of the potentia, as well as the default requirement for a smooth, continuous curve. However it must be noted that the sinusoidal representation is just the equation of the curve representing b_j, or in fact the equation of all such curves, and does not imply the unitary evolution of an endpoint along the *ac*-axis, it simply defines the entire curve as if it were stamped between *a* and *c* in a single action, not drawn as if the tip of a pen moved from *a* to *c*. The concept of an endpoint moving through space is an enhancement added much later in nature's evolution.

There is therefore no way in epoch I to enquire about the value of an amplitude at a specific point along the *ac*-axis. Instead, if the realisation of *b* were attempted this would involve the random selection of one value of the amplitude which would quantify the uncertainty that this realisation would be achieved. This is an evolutionary epoch driven by the future, that is, the random realisation of potential, the realisation of an intermediate potentia is merely a refinement of this. Where previously the future need only select a random potentia now it must look within its minimum domain of expression to also randomly select an amplitude which quantifies the uncertainty of its realisation. This further step, which can be seen as the process of random selection not just applying to all potential but to aspects of a single potentia, introduces a process to the realisation of potential that is the starting point for the development of physics. We shall call this process, the attempt to achieve the realisation of a potentia that may or may not be successful, *assertion*. There is therefore a distinction to be drawn between the pre-asserted representation of the potentia and the potentia itself. The pre-asserted represent does not define the property to be realised, for example *red*, but instead provides an extra level of complexity to the realisation of potentia involving the selection of a single amplitude from this pre-asserted representation to be applied to its assertion. As we trace nature's evolution we shall examine the relationship between the natural process of assertion and deliberate measurements performed by physicists.

In order to understand the relationship between the amplitudes of b_j, the process of assertion and probability we must return to the original motivation for studying probability, *"…a collaboration between mathematicians and gamblers to determine the odds in dice games by systematically counting the ways a desired outcome could occur* [65]*."* However while a mathematician would roll the dice many times and record the ensemble average results to prove that a calculated probability was correct, this is not how the dice game itself is played, since the gambler is allowed only a single roll. The same is true for nature with respect to asserting an intermediate potentia, the event itself only occurs once. What then does it mean if an amplitude of 0.5 is selected to be applied to the assertion of a potentia? Quantum mechanics would currently interpret this as: *If the event 'attempt to assert b' were repeated 100 times, b would be successfully asserted approximately 50 times*. But no such repetition actually occurs in epoch I, there is only one attempt to assert a potentia intermediate to *a* and *c*. An amplitude of 0.5 does not mean that 0.5 is the ensemble average probability for realising *b*, but that the gaming device randomly selected to be applied to the single event *'attempt to assert b'* is equivalent to a unbiased coin with one side representing the result *'realise b'* and the other representing the result *'do not realise b'* and that the ensemble average probability for realising *b* using this gaming device is 0.5. If a lesser amplitude had been randomly selected this would be related to a different gaming device, for example a dice where only a roll of a six would indicate successful realisation. Therefore the amplitude defines the process of assertion to be applied to a single event, which can be visualised as the selection of one of a number of different gaming devices. In epoch I, because the selection of the gaming device for each event would be random, no ensemble average could be calculated for the repetition of the same event. However nature's evolution is driven towards the provision of greater causal determinacy so that, as we shall see below, in this universe the selection of the gaming device is not random but can be determined by the physical circumstances, so that if exactly the same event is repeated many times it will employ the same gaming device and the results produced will be the ensemble average applicable to this device.

The concept that the wavefunction must represent an ensemble average arose because measurement disturbs the system so that repeated measurements cannot be taken. However this belief has recently been challenged by the concept of protected measurement, which demonstrates that repeated measurements on a single system can be done without the wavefunction collapsing and that therefore a statistical interpretation of the wavefunction that presumes measurements can only be done on an ensemble of similarly prepared systems is not necessary. Aharonov *et al* stated that, " *We have given an alternative, realistic interpretation of the wave function for a single system by means of the protective measurement …as a* time average *of a single system as opposed to the usual measurement at a given time which gives meaning to the wave function as an* ensemble average [150]*.*" However it must be noted that, "*…with the help of the ergodic theorem a time average on one system is equivalent to an ensemble average* [182]*.*" In the interpretation of the wavefunction given by this cosmology it is irrelevant whether repeated measurements of the same system can or cannot be taken, since what is important is simply the method of assertion applied to a single measurement.

We can now address an issue raised by Ord and Gualtieri, " *How can a single particle have an associated wavefunction* [183]*?*" This had been considered to contradict the ensemble average interpretation of the wavefunction, however given the consideration above we can see that the wavefunction simply quantifies an individual state's uncertainty of realisation, with the selection of a single amplitude from it defining the process of assertion, the gaming device, to be applied to a single attempt at its realisation. The ensemble average produced from the repetition of this event is the natural consequence of applying the same gaming device to each repetition[3].

e. Concluding Comments on The Intermediate Potentia and the Wavefunction

The wavefunction is nothing more or less than our best mathematical model of the pre-asserted representation of intermediate potentia and as such is not merely a convenient tool for calculating experimental outcomes, but is a reasonable description of a real aspect of nature. But note that the statistical nature of the pre-asserted representation of the intermediate potentia does not as yet provide a range of possible outcomes; the outcome will always be the realisation of *b* it is just that there is no longer any certainty that this will occur. Nor does this representation yet qualify for the label 'wave,' it is just that the curve representing the flow of amplitudes can be conveniently drawn by the equation of a sinusoidal wave. We cannot as yet include higher order solutions, that is, curves including multiple maxima, as would be the case for a potential well problem within this universe, since there is as yet no evolutionary precedent for the minimum domain of expression of a potentia to include more than one point of maximum probability of realisation[4]. Clearly what

[3] We will examine the ensemble average for situation with more than one intermediate potentia later in this chapter.

[4] The origin of multiple maxima curves will be addressed in the next chapter.

we have considered so far does not possess all of the properties that are attributed to the wavefunction, but this is to be expected since all aspects of nature evolve slowly, rather than being set down in their ultimate form at the beginning of all things. The quantum cosmologies ignore the most fundamental aspects of nature's evolution by simply presuming that all the rules of quantum mechanics pre-exist. By contrast, in this dissertation we shall patiently observe their development.

18. A Hypothetical and its Predictions for Future Evolutionary Developments

While we have not as yet determined if nature can achieve the realisation of the intermediate potentia, before we examine the actual evolution of the wavefunction to see if this is achieved, it is instructive to consider a scenario in which we simple presume that *b* has been realised. In this way we can bring hindsight to bear on our understanding of what is a very sparse evolutionary epoch, where otherwise the significance of its few events might be lost. In this way we continue to follow Quine's advice that, " *…one who approaches philosophy in the hope of understanding the best of what it affords will look for both fundamental issues and contemporary achievements* [45]." The contemporary achievement in this case is the success of quantum mechanics, which we seek to understand in terms of its evolutionary development and thereby shed light on nature's earliest evolutionary epoch.

With the realisation of the intermediate potentia, what now is the nature of the initial state? There are three definitions of the initial state, *a*, *c* and *b*, but these are no longer independent definitions that evidence over-specification, since *a* and *c* are associated by being the boundary conditions of a universe defined by *b*. This association can be considered to act as if *b* provides a translation algorithm from the reference frame of *a* to that of *c*. In this way we have a single, non-static definition of the initial state, a timeline, which can be characterised as: *if* a *then* c *because they are linked by* b. This is the ideal outcome, but as we shall see again and again little of nature's actual evolution progresses in an ideal manner.

a. The Origin of Existent States

The temporal progression of epoch I arises because no realised potentia can encapsulate all of the potential of an unconstrained initial state. However the circumstances of the realisation of *b* are different from those of *a* and *c*[5]. The realised intermediate potentia satisfies all of the potential within the boundary conditions and therefore elicits no further temporal response, that is, it does not prompt the realisation of any further potential and thereby a next event. The temporal sequence *a,c,…* will continue, while *b* remains still in time, only realised in an instantaneous present immediately passed over by the flow of time. It is this temporal condition that makes *b* the first existent state. This is in keeping with Heisenberg's concept that, " *The concept of becoming acquires a meaning in physics: The present, which separates the future from the past, is the moment when that which was undetermined becomes determined…* [184]."

Such an existent state will remain as it was realised unless subject to some external stimulus provided by physical interactions. It is this conceptualisation of

[5] We shall deal with the evolution of states such as *a* and *c* in the next two chapters. For the moment we will only state that their evolution also results in evidenced components of the current universe.

existent states that provides this cosmology's basis for Newton's *Law of Inertia* [29], a founding postulate of classical physics that has, even after nearly 300 years, never been seen to be based on more fundamental principles.

b. Past, Present and Future

Saint Augustine's long consideration of the nature of time led him to conclude that, " *It seems to me, then, that time is merely an extension, though of what it is an extension I do not know. I begin to wonder whether it is an extension of the mind itself* [60]*,*" and that, " *It is in my own mind, then, that I measure time. I must not allow my mind to insist that time is something objective. I must not let it thwart me because of all the different notions and impressions that are lodged in it. I say that I measure time in my mind. For everything which happens leaves an impression on it, and this impression remains after the thing itself has ceased to be. It is the impression that I measure, since it is still present, not the thing itself, which makes the impression as it passes and then moves into the past. When I measure time it is this impression that I measure. Either, then, this is what time is, or else I do not measure it at all* [60]*.*" Saint Augustine expands on this, " *But how can the future be diminished or absorbed when it does not yet exist? And how can the past increase when it no longer exists? It can only be that the mind, which regulates this process, performs three functions, those of expectation, attention and memory. The future, which it expects, pass through the present, to which it attends, into the past, which it remembers. No one would deny that the future does not yet exist or that the past no longer exists. Yet in the mind there is both expectation of the future and remembrance of the past. Again, no one would deny that the present has no duration, since it exists only for the instant of its passing. Yet the mind's attention persists, and through it that which is to be passed towards the state in which it is to be no more. So it is not future time which is long, but a long future is a long expectation of the future; and past time is not long, because it does not exist, but a long past is a long remembrance of the past* [60]*.*" Saint Augustine could not find an objective basis for time and therefore had no choice but to place it in the mind. Einstein also felt that, " *The distinction between past, present and future is only an illusion, even if a stubborn one* [185]*.*" But if time is merely an illusion having no objective substance, then the study of one of the most fundamental human experiences can never truly be brought within the domain of physics. However, in contrast, time is an objective element of this cosmology that originates because the realisation of any specific potential cannot fully define an initial state devoid of a first cause and thereby of constraint, with the result that the realisation of nature's potential cannot be a single event but must involve the realisation of a series of potentia. Therefore the structure of time can be understood in terms of the relationship between these realised potentia. The intermediate potentia, *b*, provides the link between its bounding states, *a* and *c*, but possesses different temporal properties to them. Since *b* represents the realisation of all the potential between the bounding states it elicits no further temporal response. It is this property that defines an existent state. However this places *b* outside of the temporal flow defined by the series of realisations of unbounded potentia, *a*, *c*,…, and therefore *b* only appears as an instantaneous aberration in this flow of time. It is this instantaneous aberration that is the basis for the present and it is only the present that is the domain of existent states. Even though *a* and *c* are also realised potentia they cannot intrude on the present since they are its boundary conditions, its past and future, which do not seem as tangible because they are not existent states. But because *b* elicits no automatic temporal response and is therefore isolated from the flow of time, while its realisation has demonstrated the association between *a* and *c* there is no longer an intermediate interval, that is, a process of change, there is just the absolute association of *a* and *c*, which we can denote as $a \rightarrow c$, read: a *goes to* c. It is in this way that the past instantaneously assumes equivalence with the future, through the catalyst of a present that is outside of the flow of temporal progression, but instead is the domain of existent states. The past, present and future are not merely impressions left on the human mind, but real elements of the realisation of nature's potential.

Despite his long meditations Saint Augustine still concluded, *" I confess to you, Lord, that I still do not know what time is* [60]*."* However for the next generation of physicists this need no longer be the case. Neither the structure of time nor its relationship with existence need remain a mystery, since they are the natural consequences of nature's evolution as modelled by this cosmology. In this way this cosmology expands the very domain of physics.

c. Predicting the Introduction of a Present Instant with a Finite Duration

While Saint Augustine's statement that, *"…no one would deny that the present has no duration, since it exists only for the instant of its passing* [60]*,"* is true in epoch I, this cannot remain the case for the present instant of this universe, since physical interaction requires a shared existent domain which can only be provided by a present instant with a finite duration. It is this that allows the establishment of a universe such as ours, where multiple existent states persist long enough to interact and produce physical consequences rather than purely temporal ones. This dramatically changes the emphasis for nature's evolution from the realisation of potential to the evolution of existent states. The origin of this universe is not about the development of galaxies and planets, this is merely its consequence, the origin of the universe is about the establishment of a present instant with a finite duration that can act as an environment shared by all existent states, thereby allowing them time to interact. As we continue to examine nature's evolution we must look for the basis for this further enhancement to the nature of time[6].

d. Predicting the Introduction of Space

The amplitude curve stamped upon the *ac*-axis models the ebb and flow of the uncertainty of realisation of the intermediate potentia within a single instant of time. The *ac*-axis has no extent that could be sequentially stepped through; instead it just represents the vague uncertainty of realisation that is now the potentia's minimum domain of expression. We characterised the temporal domain of epoch I as the future, since potentia such as *a* and *c* were randomly selected for realisation rather than being determined by the presence of a first cause. However because *a* and *c* represented two, perhaps contradictory, definitions of the one initial state they demonstrated that the absence of a first cause introduced the flaw of over-specification, which could only be overcome by setting *a* and *c* as the boundary conditions for an intermediate potentia that must be the next potential to be realised. While this introduced some determinism into the flow of events, it did not provide

[6] This will be dealt with at the end of Chapter Three.

sufficient constraints to make causally deterministic the selection of the amplitude that determines the uncertainty of realisation when an intermediate potentia is asserted. This remains a random selection, thereby merely re-applying the dominant method for epoch I's temporal progression within the boundary conditions.

Since nature's evolution is ultimately motivated by the need to overcome the flaw of there being no first cause and therefore always progresses towards the establishment of greater determinism, this situation, together with hindsight, allows us to predict the future direction of evolution - the overlaying of the abstract *ac*-axis onto a real spatial axis so that the location of an event in space, rather than random selection, determines the amplitude to be used in the assertion of a potentia. This does not provide for the certainty of realisation of the potentia, but does remove one level of indeterminism. The space of this universe is not a pre-existing, macroscopic environment through which elementary particles move, instead space is fundamentally part of the quantum world, introduced to make the selection of intermediate amplitudes non-random, so that nature can progress one step closer to establishing a clear causality.

e. Predicting the Consequences of Having Multiple Intermediate Potentia

While we stated above that there are no higher order wavefunction in epoch I, they are clearly introduced by later evolution since they are present in our description of the current universe. In the next chapter we shall deal with the origin of higher order wavefunctions, however in order to continue our consideration of the relationship between the wavefunction and the pre-asserted representation of the intermediate potentia, it is instructive to consider a situation where we merely presume the existence of additional intermediate potentia represented by wavefunctions with more than one maximum.

We have seen above how probability was introduced into the description of nature by the uncertainty of realising an intermediate potentia and that the pre-asserted representation of the potentia that quantifies this uncertainty is the ultimate basis for the wavefunction. When Schrödinger introduced his wave equation interpretation of quantum mechanics he believed the wavefunction to be the electron itself[7], stating that, *"…material points consist of, or are nothing but, wave-systems …[186]."* However Born's probability interpretation [187] separated these two things – the wave was not the particle but a measure of the probability of finding the particle at a particular location. When we say here that the wavefunction is derived from the pre-asserted representation of the potentia, this is not a return to Schrödinger concept that the wavefunction is the objective state itself. Instead, as we have seen above, the pre-asserted representation does not define the property to be expressed but merely quantifies its uncertainty of realisation and in so doing defines the process, the gaming device, to be applied to the assertion of this potentia. The overlaying of the *ac*-axis onto space ensures that if the same physical circumstances are repeated the same gaming device will be applied and therefore the results will take the form of the ensemble average applicable to this gaming device. However now we must add to this consideration the additional complication of having the possible realisation of different intermediate potentia, each with its own pre-asserted representation quantifying its uncertainty of realisation. This occurs simply because

[7] We will examine this in more detail in Chapter Three

the boundary condition can only provide limited constraints on the underlying reality for an initial state devoid of a first cause: *Anything that can happen will*. Except for the most ideal boundary conditions over-specification will still be evidenced, with each intermediate potentia providing a different definition for the limited universe within the boundary conditions. The concept of such limited universes is not without precedent but can be traced back to Hoyle, who considered models in which the constraints of nature vary from region to region, so that each region might be considered to act like a separate universe [188]. But as is the case for the initial state, this limited universe possesses multiple potential definitions. All of these definitions must be taken into account if the realised potentia is to satisfy all of the potential within the boundary conditions and thereby be an existent state. It is this process of accounting for all the intermediate potential that we model in quantum mechanics. The cosmological basis for why this can involve the cancellation of possible outcomes will be given later in this chapter, for the moment we can simply presume or ignore this, since what we are concerned with here is how nature deals with the possibility of realising two different definitions for the one limited universe and how this is related to the processes modelled by quantum mechanics.

While we are most familiar with Schrödinger wave mechanics being represented purely in the form of equations, there is a visualization, taken from Herbert [65], that can be considered in conjunction with this formalisation, in order to give a simpler comparison with this cosmology. In 1822 Joseph Fourier [189, 190] showed that any wave could be reconstructed as the sum of a number of sine waves. More recently the synthesizer theorem demonstrated that not only sine waves but also any other conceivable waveform could be used in this reconstruction. It was Newton [191] who first used a prism to deconstruct white light into its constituent colours. In this visualisation of quantum mechanics we imagine a *wave family prism* that can deconstruct a wavefunction into a particular wave family. Now we can have different wave families provide information applicable to different measurable properties. Some of the wave family representations and relationships to measurable properties are [65]

Waveform Family	Differentiating Attribute	Dynamic Attribute	Attribute Size
Impulse	x (position)	Position	X = x
Spatial sine	k (wave number)	Momentum	P = hk
Temporal sine	f (frequency)	Energy	E = hf
Spherical harmonic	n (number of nodal circles)	Spin magnitude	S = hn

Now you might reasonable ask: *What on earth does momentum have to do with a sine wave?* But as Herbert explains, “ *Ultimately this waveform-attribute association is justified because it works* [65].”

When a measurement of a particular property is undertaken, we imagine the wavefunction being passed through the wave family prism appropriate for that property, for example for the property position the impulse wave family prism would be used. The result is a number of impulse waves from which the original wavefunction could be reconstructed. Each of these waves represents a different value the property position could take and therefore a different outcome the measurement could return.

In order to understand this strange procedure it is necessary to examine it, not in terms of how it applies to problems within this current evolutionary epoch and universe, but in terms of nature's broader evolutionary history. Each intermediate potentia would provide a definition of the entire limited universe, with its pre-asserted representation determining the flow of uncertainty of realisation for the constituents of this universe. These definitions are given in terms of entire reference frames within which the universe is defined, for example we imagined above that *a* and *c* might define the initial state in terms of *colour* and *flavour*. But we also stated that in epoch I these reference frames did not contain multiple values, so that *a* and *c* only expressed the values *red* and *sour*. There is therefore no real distinction in epoch I between the reference frame *colour* and the value *red*, since this is the only colour that can be realised. However when considering the limited universe we must associate each intermediate potentia with a different reference frame which could define it. While some of the reference frames will coincide with the measurement properties listed above, the total range of properties by which a limited universe could be defined could be so bizarre and diverse as to be unimaginable. If this limited universe had to express all of these possible properties it would be so diverse in its character that its constituents would be unable to form coherent composite structures. However unlike unconstrained potentia, potentia that satisfy the same boundary conditions are simultaneous, that is, they span the same temporal instant, so that their representations are added to form a single composite wavefunction or wavepacket. This now gives a representation of the flow of uncertainty of realisation that takes into account all the potential within the boundary conditions, but is no longer expressed in any particular reference frame. In terms of our visualisation of quantum mechanics, while a distinct wave family represents each reference frame, the composite wavefunction no longer resembles any of these families. When physicists do a measurement for a particular property, it is because they recognise that this is one of the defining properties for this universe. What nature has done is restrict the number of properties actually expressed in this universe in order to simplify its evolution, while taking all possible reference frames into account. When we pass the composite wavefunction through a particular wave family prism we express all of the diverse potential of the limited universe within a single reference frame.

But something truly remarkable happens because of this process. If a pulse wave is passed through the position wave family prism it will be unaffected because position is represented by the pulse wave family. But as the composite wavefunction becomes more complex, more distinct from any specific wave family, the output spectrum from the wave family prism becomes broader, including a greater number of distinct output waves. Whereas on one side of the prism there was a composite wavefunction representing all of the reference frames by which the limited universe could be defined, on the other side of the prism this over-specification, this diversity of nature's potential, is expressed as a range of different values that could be realised within the one reference frame. These represent a number of different outcomes in terms of the same measurement property.

It is easy to look at the situation of a particle travelling between two points in space and conclude that there are multiple potential paths that it could follow. But nature must initially evolve such capacities from a purely abstract environment, which precedes the existence of space and motion as they are currently experienced. The capacity for there to be multiple spatial paths between two points fundamentally arises because for the limited universe bounded by these points there are properties other than position by which it could be defined. This is represented by its composite wavefunction being distinct from a pure pulse wave, so that when it is passed through the position wave family prism there are multiple output waves produced, multiple values for the property position, representing multiple paths linking the boundaries of this limited universe. It has long been assumed that the strange process used by quantum mechanics cannot be understood in terms of a direct description of nature, but by reference to this cosmology this is clearly not true. What quantum mechanics is describing is not just how to determine the outcome of a specific event, but the process by which nature evolved the capacity not just to be defined by multiple properties, but for each property to be able to assume multiple values. That these multiple values can apply to the outcome of a single event, that is, that a single physical circumstance can have a number of different outcomes, simply reflects the fact that they are a re-expression of over-specification. But that the value of a single property can take multiple values for a particular limited universe, a particular set of physical boundary conditions, far from being undesirable, is the necessary trade off for having a universe that is defined by a limited range of properties. The existence of multiple alternative outcomes for a single event represents neither a flaw in our understanding nor in nature's design, it is a truly remarkable approach to overcoming the over-specification inherent in an initial state devoid of a first cause. It makes perfect sense.

Quantum mechanics is not describing a process that is incomprehensible in terms of a direct description of nature; it is describing an aspect of nature's evolution. The lesson this teaches is quite profound – broad evolutionary precedents form the basis for how individual events occur within our current universe. Therefore to study interactions between the constituents of this universe without putting them into a cosmological context could have no other outcome but the confusion quantum mechanics has caused. The most fundamental of the disciplines of physics, mechanics [192], can ultimately not be understood without associating the interactions it describes with their evolutionary precedents. Cosmology is not the icing on the cake of our understanding of nature, it is the flour from which the cake is made.

f. Predicting the Nature of Measurement

Now that we have seen how the possibility of a single event having multiple potential outcomes for a specified measurement property enters into the description of physics, we can consider how nature addresses this refinement of the flaw of over-specification.

In quantum mechanics, as Penrose points out, " …*systems are described as evolving according to one or other of two apparently incompatible procedures: deterministic unitary Schrödinger evolution …and probabilistic state vector reduction. There is no clear-cut rule for deciding the stages at which unitary evolution must be suspended and replaced by the reduction procedure. This procedure has to have been invoked at least by the time an 'observation' is deemed to have been made by any conscious observer. …it is one of the powerful facts about the formalism of quantum mechanics that it makes* no difference *what stage the procedure is actually applied …, provided that this is after any stage at which interference phenomena can plausibly be measured, and provided that it is not beyond the stage of conscious perception* [68]." The conclusion drawn by John von Neumann, author of the definitive analysis of quantum mechanics [193], that the observer in an experiment need not be the physical apparatus but that the point of observation could be the human brain, was taken further by London and Bauer [194] to form the statement that it is human consciousness that completes quantum measurement and that is therefore ultimately responsible for the collapse of the wavefunction [195]. This is in keeping with the Copenhagen interpretation of quantum mechanics and leads to the conclusion that there is no reality in the absence of observation, or as Fred Wolf put it, *" You create your own reality* [196].*"* This is a philosophy best summarized by Bertrand Russell, *" In this philosophy I found comfort for a time… There was a curious pleasure in making oneself believe that time and space are unreal, that matter is an illusion and that the world really consists of nothing but mind* [65].*"* But if scientists accept Saint Augustine's proposal that time has no more objective substance than the experiences of the human mind, together with London and Bauer's proposal that reality is created by measurements undertaken by conscious observers, then ultimately physics as the study of the material world must ceases to exist, to be replaced by a study of the perceptions of human consciousness.

Which came first the chicken or the egg? The difficulty in answering this question is emphasised by Saint Augustine since, *"…to make ourselves we shall have to exist before our existence began* [60].*"* Equally if an observer is required for the measurement process to occur and if real objects only come into existence through measurement, then the observer must exist before there is existence. Applied to cosmology, the interpretation of measurement whereby an observer is required means that physics necessitates the existence of God, both to define an initial state wavefunction and to conduct a measurement using it. The most widely accepted quantum cosmology avoids this dilemma by postulating both the initial state wavefunction and a new process involving the action of repulsive gravity on perturbations, which removes the need to ever consider the measurement of the initial state wavefunction. In contrast the cosmology of this consideration details the boundary conditions by which its initial state wavefunction is defined. These boundary conditions determine the sequence of realisation of nature's potential, dictating that the next potential to be realised must be that which is intermediate to the boundary conditions. It is the process by which this is to be achieved that is modelled by quantum mechanics. Therefore measurement is not necessitated by the presence of an observer, but by the flow of time itself.

The problem with understanding quantum measurement has always been that, as Baggott pointed out, *" The collapse of the wave function is a striking phenomenon, and …it must occur. But remarkably, this collapse is **not** predicted by quantum mechanics. In particular, …it is not described by the Schrödinger equation* [95].*"* This allows a situation where there are several opinions expressed in the literature regarding wavefunction collapse. The first is that the wavefunction must collapse upon measurement, although what the process of collapse is or what it means in terms of a direct description of nature is not specified. The second, expressed by Pearle [197-200], is a slight revision of this stating that the wavefunction collapses for unprotected measurements. There is however a third scenario where the wavefunction never collapses at all and therefore all elements of the superposition of possible outcomes are realised, which was introduced by Hugh Everett III in 1957 as his doctoral thesis [201, 202], with a summary, *"Relative state" formulation of quantum mechanics* [203], published in *Review of Modern Physics*. Everett's many-worlds interpretation of quantum mechanics avoids wavefunction collapse by claiming that whenever a superposition is resolved all possible outcomes are realised, either in our universe or in a parallel universe that is established by the act of measurement. In this scenario even the simple tossing of a coin, since all outcomes must actually occur, would result in the establishment of a new parallel universe. In this way no true choice of outcomes is ever made. However Everett was so discouraged by the lack of interest in his ideas shown by other physicists that he quit physics to pursue commercial interests [204]. It was only when Bryce de Witt [205, 206] reintroduced the scientific community to Everett's work in the 1970's that it gained popularity. What had changed in the intervening period was the acceptability of the concepts of parallel universes. This was due to their inclusion is string theory and brane cosmology, as well as all other cosmologies which use a spontaneous initial event and their postulation as a way to explain the fine-tuning problem[8]. Eventually De Witt [207] and others [56, 208] presented Everett's many-worlds interpretation of quantum mechanics to the broader community.

DeWitt said of Everett's theory, *" I still recall vividly the shock I experienced on first encountering this multiworld concept. The idea of $10^{100\,+}$ slightly imperfect copies of oneself all constantly splitting into further copies, which ultimately become unrecognizable, is not easy to reconcile with common sense…*[205].*"* Yet just how broadly accepted by physicists the many-worlds interpretation has become is best expressed by Kaku's [80] retelling of the story of a Russian physicist visiting the united states for the first time and taken on his request to a casino in Las Vegas: *" Considering him to be a seasoned gambler, his American hosts were curious to learn what his gambling strategy might be. The Russian said that he would put all his money, every penny, on the first bet. But, his hosts protested, 'That's a ridiculous strategy.' 'Yes,' he replied, 'but in one parallel universe, I shall be rich beyond my wildest imagination.'* [80].*"*

Wheeler, who had supervised Everett's PhD [209], originally supported the many-worlds interpretation but later stated that, *" I have changed my view of it today because there's too much metaphysical baggage being carried along with it, in the sense that every time you see this or that happening you have to envisage other universes in which I see something else happening. This is to make science into a kind of mysticism* [210].*"* Penrose objects to the many-worlds interpretation on the basis of what he called the 'zombie' theory of the world [211], whereby as the universe branches, *"…my own consciousness through it would seem to result in my becoming separated from the tracks of consciousness of my friends. …It seems to me that one needs a reasonable theory of consciousness before the many-worlds view can hang together as a physical theory and as a viable interpretation of quantum mechanics* [160].*"* Gerard 't Hooft's opinion of the many-worlds theory is that, *" To my sober mind, all this is nonsense. Much more reasonable is the suspicion that the statistical element in our predictions will eventually disappear completely as soon as we know exactly* the complete theory of all forces, *the Theory of Everything. This implies that our present description involves variable features and forces which we do not (yet) know or understand. Such an interpretation is called the 'hidden variable hypothesis'* [158].*"*

We agree that the introduction into physics of the concept that parallel universes spontaneously poping into existence with every quantum measurement is too high a price to pay for a conceptualisation of nature claiming compatibility with quantum mechanics. But the solution is not *hidden variables* that can make the statistical elements in our predictions disappear, but to find a more reasonable

[8] All of these reasons for including many universes in the physical model will be dealt with later and solutions to the underlying problems provided in terms of this cosmology that do not require the postulation of parallel universes – see Chapter Three: 29. *The Anthropic principle and this Cosmology* and Chapter Six: 60. *A Final Statement on the Many Universes Theories in Physics*.

conceptualisation of nature that will make their presence understandable. We have already seen above that the uncertainty upon which the statistical nature of physics is ultimately based entered the description of physics because of the flawed nature of the initial state boundary conditions. We have also shown how the evolutionary process introduces the presence of multiple possible values for a measured property. There are no hidden variables, that a single event can have multiple outcomes does not represent any lack of understanding on our parts, it is simply the most recent manifestation of the over-specification that results from a flawed set of initial conditions devoid of a first cause. Physicists, like nature itself, have no choice but to confront this difficult situation. That both unitary evolution and wavefunction collapse are included in our model of physics is not surprising, since unitary evolution merely reflects the overlaying of the pre-asserted representations of the potentia onto space, while the collapse of the wavefunction simply refects the application of an amplitude taken from the association of the pre-asserted representation and a spatial location, to the process of asserting a specific outcome that is realised will be an existent state. The next question to be addressed is whether or not this process must include the realisation of all possible outcomes as Everett's theory insists.

For a realised potentia to constitute an existent state the process leading to its realisation must demonstrate that all potentia between the boundary conditions have been included in the determination of the amplitude used in its assertion. This is what the composite wavefunction does. However when a measurement is done it must be conducted with reference to a universe defined by a single potentia, that expresses the same property as the measurement outcome. This is represented in quantum mechanics by the synthesiser theorem deconstructing the composite wavefunction into components in the wave family of the measured property. But while this ensure that the limited universe is defined by a single potentia, this is still a flawed definition that continues to express over-specification, although now not as a range of possible properties that can define the universe but as a range of values this single property can potentially take. These are the superposition of possible outcomes to be resolved by measurement. However, the deconstructed output waves still represent the pre-asserted representations of all intermediate potentia. These potentia retain the defining property that they must at some point be realised. Therefore we must conclude, as Everett did, that all of the elements of the superposition must be realised. However while human imagination can conceive a scenario where quantum measurement instantaneously creates as many parallel universes as there are unrealised outcomes of the event, nature does not have the capacity to achieve this. What we are examining in this dissertation is the difficulty of nature's struggle to establish even the one universe of our experience. Nature is forced to take a far simpler approach to satisfying the guarantee that all potentia will at some point be realised, the very approach that has been evidenced in every experiment ever conducted – one outcome is realised when a measurement is done and another when an indistinguishable system is measured at some future time. The guarantee of realisation is only given in terms of nature's entire evolutionary history and so the intermediate potentia need not be realised within the boundary conditions, which in terms of events within this universe means that they need not be realised upon the resolution of a single event. Confusion arose because physicists considered the fact that the same physical circumstances can lead to different outcomes to be the problem, when in fact it is nature's solution to the problem of over-specification. Nature need not establish many universes in order to realise all the elements of a superposition, just one universe that can repeat the same boundary conditions and thereby produce indistinguishable events. This universe with its billions of equivalent particles obeying a limited set of rules must inevitably do this.

But while this solution introduces no new parallel universes, it represents a dramatic extension to the nature of time. Where there is a superposition of possible outcome of an event, no final solution can be considered to have been reached before enough time has passed to allow sufficient repetitions of indistinguishable events, so that all possible outcomes can be realised. This provides a further enhancement to the nature of time, a further motivation for its perpetuation. Not in the broad sense that no defined state can encapsulate all potential, but in the more specific sense of individual events which must be repeated until all possible outcomes for them are realised. The vastness and repetitiveness of this universe is no accident, it exists to achieve this result.

The possible existence of a multitude of parallel universes populated by variations of ourselves living out slightly different lives, perhaps even one living out the life we would ideally want, is an exciting and even appealing concept. Is the interpretation of quantum mechanics offered by this cosmology mundane in comparison? While more in keeping with the scientific method, which should rightly insist that all constituents of a theory must remain experimentally accessible, the interpretation of quantum mechanics offered by this cosmology is certainty not mundane but revolutionary, since it states unambiguously that universal evolution is purposeful. The universe is not as it is by chance. Its characteristics are necessitated in order to overcome specific flaws. Moreover, by extending the scope of cosmology to deal with nature's evolution at a far more fundamental level than has previously been attempted we can see how these flaws originate and trace how nature evolves towards their resolution. This cosmology's interpretation of quantum mechanics is certainty not mundane; it says that we can answer within the discipline of physics one of humanity's oldest and most fundamental questions: *Why is the universe here, what purpose does it serve?* This can be done because purpose is not something imposed by an external agency, but something that is inherently part of nature's physical makeup.

g. Predicting the Introduction of Macroscopic Objects

If nature's evolution is driven by the need to establish causal determinacy as this cosmology claims, there should be evidence of this in the evolutionary history of our own universe. And there is. The evolution of this universe involves the aggregation of elementary particles into large and more complex systems. It is the spatial scale and number of constituent elementary particles in these composite, macroscopic systems that allow nature to circumvent the uncertainty inherent in a universe that was established before over-specification was resolved. The wavefunction frequencies are very small, so that indeterminacy in location is also small, composite states that are defined over comparatively large spatial regions make these uncertainties insignificant in terms of the location of the group defined state. Large numbers of particles establish a single time interval ensemble average, that is, instead of indistinguishable events occurring at disjoint intervals along the timeline there are sufficient particles to have numerous indistinguishable events occur in the same time interval. In this way the most probable outcome would be evidenced in a sufficient number of cases so that from a macroscopic view only one outcome would appear to have occurred. In this way while the outcome for the individual components of the group state would still be uncertain, the majority outcome for the group state itself viewed from a macroscopic perspective would appear to be consistent. The question: *Will a specific electron arrive at spatial region B?* is still governed by uncertainty, but the question: *Will the cricket ball arrive at special region B?* is not, because in a single time interval the event defined at the elementary particle level will be repeated sufficiently for enough elementary particles to be realised at *B* for the definition of the composite state 'cricket ball' to be satisfied.

Because of the uncertainty of realisation that necessarily accompanies any attempt to realise a specific, bounded potential, nature in seeking greater causal determinacy is forced to deal with group states rather than individual elementary particles. The direction of nature's evolution that we witness in this universe, the aggregation of elementary particles to form macroscopic objects such as stars and planets, is the necessitated means to circumvent the flaws introduced by the initial state having no first cause.

If we seek causal determinacy it cannot be found by looking backwards along the cosmological timeline, we must look forward. It is the large-scale aggregate states that we see behaving in a deterministic way, these most recent consequences of evolution. It is a mistake to look to the past to provide certainty or to always look to the small to determine the behaviour of the large. Time must pass to allow the evolution of more complex structures that by virtue of their spatial scale and number of constituent elementary particles can behave in a more causally deterministic manner. When we look at smaller and smaller objects we are looking back along the evolutionary timeline, in much the same way as an astronomer looking at a distant star is looking back into the past state of the universe. Therefore examining microscopic systems does not simply involve a reduction in scale, it involves an evolutionary regression to a less evolved state, and therefore we should expect that in consequence of this it would be less deterministic. Quantum physics cannot be expected to be deterministic because in examining individual elementary particles or small aggregations we are looking back along the evolutionary timeline to an environment that precedes the implementation of nature's solution to providing greater determinacy, to a period before the evolution of macroscopic objects. Classical physics is deterministic because it deals with the macroscopic – nothing less will do. You do not find causality as the basis for the evolution of the universe, but as its goal.

h. This Cosmology and the Quantum Reality Debate

Bohr forcefully stated that, *" Anyone who is not shocked by quantum theory has not understood it* [212]*."* What is shocking, as Herbert pointed out, is that, *" Identical physical situations give rise to different outcomes* [65]*."* This represents a major challenge for physics since as Feynman noted, *" Philosophers have said that if the same circumstances don't always produce the same results, predictions are impossible and science will collapse* [2]*."* Bohm [47, 162, 169-171, 213], together with many other physicists before [164-166] and since [167], was greatly troubled by the loss of classical causality that accompanied the introduction of quantum mechanics stating that, *"…from the very beginning, it took the form of a set of laws that gave in general only statistical predictions, without even raising the question as to what might be the laws of the individual systems that entered into the statistical aggregates treated by the theory. Moreover …the indeterminacy principle of*

Heisenberg led physicists to conclude that in investigations carried out to a quantum-mechanical level of accuracy no precise causal laws could ever be found for the detailed behaviour of such individual systems, and thus they were led to renounce causality itself in connection with the atomic domain [169]*."* However the majority of physicists today attempt to avoid this debate altogether by considering quantum mechanics as just a collection of mathematical recipes that can be used to predict the outcomes of experiments, thereby accepting Bohr's assertion that, *" There is no deep reality* [65]*,"* and more, *" There is no quantum world. There is only an abstract quantum description* [65]*."* However the quantum reality question cannot simply be ignored on the basis that the quantum formalism provides accurate predictions, if this is at the expense of understanding. While this may satisfy the requirements of technology, it can never satisfy the human longing to understand. We seek knowledge of the world, not to build better machines, but in order to understand our place within it. It is this emotional need that initiated scientific enquiry. For science to say that it can no longer satisfy this need is not pragmatism, it is failure. We choose our destination at the commencement of a journey and therefore cannot claim that the point where we get lost is the journey's end.

For Jaynes, *"…it is pretty clear why present quantum theory not only does not use – it does not even dare to mention – the notion of a 'real physical situation.' Defenders of the theory say that this notion is philosophically naïve, a throwback to outmoded ways of thinking, and that recognition of this constitutes deep new wisdom about the nature of human knowledge. I say that it constitutes a violent irrationality, that somewhere in this theory the distinction between reality and our knowledge of reality has become lost, and the result has more the character of medieval necromancy than science* [214]*."* Bohm continues to look for a *real physical situation* insisting that, *" …there is good reason to assume the existence of a sub-quantum mechanical level that is more fundamental than that at which the present quantum theory holds* [169]*."* Feynman, on the other hand, resigned himself to accepting the probabilistic nature of quantum mechanics, *" Does this mean that physics, a science of great exactitude, has been reduced to calculating only the probability of an event, and not predicting exactly what will happen? Yes. That's a retreat, but that's the way it is: Nature permits us to calculate only probabilities. Yet science has not collapsed* [2]*."* But science has not collapsed only because, while quantum mechanics cannot predict which outcome will occur in an individual situation, it can predict that if the situation is repeated a large number of times a particular outcome will occur with a specific frequency. Einstein could never accept that this represented a true description of nature insisting that, *" It is hard to sneak a look at God's cards. But that he would choose to play dice with the world… is something I can not believe for a single moment* [215]*."* But while this statement presumes that probability is the antithesis of design, this cosmology shows that this is simply not the case. Probability enters physics because of the introduction of design in terms of boundary conditions that provide constraints on the realisation of nature's potential. Boundary condition attempt to impose design in terms of a specific sequence in the realisation of nature's potential, but because these boundary conditions are flawed in that they do not represent the extremities of nature's evolution, the guarantee that the intermediate potentia will be realised is lost, introducing uncertainty into the realisation of nature's potential. The probabilistic nature of physics does not arise because of a lack of design, but because of an attempt to make the realisation of potential more specific. Design need not be the product of an omniscient being, at its most fundamental design is simply the presence of any constraint on the realisation of potential, such as that introduced by the realisation of potential intermediate to specific boundary conditions. This does not occur because there is any conscious intent, but simply because evolution must progress from a flawed set of initial conditions. Einstein claimed that quantum mechanics, because of its probabilistic nature, must be presenting an incomplete and therefore flaws view of how nature actually works. But rather it is giving a view of nature's flaws. The story of nature's evolution is not one of intelligent design, but rather of a struggle to overcome inherent flaws. It is no doubt *hard to sneak a look at God's cards*, but this cosmology finds a distinct resonance with Florence Nightingale's [216, 217] assertion that, *" To understand God's thoughts we must study statistics, for these are the measure of his purpose* [69]*."* The statistical character of quantum mechanics is not the product of human interpretation, but is an inherently part of nature that ultimately arose as a consequence of the introduction of design.

Einstein could imagine no conceptualisation of nature that could accommodate the probabilistic prediction of quantum mechanics, but this need no longer be the case. That physics *has been reduced to calculating only the probability of an event* is not a *retreat* but merely an acceptance of our place along the evolutionary timeline. It is the same sort of egocentric attitude that placed the earth at the centre of the solar system, which claims that the current epoch represents the completion of the evolutionary process. Prior to this cosmology providing a basis for determining nature's purpose, there was no criterion for ascertaining what stage of completion this current epoch has achieved. But now we can see that this universe is still an unresolved state that must continue to evolve towards finding a solution to over-specification. While our ideals of Newtonian causality are a dream shared with nature, this has not as yet been achieved. The physics of quantum mechanics is a fair reflection of our time, but should not be used as an excuse to restrict a broader understanding.

If exactly the same physical circumstances do not produce the same result then strict Newtonian causality cannot apply, instead what quantum mechanics has demonstrated is that it is the wavefunction that determines the evolution of the system. But, in terms of this cosmology, why should this be the case? First we must strike from our imaginations the visualisation of elementary particles as permanently existent states. As we have seen above, in epoch I existent states had only instantaneous realisation. We shall show at the end of the next chapter how this is extended by the evolution of a present instant with a finite duration, but this duration is extremely short so that the resolution of subsequent events involving the same elementary particle will involves a new process of assertion. This is in keeping with the picture presently provided by quantum mechanics where particle properties are only evidenced upon measurement, while at all other times the system's evolution is modelled in terms of waves.

The physical circumstances only determine the boundary conditions that restrict the number of potentia that could define universal evolution for a particular limited universe, thereby acting as a constraint on over-specification. The wavefunction is derived from the sum of the pre-asserted representations of all intermediate potentia, which when overlaid on space defines the uncertainty of realisation for the constituents of this limited universe at specific spatial locations intermediate to the boundary conditions. In this way the outcome of a single event is perfectly predictable; it is just that the prediction is not whether an elementary particle will be found in the new spatial location, but the amplitude that defines the uncertainty of its realisation. This is all the overlaying of the *ac*-axis onto space adds, all it could ever add, the removal of one level of indeterminacy so that instead of the amplitude for the assertion of a potentia being randomly selected specific spatial locations map to specific amplitudes.

Quantum mechanics works so well because it accurately reflects the necessitated process for the realisation of existent states. Existent states cannot become manifest without the establishment of boundary conditions that allow a pre-asserted representation that accounts for all intermediate potentia, which we model as a wavefunction, that then determines the probability of realisation of any potential within this limited universe. Even small amplitude possibilities will occur given sufficient repetitions in order to maintain the constraint that all potentia must at some point be realised. Quantum mechanics models this process and as such is not an abstract mathematical tool but a reasonable description of the evolutionary process required to establish existent states and as such cannot be circumvented. The attempts by Hartley [218] to purge from the foundations of quantum mechanics any statement about probability could never be successful, since uncertainty of realisation is the necessitated cost of establishing bounded and thereby existent states. Nature cannot do without the wavefunction and have existent states. There is no going back for physics; the quantum description is how nature must function given the flaws it must work around. The insistence by some physicists that there is *a sub-quantum mechanical level that is more fundamental than that at which the present quantum theory holds,* persists because physicists have previously been unable to examine nature at a sufficiently primitive and sparse evolutionary epoch that they could recognise quantum mechanic's true basis. Nothing needs to be added to the quantum formalism except a conceptualisation of nature consistent with it. In the final analysis quantum mechanics is a direct description of how a flawed nature must work. We agree with Jaynes that currently *the distinction between reality and our knowledge of reality has become lost*, but hope that this cosmology can re-establish a clear distinction, thereby reasserting that physics is capable of providing a direct description of nature and is not a *medieval necromancy* concerned solely with abstract mathematical objects.

i. Quantum Mechanics and Constraints on Pre-Big Bang Cosmologies

When John Dalton [219], on chemical grounds, namely, the fixed ratio of the weights of chemical elements, declared that Democritus of Abdera's atoms [220] (about 500 B.C.) were real physical entities, he was widely criticized on the grounds that atoms were rightly only abstract philosophical entities that had no place in physics. The French chemist Jean Baptiste Dumas declaring that, *" If I were master of the situation, I would efface the word atom from Science, persuaded that it goes further than experience* [65].*"* He was joined in his criticism by the German chemist Kekulé, *" The question whether atoms exist or not has little significance from a chemical point of view; its discussion belongs rather to metaphysics. In chemistry we have only to decide whether the assumption of atoms is a hypothesis adapted to the explanation of chemical phenomena."* The criticism of the atomic theory seemed clearly justified since, as Marcelin Berthelot stated, *" And who has ever seen a gas molecule or an atom?* [65]*"*

The situation changed with Einstein's [221] publication of a series of papers explaining the Brownian motion of micron sized particles suspended in a liquid in terms of atomic theory. Einstein's work allowed the calculation of the number of atoms hitting the micron sized particle, by measuring its drift. Jean Baptiste Perrin [65] verified Einstein's model, publishing his results in 1913 in a book boldly titled *Les Atoms*. Today, as stated by the philosopher of science Hans Reichenbach, " *The atomic character of matter belongs to the most certain facts of our present knowledge …we can speak of the existence of atoms with the same certainty as the existence of stars* [65]." It is in fact now possible, using scanning tunnelling microscopes, to obtain images of individual atoms [179].

We have introduced in this dissertation a new minimum entity, potentia, which like atoms when first introduced may seem difficult to see, since they are being used to provide a detailed examination of an environment that pre-dates the big bang and the existence of any of the particle or forces that physics is normally concerned with describing. So is this just wild speculation? No, it is physics, because it provides a cosmological insight into what is now the principal tool in physics - quantum mechanics. It is quantum mechanics that the physicist turns to when probing into the workings of this universe. But if it is merely a mathematical contrivance then all that it can provide are numerical answers. But this is not enough, we must gain the capacity to interpret and understand those answers in terms of a direct description of nature. The scientific community was force to take atoms seriously because Einstein's explanation of Brownian motion made them 'visible.' Equally the potentia and the pre-big bang environment can be made visible through their relationship with the most fundamental aspects of quantum mechanics.

Currently cosmological models seek agreement with the WMAP (*Wilkinson Microwave Anisotropy Probe*) data [222] for the cosmic background radiation, however this only gives a picture of the universe some 300,000 years after the big bang and is therefore of only limited use in verifying cosmological models, such as the quantum cosmologies, that have their foundations in pre-big bang scenarios. It is this limited approach to verification that has lead to a situation where a large number of strikingly different cosmologies can claim an equal degree of credibility based on a similar degree of agreement with the WMAP data. It is clear therefore that another approach must be sought in order to place new constraints on pre-big bang cosmologies. The approach taken in this dissertation is to seek agreement not just with available data, but also with physics' most fundamental theory, quantum mechanics. A model of pre-big bang cosmology that provides a cosmological basis for quantum mechanics is not only subject to more constraints but is of more value, than a cosmology that simply presumes and utilises quantum postulates.

j. This Cosmology and the Different Flavours of Quantum Mechanics

There are several flavours of quantum mechanics that produce the same predictions while being based on quite different visualizations: Schrödinger's wavefunctions [223], Dirac's spinning ket vectors [224] Feynman's sum over histories [225] and Heisenberg's matrix formulation [8] which provide no visualization at all. It has always been assumed that no preference can be given to one formulation of quantum mechanics over another because they all give the same predictions of experimental results, despite their quite different approaches. However while the various flavours of quantum mechanics are mathematically equivalent, they may not be cosmologically equivalent. Therefore we would contend that a preference can be determined in terms of which comes closest to providing a direct description of nature. While all formulations give the same predictions of experimental results, the one that is closest to a direct description of nature will provide the best tool for interpreting these results. Science is not a matter of just getting the answer right; we must strive to understand what these answers mean.

We are presenting here only the preliminary consideration of a new cosmology that is by necessity only broadly sketched, but will be refined and expanded over time. As this is done, if researchers keep in mind the relationship between the cosmology and the selection of the most appropriate flavour of quantum mechanics, this choice can be refined even if this requires blending flavours or indeed introducing new ones, so that in the end it can be said without question that quantum mechanics is not just a mathematical contrivance without reference to any underlying reality, but is instead our current best description of nature. While Feynman stated of his formulation that, *" I can't explain why Nature behaves in this peculiar way* [2]*,"* we would contend that it will be possible for the most appropriate flavour of quantum mechanics to say that it works this way because nature's evolutionary history dictates that it must. Feynman said that, *" The theory of quantum electrodynamics describes Nature as absurd from the point of view of common sense. And it agrees fully with experiment. So I hope you can accept Nature as She is – absurd* [2]*."* We do not believe that nature is absurd, just as yet misunderstood.

k. Concluding Comments on A Hypothetical and its Predictions for Future Evolutionary Developments

The question of whether quantum mechanics is capable of providing a direct description of nature has been argued since its inception. Schrödinger wrote to Einstein on 18th November 1950 commenting on this problem, *" The present quantum mechanics supplies no equivalent* (conception of reality). *It is not conscious of the problem at all; it passes it by with blithe disinterest* [226]*."* Schrödinger was not willing to sacrifice objective reality no matter the success of quantum mechanics as a tool for calculation, *" Physics takes its start from everyday experience, which it continues by more subtle means. It remains akin to it, does not transcend it generally; it cannot enter into another realm. Discoveries in physics cannot in themselves - so I believe – have the authority of forcing us to put an end to the habit of picturing the physical world as a reality* [65]*."* Einstein responded to Schrödinger on 22nd December 1950, *" You are the only contemporary physicist, besides Laue, who sees that one cannot get around the assumption of reality - if only one is honest. Most of them simply do not see what sort of risky game they are playing with reality – reality as something independent of what is experimentally established* [227]*."* Heisenberg, on the other hand, was willing to accept the loss of objective reality, *" Some physicists would prefer to come back to the idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist independently of whether we observe them. This however is impossible* [65]*."* We do not suggest a return to classical concepts, but a progression to cosmological ones. Only cosmology can resolve the quantum reality debate by demonstrating whether or not the fundamental elements of quantum mechanics are revealed in nature's evolution. The problem is that it has become fashionable to simply presume that the initial state is a quantum state and then use some of the strange attributes of quantum mechanics such as quantum fluctuations, vacuum pair production or tunnelling as a pseudo first cause for a cosmological model. However this approach can never bring us any closer to understanding the relationship between quantum mechanics and a real description of nature.

David Finkelstein believed that the quantum reality question could not be resolved without changing out very modes of thought, “ *Einstein threw out the classical concept of time; Bohr throws out the classical concept of truth… Our classical ideas of logic are simply wrong in a basic practical way. The next step is to learn to think in the right way, to learn to think quantum-logically* [65].*”* We need not go quite that far, but can stop at a quantum common sense, based on a clear conceptualisation of nature and its evolution in keeping with quantum facts. Davies said of quantum mechanics, “ *The one thing I would recommend is: don’t try to visualise it* [228].*”* This is a valid recommendation no doubt when dealing only with quantum mechanics, since it makes no claim to provide a direct description of nature, however quantum mechanics used in conjunction with Flawed Nature Cosmology will not only be comprehensible but provide a common sense visualisation, that will provide a context for interpreting new results. This cosmology does not start with an initial state wavefunction but derives one. It does not presume the indeterminacy modelled by quantum mechanics but explains how it arises as part of nature’s evolution. It is true that the initial state of this cosmology does not provide a basis for all of the attributes of quantum mechanics, but nor should it. There is nothing to be learned by simply presuming that earlier evolutionary epochs simply possessed all the attributes we now experience. This is not cosmology. Instead we must look for the evolution of these attributes distributed along the entire length of the evolutionary timeline. Philosophers and physicists have sought to understand the origin of the universe because they felt that it represents ultimate knowledge, giving a solid foundation for all other scientific understanding, as if once we fill in this missing piece of a Newtonian causal sequence everything will be known. But Newtonian causality is the ideal rather than the reality. In cosmology we must seek a basis not for the dream of Newtonian causality but for the reality of quantum indeterminism. This cosmology describes the evolution of a flawed nature that it is devoid of a first cause and hopelessly over-specified because of this. Evolution is not a consistent causal progression but a constant struggle to overcome fundamental flaws.

What this hypothetical seeks to demonstrate is that as soon as such a flaw is recognised we can start to consider its influence on the eventual structure of this universe. This discussion is included here at the beginning of our consideration of this cosmology in order to demonstrate what can be achieved by not presuming that our current observations of the universe reveal immutable characteristics of nature, but that we can examine its evolution to reveal not just how but why these attributes arose. This is the proper function of any truly fundamental cosmology.

This cosmology describes an abstract pre-big bang environment, but it is neither invisible nor unfamiliar but instead provides insight into the evolution of those attributes of nature on which quantum mechanics is based. In this way the elements of this cosmology are not only accessible to physics, they are essential for its further development. As for *‘One model fits all’* this is now true, however that model is not the wavefunction but the potentia. The boundary conditions are potentia realised where there is no restriction on potential, while the wavefunction is simply our interpretation of the pre-asserted representation of intermediate potentia that can encapsulate all the potential within these boundary conditions. But the potentia does not only provide a basis for all aspects of quantum mechanics, they also provide an objective basis for the description of time so that it can be brought within the discipline of physics. The property that defines existent states is given in this context[9]. This is more than string theory, even after more than thirty-five years of development, has ever promised. The potentia are the new ‘atoms,’ not merely the components of molecules and matter but of a quantum mechanics that can be demonstrated to provide a direct description of nature.

Quantum mechanics will retain all of it bizarre and statistical nature, but these aspects of it need no longer be considered to be beyond comprehension or visualisation, but natural consequences of the evolution of the universe. While the conceptualisation of nature provided by this cosmology does not represent a return to Newtonian causality, we hope it would satisfy Einstein and Schrödinger’s longing for physics to once again describe the real world. But what is real to science must remain what is experimentally verifiable, as Herbert pointed out, “ *Since ‘reality has consequences’ we might anticipate that if one of these quantum realities is ‘really real,’ we will eventually figure out how to experience it directly* [65].*”* This cosmology is unique in terms of the scope for empirical verification it offers, since no aspect of it remains hidden in either the distant past or inaccessible extra-dimensions. Evolution is a cumulative process so that every aspect of it remains evidenced in the final composition of the universe. All that is needed is a sufficiently fundamental cosmology so that this can be understood and individual associations between current interactions and past evolutionary precedents recognised.

The search for understanding need not be abandoned simply because quantum mechanics works in a seemingly non-intuitive way, nor do we have to expand our model of the physical world to include innumerable parallel universes. We have added nothing to quantum mechanics here except comprehension.

19. Nature’s Attempt to Realise the Intermediate Potentia

There are no simple solutions to complex problems. This is true for defining the origin of the universe and it is true for finding a genuine understanding of quantum mechanics. In the hypothetical above we dealt with several aspects of the relationship between quantum mechanics and nature’s evolutionary history, but there is much left to cover. The universe that we inhabit is an extremely complex place. It is only by looking at its evolutionary history one small piece at a time and considering, with the aid of hindsight, how this might be related to unresolved issues in our understanding of the current universe that we can slowly strip away the complexity and truly understand.

The hypothetical above was established by simply assuming that the intermediate potentia was realised. Now we must return to reality and examine whether nature can in fact achieve this result.

a. The Origin of Two-directional Time

The hypothetical above considered how nature evolved the capacity for there to be multiple alternative outcomes within the same frame of reference, that this is just the re-expression of the over-specification of different potentia, each expressed as a different reference frame by which the limited universe could potentially be defined. But when returning to the real sequence of events we are again confronted with the situation where there is only one potentia intermediate to *a* and *c*. This is so because all potentia are unique as a result of the constraint *Anything but…*, a situation that

[9] We shall consider the relationship between the potentia and elementary particles in Chapter Four.

would have to be reflected in their pre-asserted representation, however the boundary conditions *a* and *c* provide only sufficient constraints to define a single pre-asserted representation. In this way nature has evolved so that it must not only consider the potentia but the bounded environment itself. Much of nature's evolution is about establishing increasingly complex environments where more detailed aspects of nature's potential can be expressed. However, while in general nature's evolution is driven by the need to overcome its flaws, there is no way to predetermine the consequences of the introduction of any specific environment. But at this early stage of nature's evolution what is important is not what will happen, but simply that the environment produces a consequence so that the next step in nature's evolution is not the random realisation of another potential, but the consequence of a specific environment. Every time this is true physics strengthens its influence over nature's evolution, so that the physicist can start modelling what is happening rather than the philosopher simply observing it.

The intermediate potentia if realised will be an existent state and therefore elicit no automatic temporal progression in terms of necessitating the realisation of further potentia, but it does however affect the already realised bounding states in terms of determining their direction of association. In the absence of a bounded environment there was no capacity for this, since when *a* was realised there was no consequence except due to the inadequacy of any specific property to fully define a state of unlimited potential. But since the next potential realised due to this was simply another random guess, no temporal direction could be associated with this process. But when *a* and *c* act as boundary conditions, this establishes a situation where the realised intermediate potentia provides a definition for the limited universe bounded by *a* and *c* and acts like a translation equation between the reference frames of *a* and *c*, e.g. colour and flavour. This establishes the temporal sequence associating *a* and *c*, so that in terms of a non-static definition of the initial state we can associate one boundary with the past definition, the realised potentia with its present definition and the other boundary with its future definition. In the above hypothetical we have only considered the case where the realisation of the intermediate potentia resulted in $a \rightarrow c$. However, this definition of the limited universe, or translation equation, remains essentially the same no matter whether the translation is from *a* to *c* or *c* to *a*. Therefore there are two possible outcomes and therefore two pre-asserted representations for the same potentia that encapsulated the potential – *Realise and intermediate state*. The one which provides a transition from *a* to *c* we have already labelled b_j, so we shall label the one which provides a transition from *c* to *a*, $\neg b_j$, read '*the negation of* b_j.' If b_j is realised this sets *a* as the initial state's past definition and *c* as its future definition. But if $\neg b_j$ is realised then the opposite is true, so that *c* provides the past definition and *a* the future definition of the initial state. There is no pre-determination of which of these results represents going forward and which backwards in time, they simply demonstrate that the initial state boundary conditions can be associated in two possible ways, either $a \rightarrow c$ or $c \rightarrow a$. This is the origin of two-directional time, something not anticipated by nature but discovered.

We saw in the hypothetical above how a superposition of alternative outcomes within a single frame of reference could be established, but in this case each element of the superposition represented a different potentia. What is added by two-directional time is a distinctly different type of superposition, a superposition describing a single potentia whose elements arise because of the introduction of the possibility of two different consequences upon the realisation of the one intermediate potentia. That the realisation of the intermediate potentia has a non-random consequence strengthens physics' influence over nature's evolution. But that it can have two consequences introduces superpositions into the pre-asserted representation of what will be existent states.

b. From Probability to Probability Amplitude

As stated above the sinusoidal representation is just the equation of the curve representing b_j, or in fact the equation of all such curves, and does not imply the unitary evolution of an endpoint along the ac-axis, it simply defines the entire curve as if it were stamped between a and c in a single action, not drawn as if the tip of a pen moved from a to c. It is only the later introduction of space, which associates different amplitudes of the pre-asserted representation of the potentia with different locations intermediate to the boundary conditions, that allows the concept of an endpoint of the curve moving from one boundary to the other. In epoch I, since there is as yet no space, the point by point motion of the two curves, b_j and $\neg b_j$, cannot be used to distinguish them, so that the difference between the consequences of their realisation must be represented in a more abstract way. These are mutually exclusive alternatives since there is only one intermediate potentia that will be realised. We can therefore consider the amplitudes for *'realise ¬b'* to be equivalent to saying *'do not realise b.'* We shall therefore distinguish between the two curves by having the amplitude of b_j take positive values, while the amplitude of $\neg b_j$ takes negative values. However if we must represent $\neg b_j$ by giving its amplitude negative values, this violates Kolmogorov's [229] first axiom, that *"…the probability of an event is a non-negative real number* [230]*."* Therefore to account for there being two directions of time we must follow quantum mechanics' lead and adopt the term probability amplitude curves for the sinusoidal representations of b_j and $\neg b_j$.

c. Adding the Probability Amplitude Curves

It is not simply that there are two ways to associate the boundary conditions *a* and *c*, but that there are only two ways to do this. For the simple limited universe of epoch I over-specification has been reduced to two alternative ways that the event of associating the boundary conditions can occur, both of which will involve the realisation of the intermediate potentia. This both complicates and clarifies the assertion of the intermediate potentia. It complicates it because nature must now resolve the two pre-asserted representation of the same potentia before there can be any assertion. It clarifies it because this introduces a process that physicists can model. But this is not a process involving interactions between existent states, but between the pre-asserted representations of a state that can become existent.

The association of the boundary conditions can happen in two alternative ways, either $a \rightarrow c$ or $c \rightarrow a$, and classical probability theory [231] says that in these circumstances their probabilities should be added. But nature has no knowledge of these rules of statistics; all that it can react to is the nature of time. In epoch I time cannot be counted in seconds or hours but only in terms of distinct events such as the attempt to assert a potentia intermediate to *a* and *c*. Therefore all pre-asserted representations, whether they represent a single potentia or multiple potentia, that satisfy the same boundary conditions must be said to occur at the same time, that is, to be simultaneous. This ensures that the pre-asserted representation of all intermediate potentia will be combined to form a composite wave, but this does not mean that there can be an existent expression that is in some way a blend of $a \rightarrow c$

and $c \rightarrow a$, but that the uncertainty of realising any intermediate state is derived from the combination of all pre-asserted representation within the boundary conditions. It is in this way that all potential intermediate to the boundary conditions is taken into account before realisation, thereby ensuring that the resultant state will be existent. When we add the probability amplitude curves, we are simply modelling this process.

Since both probability amplitude curves have the same shape but with amplitudes of opposite sign, when they are added the result is a curve with zero amplitude everywhere. That the sum of possible outcomes can include their cancellation is the result that most sharply distinguishes quantum mechanics from classical physics, a result that cannot be calculated using algebraic addition but must be represented by the addition of waves that can exhibit interference effects. However epoch I is sufficiently sparse that it can be clearly seen that the cancellation of possible outcomes does not occur because of the nature of a wave with its amplitudes fluctuating from positive and negative values, and different waves having different phases[10]. The two pre-asserted representations, b_j and $\neg b_j$, can be represented by simple half sine wave, one above and one below the *ac*-axis and therefore each with an amplitude taking only one sign. The cancellation of possible outcomes in epoch I is purely a consequence of two-directional time.

Note that in epoch I there is no need to consider the quantum postulate that the probability of realising a specific outcome is determined by the absolute square of the amplitude, since the combined wave has no non-zero amplitudes to consider. The cosmological basis for this quantum postulate will have to wait for further evolutionary developments, which we shall consider in Chapter Three.

d. Failure!

The result of this sum of the probability amplitudes curves is a curve with zero amplitude everywhere, indicating that there can be no realised intermediate potentia to provide a causal association between *a* and *c*, and that therefore the definition of the initial state remains over-specified. While mathematically there is nothing unexpected about this result, conceptually it is quite amazing - nature is not only flawed in having imperfect initial conditions it can fail to achieve a desired outcome!

Given that without the constraint of a first cause there were an unlimited number of potentia, realising an intermediate potentia to provide a causal association between *a* and *c* was a perfectly viable approach to resolving over-specification. It failed because an evolving system devoid of design cannot ensure that all enhancements arising from a more complex environment are beneficial. The nature of time evolves as the environment changes. Setting boundary conditions based on the two realised potentia comprising the over-specification allowed time to evolve to include two possible temporal directions. However this resulted in no intermediate potentia being able to gain existent expression. Nature can potentially be anything, except something that can be even remotely specific. Design is not only absent from the initial state, nature's attempt to introduce it by the assertion of a more specific intermediate potentia failed.

[10] Clearly these factors do become important later, as we shall see in Chapter Two.

20. The Consequences of Failure

While nature has failed physics need not, since the consequences of failure are as determinable as the consequences of success. Nature seeks causal determinacy, but what it must have at all cost is simply some consequence, some capacity for the perpetuation of evolution. It is better for a specific environment to have a definite consequence derived from failure, than for nature's potential to only ever be randomly realised.

The failure to assert an intermediate potentia has demonstrated that *a* and *c* are in fact irreconcilably independent. But the *ac*-event we have just described is only the first of many, as potentia continue to be randomly realised, form the boundaries of new environment where another attempt to associate them is made through the realisation of an intermediate potentia, which inevitably fails. It is as if we are trying to establish a point matrix to define a space, but every time two point locations are specified and an attempt made to establish their relationship in terms of a transition from one to another, it is instead proved that, *"You can't get there from here* [232],*"* and these points are lost to inclusion in a common space.

It is only now that we have seen the consequences of the failure of the attempt to realise an intermediate potentia that we can definitively answer the question: *What is the wavefunction?* The wavefunction is our model of the pre-asserted representation of all the potential between two boundary conditions whose realisation, or failure to be realised, will either demonstrate, or fail to demonstrate, a causal link between these two boundaries.

In quantum mechanics the existence of a set of orthogonal basis vectors is a fundamental postulate [224], that is, we assume it as a reasonable starting point. Nature however could not presume that the realised potentia of the initial state were orthogonal, but instead had to prove it through an event. With hindsight gained from our formulation of quantum mechanics we can see that this is a desirable outcome, nature however could not. It sees only the failure of *a* and *c* to form part of a non-static definition of the initial state.

That there is no first cause means that there is an absolute lack of constraint, but this does not mean that we can simply say: *There is unlimited potential so that anything can exist*. The *ac*-event has proven that there are two aspects to the lack of constraint, it is true that *whatever can happen will*, but two-directional time means that it is equally true that: *For every bounded potential there is an equal but opposite potential which will negate it*. Nature it appears can potentially be anything, except something even remotely specific. If design is desirable, then the evolution of two-directional time represents the introduction of a new flaw. It has demonstrated that in terms of bounded states, the realisation of nature's potential must involve equivalent opposite possibilities that cancel each other out and thereby prevent the realisation of any existent state.

a. The Evolution of the Defined Properties of the Potentia

The potentia *a* and *c* possessed no pre-asserted representations, but the intermediate potentia b_j does. This can be represented as the introduction of a new degree of freedom, graphically represented by the probability amplitude curve. But when the intermediate potentia b_j failed to be asserted, thereby demonstrating the independence of *a* and *c*, this extended the self-definition of the post-asserted states to include the property of orthogonality. What is occurring here is quite remarkable, while no universal resolution of nature's flaws has been found the process of attempting to resolve these flaws has extended the determinable properties of both the pre-asserted and post-asserted states. They have both evolved to become more complex in terms of their number of defined degrees of freedom. We can do physics in the abstract environment of this first evolutionary epoch because nature does not wait for the big bang to extend the range of defined properties a state can possess and therefore that physicists can use to model it.

But the emergence of these new properties is done without resolving the majority of the potentia's definition, since these specific degrees of freedom are only what can be revealed given the simple boundary conditions and events of epoch I. That the potentia initially have no determinable properties but only acquire then as a consequence of specific environments, or the outcome of actual events, is an essential element of the evolutionary process, since it is possible that if all aspects of the definition of the potentia were expressed independent of any process they would be too diverse to coexist in any single schema. However, if only those aspects of the definition of the potentia are made specific that arise from common environments or events, then they may provide a common basis for interactions between individual states.

Fundamental to this cosmology is the concept that we are dealing with the evolution of an unresolved state. However this evolution can still be modelled in terms of physics because the only resolved aspects of the definition of the potentia arise as a consequence of more complex physical environments and actual events, with only these common aspects of definition capable of providing a basis for any interactions between the elements of this cosmology. However this consideration changes how we must approach modelling cosmological evolution, it is no longer adequate simply to take some initial physical components, or finite energetic regions, and model their motion or geometric evolution, instead we must model the evolution of nature in terms that reveal the emergence of new aspects of its definition. The catalyst for this evolution remains the quest to overcome the flaw of there being no first cause, but as the potentia gain more specific properties the quest for causal justification will be able to utilise these to conceive new and more intricate causal schemas. We can therefore consider cosmology in terms of how more complex environments reveal more aspects of the definition of the potentia and more refined schemas for their causal association.

There will always be more aspects of the definition of the potentia than those expressed as physical properties. The properties of the discrete states of this universe do not represent a final definition of all possible degrees of freedom, just an interim one applicable to this particular evolutionary epoch. No matter the detail in which physicists examine the expressed degrees of freedom of the physical system, we will still not have a complete definition of nature's potential. All that we see, all that we can examine, are those aspects of the potentia that evolution to date has made specific. Therefore Leonardo da Vinci's statement that, " *All our knowledge has its origin in our perceptions* [41]," can never lead us to a full comprehension of nature's potential, since no degree of sensory understanding of the physical world can reveal more than that small percentage of the definition of the potentia that circumstance has already realised. This consideration therefore provides a cosmological basis for Shapere's [26] statement that observation can never be freed of theory. Our recommendation is simply that we progress beyond using only the five senses of our perceptions in the pursuit of knowledge, but instead bring all of the attributes of our humanity to bear on the problem of understanding nature, since to do otherwise can never reveal the entirety of nature's potential.

b. Concluding Comments on The Consequences of Failure

The first time a physical environment intrudes into the realisation of nature's potential it prevents it from achieving realisation. Human beings tend to look to the physical environment to provide consequences according to its characteristics, but in this earliest evolutionary epoch this is clearly not the case. If we were to take nothing more from our examination of this sparse and primitive evolutionary epoch we should take this – the physical environment provides constraints on the realisation of nature's potential that in most circumstances result in preventing its realisation. This is the mindset that we must have in order to understand quantum mechanics and in particular nature's establishment in this evolutionary epoch of the *least action principle*[11], which is all that prevents the sum of all potential from still being zero.

21. Have the Events of Epoch I been Successful?

Heisenberg emphasised that, *" We have to remember that what we observe is not nature herself, but nature exposed to our method of questioning* [233]*."* To go beyond this and understand nature on its own terms, we must reveal nature's own questions and methods for resolving them.

Above we have considered the *ac*-events of epoch I and gained some understanding from this. But in terms of cosmology this is no longer enough, since we must also take into account that *what could not be understood before the introduction of the concept that nature could be flawed, is that even if creation occurs it can only form part of the total process, since the assertion must be tested to see if it overcomes the flaw that motivated it.* Because the evolutionary process is purposeful in terms of seeking to overcome flaws, why nature acts is as important an element in determining its evolutionary development as how physical events are resolved. The random realisation of potentia lead to the over-specification of the definition of the initial state, necessitating the establishment of some causal association between realised potentia in order to establish a single, consistent, non-static definition. This was sought through the realisation of the intermediate potentia. But this failed. The question nature must pose and answer is therefore: *Is the outcome of the ac-events acceptable in terms of having overcome the flaw of there being no first cause?* If no such question could be asked then nature would be doomed to forever perpetuate a process that can have no meaningful consequence.

Such a fate is not dissimilar to what must be presumed to occur in the quantum cosmologies. Because they use spontaneous events as a pseudo-first cause they must presume that these events are perpetuated forever. They avoid the conclusion that this results in *a process that can have no meaningful consequence*, by postulating that it establishes an infinite number of inaccessible, parallel universes. We would however contend that this is not a *meaningful consequence* in terms of the development of physics.

[11] We shall return to this subject in Chapter Four.

a. Nature's Process of Learning

When considering whether the *ac*-events have been successful, we must keep in mind that nature has no foreknowledge of whether any specific attempted resolution of a flaw will be successful or not. There is no pre-ordained plan being enacted here, only a process of trial and error. But this is why we can consider even this most primitive evolutionary epoch in the context of physics - nature determines nothing independent of process. What must be considered therefore is if nature possesses any process for learning.

Nature's underlying reality is that without a first cause anything that can happen will. This represents the maximum amount of information in terms of absolute potential. But if any random elements of data can be realised, without the capacity to resolve conflicts or contradictions, there will be so much over-specification that nothing can be known. This is the situation in epoch I where random potentia continue to be realised and the *ac*-events repeatedly fail to reconcile them. The human brain deals with a similar situation by filtering out information so that the subset that remains can make sense. Without such a filtering process over-stimulation results in a crippling autism [234] that stifles any capacity for action. The action nature would take is to reduce the over-specification to a single definition of the initial state. The filtering system that it utilises is constraints of the further realisation of potential.

Originally there were no constraints since there was no first cause, so that anything that could happen did. What happened was the random realisation of the potentia *a*. But because no specific property can fully express all of the potential of an unconstrained initial state, the realisation of further potential was inevitable. But while the realisation of *a* did not directly determine the next potentia to be realised, which essentially was just another guess, it did extend the constraints from: *Anything that can happen will*, to: *Anything but* a *that can happen will*. In this way the current states of the system reflects the consequences of past events.

It was stated earlier that: *At the beginning of all things there is only the potential inherent in the lack of constraint, with no realisation at all. The initial state has no constituents prior to the realisation of some potential in the form of a specific definition of the initial state.* It might therefore be considered that what is known about nature's potential is given only in terms of realised potentia such as *a* and *c*. But this is not true. A pre-asserted representation of the intermediate potentia became possible due to the establishment of *a* and *c* as boundary conditions. A pre-asserted representation of all unexpressed potential is also built up as a consequence of the realisation of potentia such as *a* and *c*, through the constraints these events place on the realisation of future potentia. Because no realised potentia has yet provided an acceptable single definition of the initial state, nature is in fact not principally defined by the realised potentia but by the resultant constraints, which are slowly building up a practical definition of the raw potential itself. It is true that if a realised potentia did express all of the potential of the initial state no further refinement of the constraints would occur, leaving both the raw potential and its expressed definition at a static equilibrium forever. But until this is achieved it is the capacity to realise any outcome that results from the lack of a first cause, as mitigated by the growing constraints introduced by previous realisations, which provides the provisional definition of the initial state. This is a situation similar to a constitutional monarchy, where the absolute authority of the crown is mitigated by the constraints incorporated into a constitution [235]. Nature's constitution consists of its memories of past events, encapsulated as the constraints on the further realisation of nature's potential that are imposed by what has already been realised.

Because of how we are taught in schools, people tend to associate learning with remembering things. We take memory for granted but it is no trivial thing, but dependent on the physiology of the human brain, which as Isaac Asimov pointed out, *" …is the most complicated organisation of matter that we know* [236]*."* But the human brain belongs to the current evolutionary epoch and is far more advanced than anything that existed within the initial state. In doing cosmology we must be careful not to ascribe to nature a greater physiology than it possesses in the evolutionary epoch under consideration. In this first epoch nature possess no physical attributes that would allow it to retain specific memories. The physiology of the initial state is simply that it is as yet undefined. What self-definition it can possess therefore cannot take the form of a list of definite statements, but instead must be conceptualised as a single evolving question. The additional constraints are assimilated as refinements to this question, rather than representing discrete additions to it. That we have written the constraints as *Anything but a, c,…* as if it were a list is just a limitation in our current understanding. We live in a universe that is ultimately derived from the realised potentia and therefore consider only these to be real. This is why we see nature's self-definition as a pure abstraction – it describes what does not yet exist, in the only terms that such things can be described, as a constraint on the future realisation of nature's potential.

Nature does not remember what the outcomes of individual *ac*-events are, except for their cumulative affect on the realisation of the next element of potential. Nature's process of learning is not a matter of adding new information but new constraints.

b. Wigner's Dilemma and the Origin of Mathematics

Physicists observe nature's actions and try to understand them in sufficiently succinct terms that this can be expressed in the form of mathematical equations that allow the prediction of the outcome of similar events in the future. We can understand the *ac*-events, model them and predict the outcome of all future such events. But what we must ask is whether nature can do the same. This consideration goes to the heart of what Wigner referred to as *"…the unreasonable effectiveness of mathematics. Again and again, abstract and beautiful mathematical relationships, explored for their own aesthetic sake, are later discovered to have exact correspondences with the real world – a coincidence that is quite remarkable* [49]*."* There is no mystery here, no coincidence, nature is a mathematician. Mathematics originates as an aspect of nature because it cannot remember individual events, but must nonetheless reflect the consequences of past events in its future development. Nature's self-definition must reflect the effects of past events in a non-specific way. It is this generalisation that gives rise to what we would recognise as mathematical expressions. This results in the constraints that form nature's self-definition taking the form of an equation.

When Sir James Jeans stated that, *" From the evidence of his creation, the Great Architect of the Universe now begins to appear as a pure mathematician* [237]*,"* it was because he noted that all of our understanding of nature ultimately takes the form of mathematics, but we would assert that this statement is true not because of the way we act, but because of the way nature acts, and that our successful use of mathematics merely reflects our empathy with nature. Ultimately physicists must use mathematics because nature itself does so.

The answer to Wigner's dilemma is that humanity is part of nature to such a degree that not even the abstractions of our imagination make us separate from it. On the contrary, when we see in our mind's eye reality stripped of all structure we see nature in its purest form and in so doing see the mathematical expressions by which nature describes itself. In its arrogance humanity considers mathematics as evidence of higher intelligence, the unique invention of the human mind; it is not, mathematics is a necessitated element of the evolution of the universe.

c. From Learning to Prediction

We mentioned earlier Heisenberg's observation that, " *Many of the abstractions that are characteristic of modern theoretical physics are to be found discussed in the philosophy of past centuries. At that time these abstractions could be disregarded as mere mental exercises by those scientists whose only concern was with reality, but today we are compelled by the refinements of experimental art to consider them seriously* [8]*,"* and that Wang, Zou and Mandel [11] in summarising their delayed-choice experiment concluded that, *"…the state not only reflects what is known about the photon* (from an actual measurement) *but to some extent also what is knowable, in principle, under the given circumstances, whether it is actually known or not* [11]*."* This is the new physical reality that *refinements of experimental art* force us to consider and seek to interpret. This represents as confronting an experimental result as when classical physics failed to accurately predict the results of experiments involving black body radiation and heated metal rods. In pursuit of an interpretation we must therefore show the same desperation as Planck, " *By nature I am peacefully inclined and reject all doubtful adventures. But a theoretical interpretation had to be found at all costs, no matter how high …I was ready to sacrifice every one of my previous convictions about physical laws* [65]*."* We must learn how to incorporate into our model of physics not only what nature does but what it knows. This is not a new concept, since as August Stern observed, " *During the last fifty years, information concepts have been steadily penetrating physics theory, gradually but persistently shifting the interest of physicists towards the investigation of the information properties of matter* [238]*."* But this can not be successful as a piecemeal process applied to one field, such as the information interpretation of entropy [239], but totally ignored in others. The only way to achieve a broad framework for the incorporation of these concepts into all of physics is for their basis to be established in a cosmological model and thereby into our overall conceptualisation of nature.

Quantum cosmology must have its founding spontaneous events occur eternally, since there are potentially an infinite number of such events possible. In the cosmology of this consideration there is in fact only one spontaneous event: *If anything is possible then a*, everything else is a reaction necessitated by the inadequacy of *a* to express all of nature's potential, moderated by the constraints algorithm. There is however still an infinite number of times new potentia can be randomly realised and new *ac*-events instigated. But where there can be no alteration to the spontaneous events in quantum cosmology, the algorithm that moderates the series of events in this cosmology is constantly changing. As the memory of the *ac*-events is generalised and assimilated into the constraints algorithm what becomes determinable is that no record need be kept of the exact nature of the bounding states, in terms of the different properties they express, since this has no affect on the pre-asserted representation of the intermediate potentia and therefore on the outcome. If nature possessed the physiology for a memory capable of simply keeping a list of past events, it would distinguish the first *ac*-event from a future *jl*-event based on their unique bounding states. But because nature must generalise its memory, eventually the algorithm refines to the point where these two events are indistinguishable, since the differences between the bounding states does not change the outcome of the events. In this way the algorithm is refined to take on the character of the Axiom of Induction [240], which can be considered as a domino principle whereby if the first domino falls, and if whenever one domino falls, the next domino is certain to fall, then all the dominoes in the set will fall. At this point the algorithm becomes capable of predicting the results of *ac*-type events whether they actually occur or not. No matter how many times *ac*-type events are repeated the outcome will always be the same, never resulting in the association of the bounding states by the realisation of an intermediate potentia and thereby the resolution of over-specification. Physicists use mathematics so that they need not observe every instance of a type of event in order to predict outcomes. However nature goes one step further; if prediction is possible the physical process itself is no longer necessary. This is what we see in the experiments of Wang, Zou and Mandel [11], *what is knowable, in principle,* affects physical outcomes, *whether it is actually known or not*, that is, whether the physical measurement event by which we could consider this knowledge to be gained actually occurs or not. In terms of nature's evolution, when it is knowable that a physical process will not lead to a resolution of over-specification there is no longer any motivation to drive the continuation of that process. No one says to stop it is just that the constraint now reads: *Anything but what will lead to an ac-type event*. Everything suddenly stops!

Nature's self-definition is not a static, descriptive statement but takes the form of an ever-refining question. The question relates to how to overcome a specific flaw. One sequence of events can terminate, not because the underlying motivation has changed, but because the question has refined to the point where it provides guidance towards a new approach to providing an answer. In the next chapter we shall examine how the refinements of the constraints algorithm that causes the *ac*-type events to stop establishes a new approach to resolving nature's flaws and thereby the second evolutionary epoch.

d. Reconceptualizing Mathematics to be More in Keeping with How Nature Experiences It

Dirac said of his formulation of quantum mechanics, *" We have made a number of assumptions about the way in which states and dynamical variables are to be represented mathematically in the theory. These assumptions are not, by themselves, laws of nature, but become laws of nature when we make some further assumptions that provide a physical interpretation of the theory. Such further assumptions must take the form of establishing connexions between the results of observations, on one hand, and the equations of the mathematical formalism on the other* [224]*."* But this establishes no connection between nature and mathematics independent of human observation and therefore could never resolve Wigner's quandary regarding *"…the unreasonable effectiveness of mathematics* [49]*."* Nature operates on a mathematical basis not to satisfy our needs but its own. The connection between our mathematics and nature must be established on a firmer basis than simply assumptions forming connections between mathematical expressions and the results of observations, we must strive to conceive a mathematics that takes into account not just how nature acts but why nature acts as it does. Without this our mathematics will skip the crucial step of evaluating if the outcomes of an event has been successful in overcomes the flaw the event was to address. This is essential since, as has been seen above, *nature is not only flawed in having imperfect initial conditions it can fail to achieve a desired outcome!* But nature, like the rest of us, must deal with the consequence of failure and strive to go on nonetheless. A mathematics that does not reflect this struggle will ultimately fail to accurately describe nature. However since nothing in Euclid's *Elements* [241] conceived of such possibilities, it falls to this generation to re-conceptualise mathematics in conformity with how nature experiences it, *thereby giving an understanding of the mathematics of physics distinct from that of pure mathematics.*

There is an old joke about accountants: *If you ask most people what 2 + 3 equals they will say 5, but if you ask an accountant the response will be: What do you want it to equal?* Nature does mathematics, like accountants, with a predetermined goal, in nature's case the need to overcome the flaw of having no first cause. There are therefore correct answers and incorrect answers, with each outcome producing different consequences. This is quite different to how we currently conceptualise both mathematics and nature. We are used to doing mathematics by considering that the term on the left hand side of an equation, e.g. 2 + 3, causally determines the answer on the right, e.g. 5. But this represents a past causal progression, which quantum mechanics has shown is not how nature actually works. It is also presumed that whatever answer is produced by the expression on the left hand side of the equation must be correct, but this also presumes that we are dealing both with a causally deterministic sequence and one that has no goal and so must simply accept whatever outcome circumstances provide. But this is Newton's *clockwork universe* [242], which has long since faded from our physics. Today we are in the *information age* [243], a place nature has always occupied.

But we must be clear that what we are talking about here is more than how to model a particular physical situation. Variant mathematical formulations, for example quantum mechanics itself or the less broadly used spinor calculus [112], have been introduced into physics to model specific physical situations without being considered to re-conceptualise mathematics. But here we are not dealing with specific physical situations but fundamentally how nature evolves and therefore how causality and time act. We must strive to incorporate such fundamental aspects of nature not merely into applied mathematics but into the founding axioms, if not of pure mathematics, of the mathematics of physics. It is by deriving the axioms of mathematics from a cosmological model that we can ultimately make comprehensible the relationship between physics and mathematics. Whole fields of mathematics are currently based on varying Euclid's postulates [241], with the first such systems developed independently between 1824 and 1832 by Gauss [244] as well as Bolyai and Lobachevski [245]. In modern times Benoit Mandelbrot [246] has re-conceptualised geometry to be more in keeping with the true fractal attributes of nature. What we are suggesting is simply the logical extension of these endeavours, a suggestion that is not without precedent. The concept of a set theory based on physical characteristics rather than simply mathematical norms was suggested as long ago as 1936 by Birkhoff and von Newman in the context of quantum logic [67]. This approach has continued to be explored by more recent authors such as Karl-Georg Schlesinger, " *…if one is prepared to accept that even* *the abstract object notation of set theory might just be distilled from our experience of physical objects (as von Neumann believed), we have to ask which object notation (and which set theory) the fundamental theories of physics really determines* [247].*"* While not going as far as Tegmark who proposes that, *" Physical existence is equivalent to mathematical existence* [248],*"* we suggest that successful mathematical theories are based on sound, if subconscious, intuitions of the underlying physical system. A more conscious recognition that the objects of the mathematics have a physical basis strengthens the links between the mathematics and the physics and will allow a more intuitive mathematical formalism.

As stated earlier, the development of this or any other truly fundamental cosmology will necessitate the re-conceptualisation of mathematics to be more in keeping with how nature actually works. Nature's generalised self-definition is an algorithm both in our representation and to nature itself. Many physicists long to find a *Theory of Everything* (or TOE, an acronym introduced by John Ellis [249]), but this is after all just an all encompassing equation that describes the complete workings of nature. All that we are suggesting here is that such an equation is not merely a human descriptive tool but reflects the form of nature's self-definition and that this definition is not eternally static, but evolves as the physical system evolves. This concept can be seen as providing a cosmological basis for the proposal of *digital physics*, pioneered by Konrad Zuse [250] and supported by Edward Fredkin [251] and Nobel laureate Gerard 't Hooft [252], that, *" …there exists a program for a universal computer which computes the dynamic evolution of our world* [253].*"* The *strong Church-Turing thesis* [254] takes this even further stating that, *" The universe is equivalent to a Turing machine* [255],*"* which is a basic symbol-manipulating device [256] that is simpler than but similar to a computer. This cosmology does not go this far, since it does not state that nature is a gigantic computer only that a specific aspect of it can be equated to a computer program in order to make it more familiar and easier to model.

But why should we believe that nature possess an evolving generalised memory that ensures that the consequences of past events are reflected in current existent states? Because each an every one of us carries it with us, it is called the genetic code [257]. In this cosmology we would see this simply as the physical manifestation at the level of discrete states, of a precedent established on a universal scale within the initial state.

e. The Further Evolution of Memory and Quantum Measurement

John Wheeler said that, *"…I cannot believe that nature has 'built in', as if by a corps of Swiss watchmakers, any machinery, equation or mathematical formalism which rigidly relates physical events separated in time. Rather I believe that these events go together in a higgledy-piggledy fashion and that what seems to be precise equations emerge in every case in a statistical way from the physics of large numbers; quantum theory in particular seems to work like this* [258].*"* A quantum theory developed independently of cosmology may well appear to work like this, however in the above discussion of the resolution of superpositions upon quantum measurement it was stated that *one outcome is realised when a measurement is done and another when an indistinguishable system is measured at some future time,* so that *no final solution can be considered to have been reached before enough time has passed to allow sufficient repetitions of indistinguishable events, so that all possible outcomes can be realised*. Nature has no foreknowledge of when or how many times an equivalent circumstance might be repeated, but it is compelled by these constraints to be able to distinguish each uniquely defined event and to retain this at least until all possible outcomes are realised. In epoch I there was only one type of event and one element of memory, however as nature evolves each retained description of a unique set of boundary conditions will establish one instance of its memory. For this reason nature does not experience the timeline as a continuous flow with each second connected to the last, instead what are connected are indistinguishable events by their reference to the same element of memory. These indistinguishable events may occur in a disjoint manner along the timeline, perhaps separated by millions of years. Nor need they be directly causally associated, they need only be related by having indistinguishable physical characteristics to be inherently linked in nature's experience as components of the same event, which must be repeated until it gives expression to all possible outcomes.

Wheeler is correct in concluding that quantum mechanics undermines the concept of a strict causal timeline maintaining an association between two events separated in time. However quantum theory when considered in conjunction with this cosmology, demonstrates that an association between indistinguishable events is necessitated by the way nature resolves superpositions upon measurement. This is not maintained by a smooth sequence of causes linking two temporally separated events, but by their reference to a single element of memory, which plays a role in the ensemble average distribution of outcomes. This is not to imply that this element of memory keeps a strict account of which outcomes have been realised and which must still be realised, but simply that the form of this element of memory must include the constraint that all possible outcomes must find realisation at some stage.

That we must consider expanding our model of physics to include the concept of memory is a far less taxing cost of resolving the quantum measurement problem, than Everett's [201, 202] insistence that every measurement results in the spontaneous generation of alternative parallel universes. All that we are saying is that nature functions through determinable mechanisms and that the concept of memory is an adequate initial description of the mechanism underlying the realisation of different elements of the same superposition using temporally and causally disjoint indistinguishable events. Further consideration of this concept way give an intuitive theoretic basis for G. I. Taylor's [65] experimental results that an Airy ring interference pattern will slowly accumulate on a photographic plate, when a disjoint stream of single electrons pass through a tiny hole. More generally, the concept of memory may provides a link between the quantum formalism and the information interpretation of entropy [239], thereby allowing a greater degree of integration between quantum theory and thermodynamics [259].

This issue is of broader relevance than may at first be apparent. René Descartes [260] believed that by establishing axioms based on indisputable truths he could proceed logically to deduce all the laws of nature [261]. This approach was brought to fruition by Newton's *Principia* [29]. Bertrand Russell [262] and Alfred North Whitehead [263] supported the supremacy of axiomatic logic [264], but not without detractors [265], the most potent of whom was Gregory Chaitin [266] who showed that all such systems contain inherent uncertainties [267]. More recently Pete Gunter pointed out that analysis has its limitations, " *The great achievement of Sir Isaac Newton for a time supported the idea that a final triumph of analysis had been reached. Subsequent discoveries (the divide between relativity and quantum physics, the independent status of thermodynamics) have cast doubt on the ultimate success of analysis* [268]," forcing Gunter to conclude that, " *If analysis is not the final word* *in science, including mathematics, then its hegemony over philosophy is over* [268].*"* Without the reunification through a single cosmological model of science's three most successful theories, there can be no basis for a single system of axiomatic analysis.

f. Concluding Comments on Have the Events of Epoch I been Successful?

The refinement of nature's self-definition algorithm to the point where it can be predictive has allowed an answer to be given to the question: *Have the events of epoch I been successful?* The answer is clearly: *No*. Because the pre-asserted representation of the intermediate potentia, and therefore the result of their addition, are the same no matter the specific potentia that form the boundary conditions, no matter how many times such events are repeated no resolution of over-specification by the establishment of a single non-static definition of the initial states will result. Neither the random realisation of a single potentia, nor the presence of two potentia as a means of prompting the retrospective establishment of a causal association between them has been successful. The future has failed. Nature must move on to an entirely new approach to overcoming the flaw of there being no first cause[12].

22. Consciousness and Cosmology

What we have suggested above is simply that the exploration of the concept of nature possessing an evolving self-definition is more in keeping with the physical evidence than quantum cosmology's introduction of an infinite number of parallel universes. It is better science to try and determine how a spontaneous sequence of events might terminate, than to impose on physics an infinite number of inaccessible, parallel universes, because it is simply presumed that the spontaneous event postulated to have established our universe will continue to establish an infinite number of others. To further develop a many universes cosmology teaches us nothing about the human condition, but to further pursue an understanding of the evolution of nature's self-definition, may conceivably lead to insights into how human consciousness could arise from the natural system.

If we as physicists are compelled by the scientific method to ensure that our models account for all available empirical data, we can not exclude from this either the fact of or the nature of our own existence. As Penrose emphasised, *" A scientific world-view which does not profoundly come to terms with the problem of conscious mind can have no serious pretensions of completeness. Consciousness is part of our universe, so a physical theory which makes no proper place for it falls fundamentally short of providing a genuine description of the world* [269].*"* Cosmology, more than any other discipline, must take note of this advice. It can no more have nothing to say about the nature of consciousness than to have nothing to say about the big bang. Cosmology must provide a framework within which all evidenced aspects of the universe can be placed. But before we start to explore these issues in more detail, it is prudent to pause and review how such matters are already being addressed by the physics community.

[12] This is the subject of the next chapter.

a. A Brief Review of Consciousness Research in Physics

As we saw when considering the nature of quantum measurement, *the conclusion drawn by von Neumann* [270] *that the observer in an experiment need not be the physical apparatus but that the point of observation could be the human brain, was taken further by London and Bauer* [194] *to form the statement that it is human consciousness that completes quantum measurement and that is therefore ultimately responsible for the collapse of the wavefunction* [195]**.** New theories are now emerging in which it is the collapse of the wavefunction that plays a vital role in the physiology of consciousness, with Henry Stapp [271] suggesting that, *"…quantum uncertainties at the synaptic level can have effects large enough to generate superpositions of macroscopic patterns of brain activity at the level of neural assemblies. The neural correlate of conscious events is assumed to be the collapse of such a superposition into an actualized (activated) neural assembly* [272]*."* Penrose and Hameroff [273] go even further, proposing a specific location for the interface between quantum phenomena and human biology, *"…it is to the microtubules in the cytoskeleton* (the interior of a single neuron)*, rather than neurons, that we must look for the place where collective (coherent) quantum effects are most likely to be found…* [269]*."* In Penrose's model, *"…(gravitation-induced) collapse of such coherent tubulin states corresponds to elementary acts of consciousness* [272]*."* This however places the physiology of consciousness at a biological level below that of the neural network itself, which currently provides our principal model of brain activity [274]. Even though Beck and Eccles [275, 276] were able to apply quantum concepts to the activity of the neural network itself, specifically to information transfer at the synaptic cleft, the development of this research is still at a stage where, *" Although there can be no reasonable doubt that quantum events happen in the brain as elsewhere in the material world, it is the subject of controversy whether these events are in any way* efficacious *and* relevant *for those aspects of brain activity correlated with mental activity* [272]*."* While the approaches of Stapp, Penrose and Hameroff , as well as Beck and Eccles utilise quantum concepts such as superpositions and wavefunction collapse, and Stapp goes so far as to state that, *"…conscious intentions of a human being can influence the activities of his brain* [271]*,"* these are basically phenomenological models that do not greatly distinguish between the mind and the brain, but instead extend the functional description of brain activity to a quantum level.

Other models, notably those of Pauli and Jung [277-279] as well as those of Bohn and Hiley [280-282], take as their basis a conceptualisation of nature whereby it is composed of both matter and information, which can be associated respectively with the brain and the mind. This use of the concept of information in quantum physics was pioneered by von Weizsäcker [283] and Wheeler [284], with more recent contributions by Brukner and Zeilinger [285], Fuchs [286] and Clifton *et al* [287].

But if quantum mechanical processes are a fundamental component of consciousness and these processes are evident in all matter, some physicists extrapolate that consciousness at some level may be an intrinsic property of all matter in keeping with the philosophy of *Panpsychism* [288]. Feynman was even willing to entertain the concept of, *" Atoms with consciousness…*[289]*,"* a concept which Bass [290] was able to develop into a quantum model for the mind-brain interface. If all matter has consciousness then human beings would not exclusively possess it but would have a higher level of consciousness simply because they represent a more sophisticated organisation of matter.

The capacity for physics to address the issue of consciousness, which is not dissimilar from physics providing the phenomenological basis for chemistry, is emerging as the next great frontier in science, a subject of such broad interest that it has been popularised in many books [291-293]. But this is a subject that must be addressed both cautiously and fundamentally. Cosmology traces an evolution that unquestionably results in the existence of conscious beings and therefore it is compelled to explore not just how this consciousness arose, but what role it plays in the evolutionary process. As far as is possible we shall do this in this consideration.

b. The Flawed Nature Cosmology's Contribution to Consciousness Research in Physics

Let us state clearly that nothing revealed so far in this cosmology could be considered to constitute consciousness. Instead what we were considering above was the relationship between mathematics and nature, concluding that: *Mathematics originates as an aspect of nature because nature can not remember individual events, but must nonetheless reflect the consequences of past events in the definition of its current structure. Therefore the description given to the current state must reflect the effects of past events in a non-specific way, not a memory that this particular event occurred, but that the current state is a consequence of events of this nature. It is this generalisation that gives rise to what we would recognise as mathematical expressions.* If the seeds of consciousness are to be found here it is because this self-definition algorithm evolves and is not a passive definition but instead encapsulates the constraints on the further realisation of nature's potential and thereby influences future outcomes. But while we have considered above the evolution of the algorithm to the point where it becomes predictive, this is still far from the point where it could allow choice and thereby be considered to possess even a rudimentary sentience. This is a seed that would have to grow substantially to constitute consciousness.

Then how can the concept that nature possesses an evolving self-definition be applied to the debate regarding the physical basis for consciousness? Eddington pointed out that, "*…consciousness as a whole is greater than those quasi-metrical aspects of it which are abstracted to compose the physical brain* [294]." In terms of this cosmology we can consider the brain to refer to the existent, material aspects of nature, while the mind refers to the abstract self-definition algorithm. These two things are linked by nature's need to overcome flaws. Therefore the interaction between nature's 'mind' and 'brain,' although there is no capacity as yet for any true thought process, is purposeful and therefore not randomly directed. We can evidence the influence of nature's mind in terms of alterations in how the physical system attempts to overcome nature's flaws. Given these considerations some quite fundamental questions about the nature of consciousness and the relationship between the mind and brain can still be addressed by reference to this first evolutionary epoch.

Gilbert Ryle was critical of the concept that there was a mind separate from the brain calling it, "*…the ghost in the machine…*[295]." However as Wilder Penfield, a neurosurgeon and mind researcher, pointed out, " *To suppose that consciousness or the mind has location* (in the brain) *is a failure to understand neurophysiology* [296]." Therefore we must still ask: *Where is nature's self-definition algorithm* *located and how does it affect the material world?* Answering this question is equivalent to defining the mind brain interface on a universal scale when this has yet to be done on a human one. But let us nonetheless examine what this cosmology has to say about the location of the self-definition algorithm, which we have associated with mind and consciousness. What this cosmology suggests is that consciousness is not about what is, either is terms of the current physicality of a system or current events, it is about what can be retained in consequence of the events involving these structures, and how that retained memory can evolve and affect future physical outcomes. While many researchers have considered the role of the collapse of the wavefunction in providing an interface between the mind and the brain, we believe that this cosmology can give a firmer basis for these considerations. It is the realisation of the intermediate potentia, which quantum mechanics models as the measurement process, that introduces the present instant as the domain of existent states and thereby physical interactions. The brain, since it is a physical structure, can only be located in the present instant. But there is more to time than now. Primas [297-299] suggested that, *"…the distinction of mental and material domains originates from the distinction between two different modes of time: tensed (mental) time, including nowness, on the one hand, and tensless (physical) time, viewed as an external parameter, on the other* [272]*."* In Primas' model, *" Nowness and the directedness of time originate in the mental domain…*[272]*."* However we are considering an evolutionary epoch that predates the existence of any mental processes that could be used to classify distinct temporal domains. Instead we have shown above that the abstraction of the past and future as mental processes, whether due to Primas or Saint Augustine, is unnecessary since this cosmology gives them an objective reality in terms of the different temporal properties of the intermediate and bounding potentia. The realised intermediate potentia, because it can express all the potential within the bounded environment, does not elicit any automatic temporal response and is therefore isolated as an existent state within an instantaneous present. The bounding states which cannot express all the potential of an initial state devoid of a first cause cannot be existent but are causally associated by the realisation of the intermediate potentia, thereby becoming established as the past and future of this limited universe. In this way *the past, present and future are not merely impressions left on the human mind, but real elements of the realisation of nature's potential*. The disassociation of mind and brain is not a matter of distinguishing between the material and the abstract, or even spiritual, it is a matter of distinguishing between regions of time – the mind has a different temporal location to physical structures that are restricted to the present instant. It is simply a human prejudice that states that the present instant is the only real constituent of time, while recognising that there must be an immensely larger eternity stretching before and after it. In this cosmology the *nowness* of humanity's *mental time* is firmly set in the same present instant as the realised existent states, Primas' *physical time*. It is essential that the brain, and therefore humanity's perception of the world, and the realised existent states occupy the same temporal domain otherwise there would be little for us to perceive. The mind on the other hand in this cosmology is associated with the constraints algorithm that influences the further realisation of nature's potential and therefore must have a location that precedes realisation and therefore the present instant. It encapsulates the constraints on the further realisation of nature's potential and as such describes the bottom turtle in the tower and therefore is perpetually at $t = 0$. It might be considered that because it undergoes a process of learning it experiences progressive time and therefore must exist beyond $t = 0$, but this is not the case since the algorithm is not added to but refined, thereby making the learning process one of assimilation rather than progression. Once the algorithm has changed it is as if it has always been that way.

The consequences of the mind being located at $t = 0$ while the brain is located in the present instant are quite remarkable, since it implies that the mind can influence a being's entire history of experience, while the brain only affects their current actions. We cannot change past physical events, but the evolution of the mind must inevitably change our perception of them, in ways that are far more fundamental than the simple alteration of our memory of these events, instead what can changes is how these events have affected our development up to the present. The physical past is not different but we are, exactly as if the past had actually changed. This will lead to the divergence of shared memories as each individual's past changes as their mind evolves to assimilate constraints added by the outcomes of new events in their lives. It is as if the shared memory is like a commonly observed measurement, a quantum wavepacket peak that quickly starts to spread as the individual components of it continues to evolve in accordance with their own unique frequencies, or in the case of human beings their own unique experiences. The location and evolution of the mind makes the past in a very real sense non-immutable. This may seem a confronting concept but it is one that has already been explored by Fred Wolf [300] who takes the view that, *"…the past is not fixed, that there is no absolute past* [301]*,"* although his basis for this is different from that given here, *" I'm talking about that interpretation is equivalent to creation – that there really is no fixed, solid past, and that when you go back and look at the past, what you're doing is making an interpretation which will best rationalize the present position you're now holding* [301]*."* By contrast what we are saying is that the non-immutability of the past is a natural process that occurs as a consequence of the evolution of the mind, independent of a conscious reinterpretation of past events.

Nature's self-definition algorithm encapsulates the constraints on the realisation of nature's potential and affects the material world through its influence over the measurement process. This cosmology would therefore seem to give support to Penrose and those other physicists who propose that the collapse of the wavefunction plays a fundamental role in the mind-brain interface and the emergence of consciousness. However what we are saying here goes beyond what has previously been suggested. This cosmology suggests that it is not simply wavefunction collapse itself, but the evolution of the process of collapse that reveals the effects of the constraints algorithm. However we would note that the number of times this has occurred in all of evolution is very small. If nature itself has a consciousness that can evolve from its self-definition algorithm it is very slow to act and then only produces outcomes that can be considered to be derived from the determinable refinement of the algorithm. Nothing is happening here that cannot be understood in terms of simple evolutionary processes. It would only be the rejection of an outcome produced by a natural process that would distinguish an event as being the consequence of an emerging sentience. No such event is evident in this first evolutionary epoch.

When asked about his conception of God Davies responded, *" The closest analogy that I can get to the sort of timeless, abstract being – maybe it's more than an analogy – is mathematics. If you ask the question, 'Where is the number eleven?' well, it isn't anywhere. It's not in space, it's not in time. Or consider the statement: eleven is a prime number. This is a true statement whether there is a universe here or not. Mathematical objects and statements reside in an abstract, timeless realm that* *transcends the physical universe, yet they apply to the physical universe, too* [302].*"* As we have seen, the self-definition algorithm does not exist outside of time just beyond the present instant of time that is so important to humanity and the physical world. It resides in a *timeless realm* in that it undergoes assimilative refinement rather than progressive addition. However in this cosmology we have no need to utilise mathematics as an abstraction capable of being external to the universe and time, to act as a pseudo-god. This cosmology requires no external observer to stand beyond the universe to provide either the boundary conditions for or the measurement of the initial state wavefunction.

As for the questions: *What is the substance of nature's consciousness?* One approach to this problem, which allows the retention of a somewhat familiar environment, is the concept that nature can be modelled in terms of a universal abstract computer. This approach has been researched by Jürgen Schmidhuber [303, 304], with the computer possessing an ensemble of all programs governing nature's operation, using the *self sampling assumption* [305]. This cosmology however goes further in that it does not presuppose an ensemble of possible programs, but instead deals with the inception and evolution of a single program. As for the substance of the computer, we have answered only that it is an evolving self-definition algorithm encapsulating the constraints on the further realisation of nature's potential. In short the substance of nature's consciousness is mathematics. Is this a wholly satisfactory answer? No, but it is probably as much as we could currently comprehend.

However we note that since nature's self-definition is fundamentally a generalised memory it might seem tempting in formally representing it to utilise the work of Ricciardi and Umezawa [306] who suggest that brain states, and in particular memory states, can be model as inequivalent representations of vacuum states of quantum fields. We could associate the location of such vacuum states with $t = 0$ in this cosmology since, *"…the lifetime of vacuum states is in principle infinite, implying that their memory content can never be forgotten* [272].*"* The sum of such vacuum states would act within the cosmology as a generalised pre-asserted representation of all as yet unasserted and unbounded potentia, in a similar way to the wavefunction's pre-asserted representation of a specific potentia such as b_j which arises from boundary conditions, where both types of pre-asserted representations encapsulate constraints on future assertion. In this manner the representation of nature's self-definition is only more abstract than the wavefunction representation of discrete states, in that it applies to all non-asserted potentia and is not dependent on specific boundary conditions. However, while Ricciardi and Umezawa's proposal has undergone considerable scrutiny and refinement [307-309], particularly in terms of an analysis of the stability of such vacuum states and the role of external stimuli [310], the problem of overprinting them with additional information has not yet been solved [272]. Therefore at this point we simply note the possible application of these concepts to the formal development of this cosmology using quantum field theory. But for the purpose of this preliminary consideration we shall continue to treat nature's generalised self-definition simply as an abstract mathematical algorithm.

However this purely mathematical representation does not limit our understanding, but can be used to increase it. If the mind at the most fundamental level is a mathematical system, then we can understand humanity's amazing capacity to conceive and develop mathematical concepts. These concepts are not unreasonably effective in describing nature, as Wigner suggested, since they simply reflect the structure of nature's own self-definition algorithm and the fact that our own creative minds must have evolved from this precedent. Far from losing anything by this abstraction of the fundamental nature of the mind, it is worth noting that our current comprehension of mathematical systems far outstrips out understanding of neural ones. The operations of this abstract mind can be modelled in as strict a mathematical sense as any other aspect of nature dealt with by physics, because it is just a mathematical system. What must be understood though in applying these concepts is that we are modelling the evolution of the mathematical system itself rather than its application. The mind is evident at those points when nature's self-definition algorithm, after undergoing long periods of incremental change, makes a phase transition to a new capability such as the capacity to predict the outcome of the next event in a series whether it actually occurs or not.

c. Concluding Comments on Consciousness and Cosmology

On the scale of nature as a whole this cosmology allows us to understand a great deal about the relationship between the mind and the brain. Each occupies a different temporal location. The mind affects the brain through the evolution of the process by which potential states become existent. They are linked by the motivation to overcome nature's flaws. The actions of the mind can therefore be evidenced when there are alterations to the overall approach taken to addressing these flaws. The mind establishes this overall approach, which is evidenced by the establishment of a new evolutionary epoch, while the brain applies and refines it. The brain therefore acts as we expect, providing reasoned and incremental refinements guided by and acting upon the physical environment. The mind in contrast provides discontinuous instances of inspiration that instigate totally new approaches to solving a problem.

How is this related to the human experience of consciousness? We will need to examine nature's further evolution to determine this. But what this cosmology suggests is that we can trace the evolution of the seeds of consciousness all the way back to the first evolutionary epoch, to a time that long predates the emergence of higher biological organisms. This is a much simpler environment in which to grapple with long outstanding issues regarding the fundamental nature of consciousness and the roles of the mind and the brain. For this reason we believe that cosmology may have much to contribute to this research.

In conclusion it is worth noting the opinion of Ilya Prigogine, winner of the Nobel Prize for Chemistry in 1977, who stated that, *"…if I was a young researcher now, I would study the mind-body problem. This is the great challenge of the 21st centaury* [311]*."*

23. Concluding Comments on Chapter Two

Weinberg pondered that, *" Maybe nature is fundamentally ugly, chaotic and complicated. But if it's like that, then I want out* [5]*."* The initial state is indeed chaotic; if not complicated at least hopelessly over-specified, and ugly if for beauty we require success and neat causality. Nature is not perfect, but in this we do not see a reason to quit the study of science, but an opportunity to allow that study to teach us more than how to track the motion of inanimate objects, but instead through coming to understand nature's struggle for life to give meaning to our own.

The lesson of epoch I is extremely harsh, that even given unlimited potential there can be no realisation of a specific existent state. But there are still states such as *a* and *c* which, because they are not bounded, are not subject to temporal negation. What if anything can be done with these?

Chapter Three:

The Origin of the Present

“ *Please, Sir, can I have some more* [312].”

24. Introduction

The realisation of any random potential independent of causal justification resulted in multiple, potentially incompatible definitions of the initial state. This event demonstrated that the lack of a first cause is a flaw that leads to over-specification. For there to be a definition of the initial state without anomaly causal justification is required. The new environment consisting of the first two realised potentia provided boundary conditions that allowed a complex pre-asserted representation of an intermediate potentia. This determined the method for providing causal association between the bounding states – if an intermediate potentia could be realised then all three definitions of the initial state, instead of being independent, could form parts of a single non-static definition that could realise all of nature's potential without the catastrophe of introducing contradictory definitions. It was a valid approach but it nonetheless failed, since *an evolving system devoid of design cannot ensure that all enhancements arising from a more complex environment are beneficial*. This enhancement was two-directional time introduced by the boundary conditions that defined the intermediate potentia. This is a flaw because a pre-asserted representation composed of two equal but temporally oppositely directed probability amplitude curves could result in no existent expression at all. *The cost of having a more complex pre-asserted representation of the potentia is that they can no longer be asserted at all.* This attempt to resolve over-specification failed.

But nonetheless this whole sequence of events continued to be repeated - the assertion of new potentia independent of any causal justification established new boundary conditions, which defined new intermediate potentia that if successfully asserted could provide a causal link, but because this bounded environment introduced two-directional time every attempt to realise the intermediate potentia failed. However as these events repeatedly occurred, nature incorporated them into its self-definition, but not as a sequence of remembered events, but rather as a generalised form that we can associate with an evolving mathematical algorithm. The individual sets of events never changed, no intermediate potentia was ever successfully asserted, what changed was nature's self-definition algorithm, its only memory of these events. Its generalised nature allowed the algorithm to be self-refining until it took on more of the character of the Axiom of Induction, becoming predictive. It was no longer necessary for more of these physical events to occur for their outcome to be known.

The assertion of any potential independent of causal justification can be considered as an act of creation. *But what could not be understood before the introduction of the concept that nature could be flawed, is that even if creation occurs it can only form part of the total process, since the assertion must be tested to see if it overcomes the flaw that motivated it…*, this is why *nature does mathematics, like accountants, with a predetermined goal, in nature's case the need to overcome the flaw of having no first cause. There are therefore correct answers and incorrect answers, with each outcome producing different consequences.* Physicists have always presumed that any consequence of a physical event is the 'correct' outcome. Nature can not. Only those outcomes that successfully overcome its flaws can be considered to be correct. A sequence of events which can never resolve the over-specification that arises as a consequence of the lack of a first cause, clearly represents a failed test and an incorrect answer. Something different, something new, must happen.

But nature has no capacity for overt actions no matter the strength of its motivation, since *while the lack of restraint inherent in an initial state devoid of a first cause ensures that anything that can happen will, only knowledge provides complexity in the application of this potential. Such knowledge only comes from the actual occurrence of events, not from an overabundance of untested potential*. But now such events have occurred. The assertion of two possible definitions of the entire initial state provided boundary conditions so that the intermediate potentia could acquire a complex pre-asserted representation, which we can describe as a wavefunction. The realisation of this intermediate potentia was meant to provide a causal link between the two bounding potentia but this failed, but in terms of the evolution of specific properties for the potentia this does not matter, *since the consequences of failure are as determinable as the consequences of success*. When the intermediate potentia failed to be realised, it demonstrated that the two asserted potentia were in fact independent, thereby extending the self-definition of the post-asserted states to include the property of orthogonality. The events of epoch I have extended the determinable properties of both the pre-asserted and post-asserted potentia. The potentia's previous vague physical properties were inadequate to address the question: *Are a and c two incompatible definitions that would make the physical realisation of nature's potential no more than an insane bedlam or could they be components of a single composite definition that would retain the integrity of the initial state?* therefore a resolution in terms of action was required, specifically the assertion of the intermediate potentia. But perhaps by utilising the enhanced properties of the potentia, this question can now be address independent of action, that is, purely by assertion. Can nature again assume that no first cause is required, given the more detailed specification of the potentia?

25. The Origin of the Present

Nature again tries to ignore the lack of a first cause, but now it has a greater range of tools available to achieve this objective. The events of epoch I have demonstrated that realised potentia such as *a* and *c* cannot be causally associated in order to form components of a single changing definition of the initial state, a causal timeline encompassing the expression of all potential. Originally each realised potentia such as *a* and *c* was separately asserted as a definition of the initial state, but found to be inadequate. The presence of more than one definition represented a potential catastrophe, since no relationship between them was established and they could in fact be contradictory. But the events of epoch I have proven them to be independent. Therefore, can these same realised potentia that had not independently been sufficient to define the initial state, provide the components of a composite definition for it? While a cause is required to justify why one definition must follow another, no cause is required if all definitions can be simultaneously present without contradiction or conflict. In the same way that we take change for granted, we also take the existence of composite structure for granted, but like change this is simply a consequence of a specific attempt to resolve the over-specification of the initial state – the introduction of a single, universal present.

In epoch I there was a series of independent environments established, defined by two potentia forming the boundaries of a limited universe within which a pre-asserted representation of the intermediate potentia could be established. The second method attempted to accommodate over-specification is the establishment of a single temporal environment, a single present instant, shared by all realised potentia that had been proven to be independent. This is epoch II. But while this represents a dramatic change in the environment of the initial state, it is brought about by just another incremental step in the refinement of the constraints algorithm, the step that leads to the algorithm becoming predictive. The capacity to predict the outcome of further attempts to provide a causal link between asserted potentia through the realisation of intermediate potentia had two affects. Firstly, it could be determined that no matter how many times this resolution of nature's flaw was attempted it would always fail. Secondly, no matter how many more such events occurred they can add nothing to the sum of knowledge, that is, they could not refine nature's self-definition algorithm further. These would be events that could contribute nothing to the resolution of nature's flaws, occurring independent of purpose or the progress of evolution. The overwhelming majority of physicists believe that physical events occur without purpose, but we submit that this view arose because a nature presumed to be perfect, like a perfect god, could have no needs. But what we are considering here is an imperfect nature and *A Physics Beyond: How?*, a physics totally determined by the need to overcome specific flaws. This is a physics that not only acts purposefully, but that cannot act where there is no contribution to this purpose. The events that constitute epoch I therefore cease. But this cessation and the establishment of a universal present are the same event. Evolution does not stop and then seek a fresh motivation to continue. One approach to overcoming nature's flaws gives way to another, thereby establishing a new evolutionary epoch. The establishment of the present is the cessation, or at least the suspension, of the random assertion of further potentia and the consequences of this which constituted epoch I. The next approach nature takes to overcome its flaws is established from the consequences of the failure of the *ac*-type events of epoch I and from the physical residue it has left behind. Epoch II represents a new approach and a dramatically different environment, but in terms of understanding we can see why this must be the next step – the power inherent in the lack of restraint resulting from there being no first cause is not enough, knowledge is required for its successful application and this is what the evolving constraints algorithm provides. There is no need for reasoned choice in the selection of a new approach to overcome nature's flaws; this progression can be understood as the natural consequence of the evolution of the constraints algorithm.

But simply because the progression to epoch II can be understood does not mean that it is a temporally linear event. What nature learns does not simply affect the next action to be taken, but all action that has been taken. Because nature's evolving constraints algorithm is located at $t = 0$ it retrospectively influence nature's entire history of experience. The past cannot be erased and therefore what physically occurred in epoch I has not changed, but the new environment of epoch II is established as if nature's first action was to realise multiple potentia as a composite definition of the initial state with foreknowledge of all the properties established by epoch I. Nature's evolution would seem to involve temporal anomalies that would confound Dr. Who [313], but they need not confound a new generation of physicists born to the 21st century. What must be remembered is that time itself evolves and that the introduction of a universal present instant is just part of this process. But there is nothing in nature's assertion of a shared present environment containing orthogonal realised potentia that needs to fall beyond human comprehension and therefore nothing that needs to be excluded from the domain of physics.

26. Non-Linear Evolution

The most persistent aspect of Newtonian thinking in cosmology is to believe that nature's evolution can be modelled as if it is limited to one causal timeline. This is so even for quantum cosmologies, since after a perturbation is affected by repulsive gravity its evolution is modelled along a single deterministic timeline. This seems desirable since it suits our tools of formalisation - mathematics. But as we have already emphasised, we should not alter reality to suit our mathematics but rather re-conceptualise mathematics to be in closer conformity with how nature actually works. As we have seen, *nature is not only flawed in having imperfect initial conditions it can fail to achieve a desired outcome!* The consequence of this is the discontinuous flow of evolution, as the attempt to overcome nature's flaws that has failed is replaced by a distinctly different approach. We can understand these transitions by modelling the evolution of nature's self-definition algorithm, but this makes them no less discontinuous in terms of a model of physical processes.

If 2 + 3 represents some observed natural event, if nature is considered to be perfect, it must be presumed that it will not fail to achieve the answer 5 and that this answer is correct. What this cosmology says however is both that nature can fail to achieve a desirable outcome and that just because an answer is derived from a physical event does not mean that it is correct, that is, it may not succeed in resolving the flaw that the event was meant to. While standard causally determined mathematics would simply proceed along the one causal timeline to a point labelled '5' and from there consider the next event, for example 5 + 3, nature proceeds quite differently. If 5 is successfully realised and does overcome the relevant flaw, then nature's next event does proceed along the same timeline. But if 5 is not a desirable outcome nature suspends progression along this timeline and establishes another which attempts a different approach to overcoming this flaw. This is what is happening with the establishment of the present.

Charles Darwin [314] proposed that natural selection, the survival of the fittest, drives biological evolution. This may be so, but it is certainly not successful adaptation that drives physical evolution at its most fundamental, rather it is the opposite – failure. Physical evolution is self-perpetuating because progression will as likely as not result in the introduction of new flaws that must then be overcome. Ultimate success, that is, the resolution of a single definition of the initial state, would see evolution stop. There are not many universes in terms of parallel evolution springing from a common successful spontaneous process, but instead a series of attempts to establish a single definition of the initial state built upon the consequences of previous failures. One evolutionary epoch progresses to the next not because it was so successful that it provides causal justification, but because it failed and therefore there is more to be done. Physical evolution is a crooked journey, one necessitated by failure rather than causally driven by success. But far from this making evolution incomprehensible it sheds light on some long hidden aspects of it. For example, much has been written in the literature of physics [315-319] about the fact that time has two intrinsic directions while our universe seems to possess a single forward directed arrow of time. But this is not surprising since the dual direction of time represents the introduction of a new flaw that nature has striven to overcome.

It must be noted that the concept of desirable outcomes is somewhat dubious. Nature failed to achieve an expected result, this is hardly desirable. The consequence of this is the introduction of new flaws, which to nature is also not desirable. But as human beings we see that it is these new flaws that drive evolution and therefore contribute to the environment we now experience and therefore would see them as desirable. But it must always be remembered that nature had no knowledge of or desire to create the universe we inhabit, it acts only to overcome its flaws. That this vast universe with all its complexity is a necessary part of this process simply reflects how difficult the task is.

A cosmology modelled along a single causal timeline is simply too simplistic to capture the complexity of nature's struggle to overcome its flawed initial conditions. This necessitates a dramatic rethink of the mathematical models currently being applied to cosmology.

27. Cosmological Models and Ockham's Razor

The fourteenth century philosopher William of Ockham [32] advocated that if two theories equally explain some aspect of the universe, the one that begins with the fewest assumptions is to be preferred [33]. It is this test that is most often applied to scientific theories in the absence of experimental results. Quantum cosmology only progresses beyond the appearance of perturbations through the introduction of a second postulate, repulsive gravity. The cosmology of this consideration progresses to a second evolutionary epoch through the reapplication of its initial postulate, that nature must act to overcome flaws, given that it first attempted resolutions has failed, but applying the lessons learned from the attempt.

Quantum cosmology utilises repulsive gravity to quickly progress from an unfamiliar initial state to a more familiar and comfortable environment. Epoch II of this cosmology is still an unfamiliar pre-big bang environment. But the test of Ockham's razor is not concerned with our comfort, but purely with the number of assumptions required as a basis for a theory.

28. A Further Consideration of the Relationship between Creation and Physics

In this cosmology we now have minimum entities, the potentia such as a and c, and these have a definite relationship – orthogonality. Are these now the substance that must be reshaped to establish our universe? Shall we plot their motion and interactions as if they were grains of dust destined to form galaxies? All of the precedents in the literature would have us do just that. But everything evolves, including the science of cosmology.

We have imagined creation as a one-time event. There was nothing, or alternatively some scientific abstraction that could not be considered an existent state, and then there is some miraculous or spontaneous event by which physical states are formed. Oblivion has been overcome once and for all and now only these new physical states matter. But the reality is not so simple or so linear. There can be realised states such as those of epoch I which fail to satisfy nature's needs. Oblivion, or rather the catastrophe of over-specification, is not so easily defeated. More needs to be done.

Wheeler said that, *" There may be no such thing as the 'glittering central mechanism of the universe.' Not machinery but magic may be the better description of the treasure that is waiting* [196]*."* Perhaps this is so since all fundamental cosmologies start with something popping up out of nothing as if by magic, whether this process is called wavefunction fluctuation, vacuum pair production or tunnelling from another space. Physicists call these *spontaneous events*, but the use of this term comes at an enormous cost, since it is equivalent to saying that these are postulated events with no further explanation either offered or possible. This approach therefore provides no description of the initial conditions that could necessitate this first event of the cosmological model, thereby leaving the issues of first cause not only unresolved but unaddressed. It also introduces the non-uniqueness problem, that is, that an event that is spontaneous, given an infinite time span, must occur an infinite number of times, and this inevitably leads to cosmologies that propose the existence of an infinite number of parallel universes in addition to our own. In contrast this cosmology addresses the issue of first cause not by simply postulating one, or by using some quantum effect as a pseudo-first cause, but by detailing the consequences of there being an initial state devoid of a first cause - a total lack of constraint so that anything that can happen will. This is what we evidence in our study of physics every day, a fact derived from our observations of the quantum world. It can no more be denied than the motion of a body acted upon by gravity. This observed behaviour is not an anomaly, or isolated 'quantum strangeness,' it is the most fundamental and dominant feature of nature. If we are to do science, our models of the workings of nature must at least incorporate, and hopefully explain, this observed behaviour.

The first event in this cosmology is the natural consequence of this lack of constraint, the random realisation of any resultant potential independent of causal justification. It is the simplest thing that could possibly happen. We could call this a *spontaneous event* but find no need to do so, instead we have stated that: *The assertion of one possible definition of the initial state independent of causal justification can be considered as an act of creation.* We are content to call this a *creation event* and thereby directly confront physics' ultimate taboo and hopefully demystify it. As was stated earlier: *If you choose a starting point for a cosmological model that is recognisably part of physics, then the exercise engaged in cannot be an attempt to understand the origin of physics.* Modelling the evolution of a creation event provides a better understanding of the origin of physics than denying that such events can occur, since physics is not separate from the creation event but develops from the description of the constraints it is gradually forced to incorporate due to the progress of evolution. When we can clearly define sufficient of these constraints the term 'creation' can be dropped, since we would claim that the event can be understood in terms of constraints defined within physics. Nor does the fact that creation events precede the provision of causal justification present a problem for modelling such events within physics, since an act of creation that then requires retrospective causal justification is as determined by events within the domain of physics as any Newtonian causal sequence; it is simply that *if a cause proves to be required nature is as content for it to be provided by the future as by the past.* As Saint Augustine stated, *" Miracles are not contrary to nature, but only contrary to what we know about nature* [5]*."* Human understanding cannot diminish the miraculous, but it can make it part of science.

We must confront these issues as we consider the emergence of epoch II because it is not a new event, but the same events that established epoch I, that is, it consists of the assertion of the same potentia but with the added constraint that they must all be asserted within the same present instant. This is the first evolved constraint placed upon the act of creation. This constraint results in the establishment of the first universal environment.

But it must be clearly understood that this is not the second time these potentia have been realised, it is still the first. Once the process of assertion was forced, because of the flaw of two-directional time evident for bounded potentia, to take on the constraint of realising potentia only in a present instant of time devoid of any temporal direction, it was as if this constraint had always existed. The events of epoch I were not erased by this, but the asserted potentia nonetheless assumed characteristics in keeping with this constraint as if it had always applied to their assertion. As we have seen, the location and evolution of nature's self-definition algorithm, which encapsulates its evolving constraints, makes the past in a very real sense non-immutable.

We stated earlier that: *The gulf between science and religion, their presumed irreconcilability, is most sharply focused around this difference in the conceptualisation of the origin of the universe, whether it is an act of creation or the consequence of a physical process.* But that creation occurs does not deny the capacity for there to be science, nor need science deny the capacity for creation events, if we do not allow blind prejudice to make us look away and refuse to understand. There is an evolving relationship between what can be characterised as creation events and what we would describe as physics. These are not diametrically opposed concepts, but real events interrelated through the evolutionary process. The very first thing to happen must occur independent of causal justification and therefore can be characterised as a creation event. But this gets a *do over*, that is, it is not repeated in the normal sense but instead is refined. Physics evolves from this since these refinements are determinable constraints, which can only arise as a consequence of specific environments or events. The last time this do over occurs these constraints will have evolved to the point where they constitute a cause and therefore the first event will no longer be a creation event, but will be causally determined in terms that fall within the domain of physics. But you cannot have the end product without the process. Therefore in answer to Wheeler this cosmology states that there is a *'glittering central mechanism of the universe,'* but there must also be magic, creation events, from which this evolves. There must be creation and its evolution to a causally determined origin of all things.

a. Comparison with Hawking's Flexiverse

The concept of retrospective change is not unique to the cosmology of this consideration, Hawking's cosmology models a universe where, *"…there are many possible histories, and the universe has lived them all. And if that's not strange enough, you and I get to play a role in determining the universe's history. Like a reverse choose-your-own-adventure story, we, the observer, can choose the past* [320]*."*

Hawking's model applies Feynman's [225] sum over histories interpretation of quantum mechanics to the evolutionary history of the entire universe, thereby suggesting that the universe does not have a single history but must include all possible histories. This schema is then used to explain why the measuring apparatus used by a physicist determined whether a particle or wave result would be detected. According to Hawking and Hertog [321] the choice of measurement apparatus made today affects the entire past history of the universe, effectively selecting the history appropriate for the particle or wave dominated universe that will determine the outcome of the experiment. In this way, *" A measurement made in the present is deciding what happened 13.7 billion years ago; by looking out at the universe we are assigning ourselves a particular, concrete history* [320].*"* As Hawking puts it, *" Observations of final states determine different histories of the universe. A worm's-eye view from inside the universe would have the normal causality. Backwards causality is an angel's-eye view from outside the universe* [320].*"*

The Flawed Nature Cosmology gives a precise definition of the origin of the wavefunction[13] that shows that it affects the temporal sequence in which attempts are made to realise nature's potential. However this is determined by each individual set of boundary conditions. The simple *ac*-environments of epoch I could be considered to be a limited universe with potentially multiple histories, although because the pre-asserted representation of all intermediate potentia would be exactly the same, since multiple maxima were not introduced until epoch II, the evolution of this limited universe would only involve multiple histories to the extent of two-directional time. The wavefunctions of epoch II are either independent orbitals or the pre-asserted representations of potentia intermediate to orbitals. But because of the difference schema that defines the environment all the wavefunctions based on orbitals are unique in terms of the number of maxima. For the potentia intermediate to orbitals there is a single value of *n* and therefore multiple histories can again only apply to the extent of two-directional time. But this becomes even more restricted, since the intermediate potentia is only realised because only one temporal direction is taken into account. As for this universe, wavefunctions are still determinable for any pair of boundary conditions. The individual wavefunction represents all the potentia by which this limited universe can be defined, with each determining universal evolution according to its wave nature. The composite wavefunction ensures that all the potential within the limited universe is taken into account when a realisation is attempted. Because the causal gap between the boundary conditions is only closed upon measurement these wavefunctions can be reasonably associated with all possible histories for the evolution of this limited universe, as Feynman and Hawking suggest. However if a series of such composite wavefunctions was used to determine the location of a single particle at several different points, the location of that particle is definitely determined for the instant when each measurement is completed. In this case the causal gap is resolved, thereby removing the boundary conditions, and the wavefunction collapses. This then fixes one of the subsequent boundary conditions, with the next spatial region where a measurement is conducted to locate the particle fixing the other. There is no composite wavefunction describing the entire evolutionary history of this particle, only a separate composite wavefunction for each pair of boundary conditions, for each causal gap. When the physicist in Hawking's scenario chooses to set up his experiment using a particular measurement technique, every elementary particle in the limited universe bounded by the experiment has undergone countless naturally occurring measurement events since the big bang. For this reason there cannot be a composite wavefunction, representing multiple possible histories, stretching from the big bang singularity to the physicist's final measurement device. The sum over histories involved in this experiment is of a far

[13] Chapter Two: 17. *The Intermediate Potentia and the Wavefunction.*

shorter duration. Hawking could claim, in keeping with von Neumann's [193] interpretation of quantum measurement, that there are no naturally occurring measurement events since wavefunction collapse requires the presence of a conscious observer. But this would result in the disturbing situation where the extent of the sum of histories, and perhaps the outcome of the experiment, would be different depending on whether any of the particles involved had been subjected to human measurement in the past.

Hawking uses the selection of a 13.7 billion year spanning history of nature's evolution to resolve the anomaly of wave-particle duality. There is one history appropriate for a wave description of the current universe and another for a particle description, with the physicist's choice of measurement apparatus retrospectively selecting which one is appropriate. However in the resolution of wave-particle duality given later in this dissertation[14], which includes the affect of the selection of different measurement equipment, no reference to the concept of altering the history of universal evolution is required. Both the Flawed Nature Cosmology of this consideration and Hawking's cosmology include the concept of retrospective change but this is introduced in entirely different ways.

b. Do overs and the Delayed-Choice Experiments

We detailed earlier[15] the delayed-choice experiments proposed by Wheeler [9] and conducted by Hellmuth, *et al* [10][16]. You will recall that this experiment involved sending a single photon pulse through an interferometer via a beam splitter BS1[17]. In the absence of the second beam splitter, BS2, Detector *x* and Detector *y* determine the path the light quanta took, either Path *x* or Path *y*. With BS2 inserted the path information is lost and an interference pattern is detected. The delayed-choice aspect is introduced, according to Wheeler, since we only choose *"…whether to put in the second beam splitter or take it out at the very last minute. Thus one decides whether the photon shall have come by one route, or by both routes after it has already done its travel* [10].*"*

The problem with interpreting such experiments is that physicists have not had a clear conceptualisation of nature that is independent of their experience of it. Human beings stare at a clock on the wall and count time in seconds, remembering what transpired in each one. When an object being observed fades temporarily from view we extrapolate from our last observation, filling in each second until the object is again directly observable. This is at the heart of Wheeler's description of the delayed-choice experiment, that an alteration to the experiment is made after the photon *has already done its travel*. The problem is that this travel has only occurred in human imagination. Nature simply does not experience time or events in this way.

To nature no event is established until boundary conditions are set and there is therefore a causal gap that must be resolved. It is not just physicists that must determine boundary conditions before they can define a wavefunction, nature also must do this. As this cosmology has shown, quantum mechanics is about what

[14] Chapter Three: 40e. *The Origin of Wave-Particle Duality* and Chapter Four: 47h. *Wave-Particle Duality and the Big Bang Initial Conditions*.
[15] Chapter One: 2. *Physics or Metaphysics?*
[16] The delayed-choice experiments of Wang, Zou and Mandel we will examine later, Chapter Four: 57d. *Cramer's Enhanced Delayed-Choice Experiment,* since these involve evolutionary factors we have not yet encountered.
[17] See Figure 1, Chapter One: 2. *Physics or Metaphysics?*

happens when there are boundary conditions, when something specific is attempted at the expense of the guarantee of realisation. One boundary condition is usually the last measured location of the particle being examined, its past. The other is the location where it is now being sought by measurement, its possible future location and state. It is only once these two boundary conditions are established that all intermediate potentia can assume a pre-asserted representation to provide the basis for a composite wavefunction that determines the fluctuating uncertainty of realisation for the particles within this particular limited universe. There is no universal wavefunction only those individual ones established by specific boundary conditions.

The resolution of bounded events is determined by an attempt to resolve an intermediate potentia. This occurs only at those spatial locations where a measurement is performed. Before the second measurement has been conducted there is no way to ascribe any physical significance to our imagined location of the photon within the interferometer. This is a concept familiar to anyone who does quantum mechanics. In fact Hellmuth *et al* [10] concluded the account of their delayed-choice experiments with the statement that, " …*Wheeler emphasized that 'No elementary phenomenon is a phenomenon until it is a recorded phenomenon, …until it has been brought to a close by an irreversible act of amplification such as the breaking of a grain of silver bromide emulsion or the triggering of a photodetector* [9]*.' We therefore have no right to say what 'the photon is doing' during its journey in the interferometer. During this time the photon is 'a great smoky dragon* [9]*' which is only sharp at its tail (at the beam splitter 1) and at its mouth where it bites the detector. We conclude by noting that the delayed-choice experiment thus has far-reaching consequences for our picture of the past. As Wheeler has frequently pointed out, the strangeness of the delayed-choice experiment reminds us more explicitly than ever that 'the past has no existence except as it is recorded in the present* [9]*'* [10]*."* All that we are doing in this consideration is providing a cosmological basis for this. Nature does not track the particle instant by instant as it moves from it past to its future location. Instead when there is an interaction that could potentially involve this particle, such as the physicist's measurement, the causal association between the two bounding spatial regions is sought through the timeline of this particle, that is, by its successful realisation in the initial location as well as in the spatial region where the experiment is being conducted. The sequential motion of the photon through the detector presumes that each new instant of its motion is causally drives by the photon's previous state. But as we have seen above, while nature seeks such causal certainty it has not yet achieved it. Instead retrocausality, that is, the establishment of a cause only after the initial and final boundary conditions have been set, is inherently the way nature resolves events.

The delayed-choice experiment is conceptualised as changing the circumstances for the event of the photon moving through the interferometer. But you can never change the boundary conditions for an event; only ever establish a new event. When altering the experimental apparatus changes the boundary conditions this represents the establishment of a new event, even though it involves the same photon. This change may be made after a period of time when we could imagine the photon as having travelled a certain distance along the arms of the interferometer, but as we have seen above[18], *nature does not experience the timeline*

[18] Chapter Two: 21e. *The Further Evolution of Memory and Quantum Measurement*

as a continuous flow with each second connected to the last, instead what are connected are indistinguishable events by their reference to the same element of memory. The first event was aborted by changing the measuring device before a measurement at the second spatial location was performed, the photon has neither been realised nor failed to do so. There is no result here for nature to remember. Therefore that the second event has been established after the photon has had time to enter the interferometer is quite irrelevant, since the photon has had no realised location except where it was last measured outside the interferometer and has no potential future location except as defined by the new boundary conditions imposed by the changed experimental apparatus. The only choice nature ever experiences is whether or not a potentia is realised. Since the first event was abandoned before a measurement was attempted there can be no delayed-choice, no change of mind at all. The new event is a complete do over that need take no account of imagined locations of the photon that were not tested by its attempted realisation.

We experience time and events in a manner different to nature, there is no fault in this, but we must do physics as a description of nature's methods of experience.

c. Cramer's Transactional Interpretation of Quantum Mechanics

To explain how the photon could be affected by the change of experimental configuration done ahead of its flight path John Cramer's [322] proposed a *transactional interpretation* of quantum mechanics whereby *"…particles interact by sending and receiving physical waves that travel forwards and backwards through time* [108]*."* This suggestion is obviously reminiscent of de Broglie [172, 173] and Bohm's [170, 171] *pilot wave* concept, but seeks to overcomes the objections that the pilot wave must travel paster than light, and thereby violate the postulates of general relativity [174], by having them travel *backwards through time* instead. However this concept is simply not required given the conceptualisation of quantum mechanics revealed by this cosmology. Each detection device represents a different boundary condition and therefore a different causal gap to be resolved by retrocausality. Nature is never fooled by an aborted event that attempts no realisation of the photon, the causal gap is only ever addressed once the final boundary conditions are set. If the conditions are changed while the particles is in mid-flight, there is no need for a signal *that travel forwards and backwards through time* to tell the photon to retrospectively change its path, the change of boundary conditions simply means that the whole event is addressed by nature as a do over. This we would submit is a simpler interpretation of the delayed-choice experiment, since it does not require adding to the physical model the extra complication of *particles interact by sending and receiving physical waves that travel forwards and backwards through time*. There is just an aborted and therefore irrelevant event and a new event that was allowed to reach a conclusion. We remember the first event, even though it did not reach fruition, but nature has no physiology or reason to do the same.

d. Comparison with the Proposals of Digital Physics

As we have seen above Zuse's [250] *digital physics* proposes that, *" …the universe is being computed on some sort of discrete computing machinery* [323]*,"* this has the effect of, *"…challenging the long-held view that some physical laws are continuous by nature* [323]*."* Digital physics, like this cosmology, has the laws of physics evolve as a computation abstracting and controlling nature's operation. The mechanism proposed by Zuse for the emergence of physical laws was *cellular automata* [324, 325], *"…an infinite, regular grid of cells, each in one of a finite number of states. The grid can be in any finite number of dimensions. Time is also discrete, and the state of a cell at time t is a function of the states of a finite number of cells (called its neighborhood) at time t-1. These neighbors are a selection of cells relative to the specified cell, and do not change. (Though the cell itself may be in its neighborhood, it is not usually considered a neighbor.) Every cell has the same rule for updating, based on the values in this neighbourhood. Each time the rules are applied to the whole grid a new generation is produced* [326],*"* a model popularized by John Conway's [327] computer simulation *The Game of Life*. The mechanism proposed by this cosmology is more directly applicable to physics, a continuous feedback between physical events and an evolving generalised memory of their consequences. The laws of nature are thereby not continuous or immutable, but nor are they purely computed from an initial and unchanging set of rules, instead there is a gradual evolution of the rules themselves based on the outcome of actual physical events. These rules are the constraints placed on an otherwise unbounded potential, applied at the instant of measurement as the process by which the pre-asserted representation is reduced to an existent expression. This provides the interface through which the computer program affects the material world. The generalisation of the memory of the outcome of specific events provides the interface through which the material world feeds data into the program. But there is no distinction in this computer between data and the program, the data is therefore not simply stored but incorporated into the program itself as a refinement that can lead to new capabilities, such as the capacity to predict the outcome of similar future events, providing the basis for the evolution of the rules and thereby the laws of physics.

However you might retort that we do not see new laws of physics emerging in the universe. Of course not, the retrospective nature of these changes means that they will appear to always have applied. We can only clearly see these changes by examining the establishment of a new evolutionary epoch, as we shall do in this chapter. To understand how nature works requires more than the observation of the single evolutionary epoch within which you find yourself, therefore the study of cosmology is essential to a full understanding of physics.

29. The Anthropic Principle and this Cosmology

The *anthropic principle* was proposed by Brandon Carter [328] in 1973 and in its most basic form, *"…states the truism that any valid theory of the universe must be consistent with our existence as carbon-based human beings at this particular time and place in the universe* [329].*"* We have already stated our agreement with this broad principle in the section *Consciousness and Cosmology*, however there are serious issues to be addressed regarding its application since as Hawking pointed out, *" The laws of science, as we know them at present, contain many fundamental numbers* [330], *like the size of the electric charge of the electron and the ratio of the mass of the proton and the electron. …The remarkable fact is that the values of these numbers seem to be very finely tuned to make possible the development of life* [94].*"* This is called the *fine-tuning problem*. Barrow and Tipler [331] suggest three approaches to this problem based on the anthropic principle. Firstly, the *weak anthropic principle* states that, *" The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by* *the requirement that the Universe be old enough for it to have already done so* [331]*."* Secondly, the *strong anthropic principle* states that, *" The Universe must have those properties that allow life to develop within it at some stage in its history* [331]*."* Thirdly, the *final anthropic principle* states that, *" Intelligent information-processing must come into existence in the universe, and, once it comes into existence, it will never die out* [331]*."* But these concepts would appear to have the consequence, carbon-based life, dictate the cause.

One approach to avoiding the suggestion that the anthropic principle indicates the presence of intelligent design is to evoke what is called the *monkey theorem*, originally proposed by the French mathematician and politician Émile Borel in 1913 [332]. The later Borel-Cantelli version proposes that a chimpanzee typing at random, given enough time, will almost certainly type out a copy of one of Shakespeare's plays [333]. While this may seem highly unlikely, given an infinite amount of time it is not impossible and therefore by taking into account Kolmogorov's [334] *zero-one law*, which states that such an infinite series of independent events must have a probability of zero or one, the probability that a Shakespeare's play will be produced by the chimpanzee is indeed one. Therefore given an infinite amount of time for the evolution of the universe, the random development of the appropriate values for the constants necessary to support life is also inevitable. The *development* of *constants* may seem a contradiction in terms, however many cosmologists now suggest that nature's 'constants' may have in fact changed over time [335].

However, this cosmology demonstrates that our clock based conception of time is too naïve, since it shows that time has an origin and undergoes a process of evolution. Therefore before we can give an answer to the proposition of the anthropic principle in terms of this consideration, we must examine if the concept of infinite time has any validity within this cosmology. This cosmology has a definite first event and therefore evidences no infinite past. There are do overs but even these are the consequence of learning due to a finite number of actual events. Fundamentally since nature's evolution is directed at overcoming specific flaws, it will either achieve this or, as we have seen, terminate a pointless sequence of events and establish a new evolutionary epoch. If nature can never resolve its flaws there may be an unending progression to new evolutionary epochs, but each extends the nature of time rather than being the perpetuation of one temporal sequence. When nature has finally overcome the flaw of over-specification and has a single definition of the initial state, it is more likely than not that this will be eternally static. But even if it initiates a timeline that will not be broken by the need to establish new epochs, this will be absolutely causally deterministic, leaving no room for random events. We must therefore conclude that an infinite period of time as envisaged by the anthropic principle does not exist within this cosmology.

Gian-Carlo Rota pointed out that, *" If the monkey could type one keystroke per nanosecond, the expected waiting time until the monkey typed Hamlet is so long that the estimated age of the universe is insignificant by comparison…*[333]*."* Given this it is worth noting that there are more sequences in human DNA [336] than letters in Shakespeare's *Hamlet* [337], yet nature was able to bring forth Shakespeare to write his play, in a small fraction of the time it would take to produced it by random events. On a universal scale there should be no doubt that evolution occurs, but it is highly unlikely to be driven solely by random events, there has simply not been sufficient time to produce by this method alone the level of complexity evident in the universe. No chimpanzee randomly striking typewriter keys has had enough time to come up with a Shakespeare play, but perhaps a poor playwright given even a finite number of revisions could. Evolution is not about a headlong progression into the future, it is about learning and refinement. Note that this is not an argument for design, since while it is true that refinement is directed by the need to overcome flaws, as we have seen, this involves a process of trial and error rather than the pre-existence of a flawless plan. Still it is no wonder given this process that when humanity looks at nature within this latest evolutionary epoch, we cannot help but consider that it is perfect.

However, evoking the concept of an infinite period of time is not the only approach to solving the fine-tuning problem, as Michael Shermer notes, *"In its current version, the anthropic principle posits that humans live in a multiverse in which their universe is only one of many universes, all with different laws of nature* [338]*."* This is a rather simple approach which states that if the probability that by chance all the conditions in our universe are such that molecules, galaxies and life are possible is extremely small, this can be overcome by simply postulating that there are an immense number of universes. It is as if each universe represents a random mutation evolved from some common initial conditions, however there is no equivalent to natural selection [314] offered, instead this proposal maintains that the fine-tuning problem is overcome by sheer weight of numbers – if the probability of having a universe that supports life is a billion to one, if we postulate that there are a billion billion universes one that supports life must exist. But as Gefter reported, *"Many physicists argue that this is just giving up on the problem of explaining why our universe is the way it is – it is not, they say, science* [320]*."*

In science when there are no absolute answers available we must look for the most plausible and those resolutions that introduce the minimum of new complications into our model of physics. The statistical approach outlined above is plausible, but the introduction of an immense number of parallel universes is an enormous new complication to add to our model of physics. The suggestion of this cosmology that nature's actions are not only directed by the motion of material objects but by the evolution of information, may at any rate, as we have seen earlier, be compelled by the results of recent experiments. That this allows the type of do over described above is a new and no doubt confronting concept, but we submit that it is a simpler solution to the fine-tuning problem and introduces fewer new complications to our model of physics than a schema that necessitates the introduction of countless billions of inaccessible parallel universes.

The *final anthropic principle* goes further than this cosmology would warrant. We agree that *information-processing must come into existence in the universe, and, once it comes into existence, it will never die out*; but do not agree that intelligence, let alone carbon-based human life, is a prerequisite for this. Nature's self-definition algorithm is not only an information-processing tool, because it encapsulates the evolving constraints it also affects future action, but there is no prerequisite for intelligence in either its inception or operation. As for how the anthropic principle applies to the fine-tuning problem, this cosmology suggests that this can best be done by restating the principle as: *If there comes a point in nature's evolution where sentient life within the universe is required, then any factors which would prevent this become classified as flaws which nature will seek to overcome*. The mechanism by which this is achieved is not simply random mutation, which would require either infinite time or infinite universes, neither of which are available, but rather the capacity for retrospective refinement.

The presence of sentient beings within the universe is not preordained, but neither can they exist without purpose, since for nature to have refined itself to allow their presence, they must play a necessary role in overcoming its flaws.

a. This Cosmology and Astrobiology - The Shape of Alien Life

S.E.T.I. (Search for Extra-Terrestrial Intelligence) [339, 340] has a huge scientific budgets [341], yet before the 1990's there was no evidence that there were any extra-solar planets and therefore the existence of alien life was highly speculative. However as at 13th June 2005, almost 200 extra-solar planets have been discovered [342], with further discoveries becoming so routine that Geoff Marcy points out that, " *Every week or two we find another new one on average* [343]." While the first planets detected were gas giants orbiting close to their stars [344-346], gradually planets with more distant orbits [347] and then entire planetary system [348-350] were discovered. As Brad Carter explained, " *The feeling I have in knowing about this new planet is I suppose a certain sense of relief that our solar system is not entirely a freak of nature. We are now starting to find other planetary systems that more and more look like home. We are now beginning to find the cousins of our own solar system out there amongst the stars* [351]." These discoveries have reinvigorated scientific interest in the search for alien life [352-354], with NASA increasing its funding for astrobiology research [355].

Now that it has been proven that there are other solar systems in our galaxy similar to our own, the question is being asked: *What kinds of alien life might exist on them?* Jack Cohen [343] ridiculed science fiction's frequent depiction of alien life forms that are simple variants of terrestrial or even human anatomy. But this cosmology gives three very clear reason why there may be in some sense common features shared by terrestrial and alien life forms. Firstly, all equivalently advanced life forms would serve the same purpose within nature and must therefore share in common those traits this task necessitated. While these traits may not dictate physical appearance, they may nonetheless ensure that there is sufficient commonality for all intelligent races to acknowledge kinship, a necessary prerequisite if S.E.T.I.'s dream of communicating with intelligent aliens is to be fulfilled. Secondly, all of evolution no matter where it occurs is this vast universe is feeding data into nature's self-definition algorithm. This would allow an evolutionary development that has been established anywhere in this vast cosmos, to be reapplied wherever there is a similar environmental problem to be overcome or opportunity to be exploited. This could be detected both in terms of evolution occurring at a speed that could not be accounted for by random mutation and natural selection, and because it would promote the tendency for the same basis designs to be repeated, independent of any biological link between two similar species. Both these traits are evidenced in terrestrial evolution. The divergence of the Galapagos Finches to exploit every food source on these sparse islands was so rapid that Peter and Rosemary Grant, who have studied the finches for twenty years [356], have shown that " *…among the finches of the Galapagos, natural selection sometimes takes place so rapidly we can watch it at work* [357]." Biologists offer explanations for several such cases of rapid evolution ranging from human interference [358], to female frogs instigating selective breeding [359]. The repetition of basic designs amongst unrelated species is well documented, for example the great auks of the Northern Hemisphere are remarkably similar to the penguins of the Southern Hemisphere although not biologically related [360]. Biologists account for these two remarkably similar species in terms of *biological* *relay* [361], explaining it as the result of evolving in similar ecosystems. But is a flightless bird really the only biological adaptation that can exploit fish stocks in an extremely cold climate? And even if it is, how long should it take for two independent sequences of random mutations to arrive at this strange design? It is harder to use the same argument to explain cross-species similarities in organs, such as why the smelling organs of the terrestrial coconut crab are similar to those of insects [360]. What we are suggesting here is simply that these trends may be more widespread than the isolated cases so far studied and that they may have a general, cosmological basis that extends beyond this planet. The third reason suggested by this cosmology that the evolution of life may be more rapid and more successful than otherwise possible is the concept that the non-immutability of the past allows nature to retrospectively take advantage of new evolutionary developments. Given these cosmological factors it may be quite valid to consider the evolution of life on this planet as both being influenced by and influencing the evolution of life on alien worlds.

The Galileo Mission showed that Europa, one of Jupiter's moons, appears to have vast oceans beneath its icy surface [362], leading Lipps and Riebolt to point out that, *" The inferred presence of water, tidal and volcanic energy, and nutrients suggests that Europa is potentially inhabited by some kind of life* [363]*."* Once biologists would have considered that no life could exist in such an environment, since it is not conducive to photosynthesis, but deep sea exploration has revealed an entirely different lifecycle, chemosynthesis *"…the biological conversion of 1-carbon molecules (usually carbon dioxide or methane) and nutrients into organic matter using the oxidation of inorganic molecules (e.g. hydrogen gas, hydrogen sulfide) or methane as a source of energy, rather than sunlight* [364]*,"* around sulphurous hot vents on the ocean floor. *" It has been hypothesized that chemosynthesis may support life below the surface of Mars, Jupiter's moon Europa, and other planets* [364]*,"* a concept popularised by the documentary *Aliens of the Deep* [365]. But even if the conditions at the bottom of Europa's oceans prove to be different from those on earth, C. Allen's work *"…provides evidence that a non-volcanic, topography driven geothermal system, that harbors microbiological communities, can operate in extreme cold environments and discharge through solid ice. This conclusion supports the idea that life can exist in isolated geothermal refuges despite subfreezing surface conditions such as those on Snowball Earth, and perhaps on Mars or Europa* [366]*."* The extreme pressure and sub-zero temperatures of Europa's oceans are not seen as an impediment to the development of life specifically because there is evidence of life overcoming such obstacles on earth [367, 368], yet if evolution is driven by truly random mutations the only current basis for this and similar comparisons is the *fullness of time* argument. But as we have seen above with reference to the monkey theorem, the amounts of time required to make this argument feasible may well exceed the current age of the universe. Alternatively this cosmology suggests that a random mutation need only occur once in order to be universally applied to all similar environments. With this in mind, it is interesting to consider however whether the precedent for life based on chemosynthesis first evolved on earth, which is dominated by life based on photosynthesis, or whether it first evolved on Europa where there may be no other alternative for life's development. We may have already discovered the first evidence of alien life, in terms of life that is based on an evolutionary precedent first established elsewhere in the universe, on our own ocean floors. The NEMO mission which would *" …explore and return samples and possible life forms from Europa's sub-surface oceans to Earth* [363]*,"* is proposed for launch as early as 2013. If any life forms are discovered, it will be instructive to note how similar they are to terrestrial chemosynthesis based life forms and whether they are more advanced, and therefore may have started their evolutionary journey before similar species on earth.

It is not that random mutations proved to be beneficial by natural selection are not important factors in the evolutionary process; it is just that nature uses these rare events far more efficiently than the random keystrokes of the monkey theorem. What is learned in one isolated corner of the cosmos can be applied both everywhere else and retrospectively in order to enhance life's capacity to overcome harsh environments. Nature's troop of monkeys randomly bashing on typewriters can be vast indeed since they can occupy the entire universe rather than one shared room, but still when one monkey stumbles upon the word 'Hamlet' not only do all the other monkeys now know how to type this word, they knew it from the first moment they sat before their typewriters. Nature's troop of monkeys, who use random events in an enhanced way, could produce Shakespeare's *Hamlet* in the finite span of time that is the age of this universe.

What role then is played by DNA? This may act as a counterbalance to the conformity that could otherwise result from a universal shared memory. By providing a biological evolutionary memory DNA may ensure a greater local diversity of species. While there must still be some universal traits dictated by a common cause, and still some involvement of nature's centralised memory in terms of overcoming common environmental difficulties, a greater local variability will allow nature to experiment with a wider variety of possible approaches to overcoming its flaws, instead of the entire universe developing only one common approach. This expands the functionality of a single evolutionary epoch and thereby in all likelihood its longevity.

The science fiction writers may have been correct after all, that it is more likely than not that alien life forms will share common traits with earth based species, a situation only moderated by the provision of a local evolutionary memory in the form of DNA.

Why should cosmology make predictions regarding astrobiology? Experiments to verify cosmological models are notoriously expensive, therefore it is prudent to take advantage of all research funding in astrophysics. The search for life, whether in the form of intelligent radio signals detected by S.E.T.I. or actual life forms detected or even retrieved from Europa, are projects currently receiving funding. By making predictions that such research might verify or disprove, cosmology can seek the broadest possible base for empirical verification.

30. Creation Not by Addition but Refinement

As we stated earlier, *while the lack of restraint inherent in an initial state devoid of a first cause ensures that anything that can happen will, only knowledge provides complexity in the application of this potential. Such knowledge only comes from the actual occurrence of events, not from an overabundance of untested potential.* Nature can neither realise all of its potential, nor resolve all of its flaws, by random acts of creation. This was the lesson learned by the events of epoch I. Humanity's insistence that a single act of creation establishes an immensely complex universe, necessitates the introduction of a divine being possessing knowledge gained independent of experience. By contrast, in this cosmology it is previous events that provide a gradual refinement of the process of creation, since the consequences of events are incorporated into the constraint that are then evidenced in the nature of the realised potentia as if they had always applied. We asked earlier, with reference to the asserted potentia: *Shall we plot their motion and interactions as if they were grains of dust destined to form galaxies?* The answer is: *No*, the nature of cosmology must change, *it is no longer adequate simply to take some initial physical components, or finite energetic regions, and model their motion or geometric evolution, instead we must model the evolution of nature in terms that reveal the emergence of new aspects of its definition*. Epoch II of nature's evolution is not about the reorganisation of the realised states, it is about how the additional constraints on assertion refine their properties, so that what is evidenced of them is more complex, thereby providing a greater array of tools to address nature's flaws. To believe that a single act establishes all that is required for the existence of this immensely complex universe is a historical artefact that we must now progress beyond.

a. The Pre-asserted Representation of *a* and *c*

The events of Epoch I demonstrated that the realisation of potential could involve a process applied to a complex pre-asserted representation of the potentia. Therefore this precedent must be applied to the initial assertion of *a* and *c*, necessitating that they first assume a complex pre-asserted representation. Note that this is not to say that they regress from their realised expression to a pre-asserted state, but that now their initial realisation must include this phase. The pre-asserted representation of b_j had been based on the existence of *a* and *c* to provide boundary conditions, this clearly cannot be the basis for the boundary conditions for *a* and *c* themselves. Their boundary conditions cannot be environmental, but must be derived from the properties of the individual states. The only specific property they possess is orthogonality, that is, each potential has been proven to be independent of all others. Whereas the intermediate potentia b_j had as its boundary conditions *a* and *c*, the pre-asserted representation a_j must be self-bounded, that is, its probability amplitude curve must be drawn along a path that leads from *a* to *a*, which can be visually represented by a circle serving the same function as the *ac*-axis in epoch I. In this way the potentia's minimum realm of possibilities becomes what we might have originally presumed it to be, the state's own self-definition as determined by a range of probability amplitudes leading from and to it.

There is an obvious temporal paradox here in that the property of orthogonality had originally only been defined as a consequence of the assertion of *a* and *c*, but now forms the basis for their pre-asserted representation. But as we stated earlier, *the initial state of this consideration cannot be influenced by any causal past and therefore its evolution must involve self-exploration rather than progression*. The events of epoch I taught nature more about the initial state itself, enough to alter how it is defined. It has learned that there are a finite number of independent potentia whose pre-asserted representation must therefore be based on self-definition.

Self-definition allows a more complete expression of all of the consequences of there being no first cause and all that has been learned from epoch I. Now it is known that not only can anything that is not prohibited by a specific constraint happen, but that every bounded potential must incorporate two directions of time and thereby two negating consequences of realisation. There was no realisation of this in epoch I prior to the establishment of the boundary conditions, now this knowledge is applied to the pre-asserted representation of every potentia.

b. The Difference between *a* and *c*

But there is still a problem - there are multiple potentia that are independent but must nonetheless form components of a single definition of the initial state. In epoch I while we could imagine there being any number of intermediate potentia, *the boundary conditions a and c provide only sufficient constraints to define a single pre-asserted representation* and since all potentia are unique, we must consider there to be only one intermediate potentia. For there to be multiple potentia between the boundary conditions of epoch II therefore, their pre-asserted representations must be unique. This requires that all of the pre-asserted representations must be defined by a common property that takes a unique value for each potentia. However, the capacity to distinguish between different orthogonal potentia must be achieved without arbitrarily adding new attributes. The only property that the pre-asserted representations have so far acquired is the probability amplitude curve, but even that was nothing new, but merely a more refined representation of the potentia's fundamental property, that they will at some point assert themselves. The probability amplitude cure is a refinement of an existing property that arose as a consequence of a more complex environment. In response to the new environment of the present, which must include multiple independent but related potentia, this fundamental property is again refined. This refinement is repetition – one state can be distinguished from another by the number of times the cycle of probability amplitudes is repeated in one self-definition path, that is, by the number of probability amplitude maxima. In this way no new properties are introduced, while the pre-asserted representation of each potentia is made unique but related to all other representations through a common property.

There are only three constraints imposed on repetition. Firstly, that it cannot introduce an imbalance in the number of x_j to $\neg x_j$ maxima regions, since this would represent a preference for one direction of time over the other. Secondly, since what is occurring is repetition the footprint of each maxima region on the circular *aa*-axis remains constant[19], so that as maxima are added the circumference of the circle the probability amplitude curve is overlaid on increases in a quantised manner. Thirdly, the addition of extra probability amplitude maxima cannot make it possible for the one potentia to have multiple existent expressions. This constraint is maintained by normalization, that is, ensuring that the sum of the probabilities remains 1 even for potentia with different numbers of maxima. Nature needs no mathematician to decide that normalization is necessary, since it is a fundamental constraint that every potentia result in only one realised expression.

This difference schema, based on the repetition of probability amplitude maxima, can be introduced because this refinement to the potentia's pre-asserted representation makes no real difference, in that there will still be only one realised expression for each potentia after assertion and there is still an equal representation of x_j and $\neg x_j$. Nature's evolution does not progress by the utilisation of great power, but by doing little things that of themselves are unimportant. Evolution progresses, for the most part, without anything truly significant ever happening.

But repetition is not without a cost. The zero points in the self-definition of b_j in epoch I were imposed by the existence of *a* and *c*, that is, imposed by the environment. It can be considered to represent a geometric boundary, that is, b_j has

[19] In the terminology of waves, the wavelength remains the same.

no potential to be realised at these zero points because either *a* or *c* is already there. By contrast the zero points around the self-definition path are self-imposed and therefore state that nothing at all can exist there. There is a definite flow of probabilities from the certainty that there can be realisation, to the certainty that assertion will fail and back again, reinforcing once more that *the cost of a more complex definition of the potentia is that to each is added a degree of uncertainty in its own existence*. This does not contradict the potentia's defining property, *that it is guaranteed realisation given the full extent of nature's evolution*, because the environment of epoch II must be considered to be a limited universe since it contains a finite number of orthogonal potentia. In the same way that b_j need not be realised within the limited universe bounded by *a* and *c* in epoch I, a potentia included in epoch II is not guaranteed realisation within this limited universe. All that is added by repetition is zero probability amplitude points within the potentia's own minimum domain of expression.

c. The Pre-asserted Representation of *a* and c, and Standing Waves

This new pre-asserted representation of potentia such as *a* and *c*, although self-bounded and containing multiple probability amplitude maxima, is not significantly different from the pre-asserted representation of b_j in epoch I and therefore what was learned about it, that it could not lead to a successful realised, also applies to this new representation. Any attempt at assertion would be pointless and therefore instead the pre-asserted representation is maintained.

The probability amplitude curves had been added in epoch I because by satisfying the same boundary conditions they were simultaneous. To prevent this addition in epoch two this simultaneous nature must be circumvented. All the constraints can still be met and the pre-asserted representation maintained provided that both the positive and negative probability amplitudes are never simultaneously expressed. This can be achieved if at every point around the *aa*-axis one value of the probability amplitude is taken and then the other. Therefore prior to assertion the probability amplitude values oscillate, in a way that can most conveniently be represented as a standing wave. The oscillation of probability amplitude values from their positive to negative values is the manifestation of the postponement of their addition. We need not consider any intermediate values of this wave, since as Born pointed out, *"…of course the instantaneous value of the oscillating function itself cannot play any part, on account of the high frequency* [369]*."* It is only the amplitude, the extrema, which are used in determining the probability of a specific outcome occurring.

d. Concluding Comments on Creation Not by Addition but Refinement

The complete set of orthogonal potentia can be most naturally represented by a series of concentric circles of increasing diameter each representing one pre-asserted potentia, with a standing wave with a unique number of wavelengths superimposed on it. This is a significant lesson that nature has learned and physicists must heed – an environment need not be composed of realised states but can instead involve pre-asserted representations provided that they are sufficiently complex. But this is a remarkably familiar environment, since when first proposing his atomic orbital model Bohr [370] restricted his consideration to a similar set of simple circular orbits since, as one commentator put it, " *When in perplexity the beguiling simplicity of the* *circle is like a raft to a drowning man* [371].*"* What we are describing, and what nature is establishing in epoch II, is clearly the precedents for the space of atomic orbitals.

31. The Further Evolution of Physics

If nature abandoned the residue of epoch I as irrelevant and simply continued to realise fresh potentia there would be no consistent evolutionary sequence and therefore no physics. We can model nature in terms of physics because evolution builds on those states that have already undergone change, thereby utilising the consequences of previous events. There are as yet no stones or trees, none are needed for us to do physics, all that is required is that the next event utilises not just knowledge of past interaction but their physical residue.

We have at this point in human history a physics that really does not take evolution into proper account. We examine the evolutionary epoch in which we live, but only in terms of establishing relationships between different observed properties of nature. Yet the origin of physics itself is a specific aspect of the evolutionary process and therefore can only be fully understood in these terms. For physics to mature and move on to address questions currently considered to be unsolvable or beyond its domain, it must acknowledge that evolution cannot be isolated as the sub-discipline of cosmology, but must be incorporated into every aspect of our description of the material world. To look out of our window and describe what we see today does not constitute a full description of nature. We must be able to describe all aspects of nature in terms of their past and future evolutionary history, in terms of why they are here and what purpose they serve. This is a degree of understanding worthy of the title 'science,' while to imagine that this universe is just an island isolated from all history or purpose and that we therefore need only describe what we see here, and how it acts now, is not.

32. The Boundary Conditions for Epoch II and the Natural Numbers

The boundary conditions for epoch II are derived from there being a finite number of orthogonal potentia. This is not a geometric boundary in the sense of one state ceasing where another begins; this is a boundary that requires no external agency.

However nature can know nothing independent of process and therefore cannot know that there is a finite number of orthogonal potentia unless they are counted. But simply counting cannot provide boundary conditions unless the items counted retain a label so that the first and last can be distinguished as the bounding states. In nature the introduction of numbers cannot be a passive thing but must alter the states being counted. It is therefore by counting the orthogonal potentia that the boundaries of the epoch II environment are established, with the orthogonal potentia retaining a label in the form of a unique number of probability amplitude maxima.

Before we can do mathematics we will need numbers. Number theory is a highly specialised discipline within mathematics with a history dating back hundreds of years [372]. The application of so many brilliant minds over such an extended period cannot be recreated here. But nonetheless if we are to use numbers in physics, where at the end of a calculation we must give an interpretation of the numerical results in terms of a physical consequence, it is essential that the numbers themselves be associated wherever possible with physical states or processes. This is in keeping with our earlier statement that *we shall reverse the roles of cosmology and mathematics so that the initial environment and its evolution defines the mathematics, rather than the mathematics defining the cosmology*. *By doing this we hope to emphasise that there are two distinct types of mathematics, pure mathematics whose components are conceptual and need refer to no material states, and the mathematics of physics that must, by the very nature of this science, refer to real constituents of nature*. The introduction of counting and the natural numbers is one example of this. We have not relied on concepts from pure mathematics to allow us to use numbers but have given a cosmological basis for why nature needed to introduce them.

In pure mathematics we usually think of the introduction of the natural numbers in terms of Peano's Axioms which informally consist of [240]

1: A *successor function,* α such that for a set N $\alpha : N \rightarrow N$, which maps x to $x + 1$. This function must be one-to-one: $x+1 \neq y+1$ if $x \neq y$.

2: 1 must not have a predecessor: $1 \neq \alpha(x)$ for any $x \in N$, therefore the successor function is not *onto*.

3: The use of the *Axiom of Induction*.

The distinction between pure mathematics and the mathematics of physics could not be emphasised more sharply than the capacity for the physicist to say that this is not how nature established the natural numbers. Peano used the Axiom of Induction to produce an endless series, but nature's motivation for the introduction of numbers was to verify that there were a finite number of orthogonal potentia and to label them so that the first and last could be distinguished and used as boundary conditions for the establishment of the present and the first composite state. Peano must postulate that there is a first number without a predecessor, but nature has a real state on which to base this concept, the pre-asserted representation of the potentia as first expressed in epoch I, that is, with a single maximum. This is an unavoidable condition common to all potentia, since it reflects their defining property, that the potential they encapsulate must at some point be realized. Therefore the first number in nature's counting series is 1. Nature's *successor function* is derived from the capacity for repetition without violating any constraints that then existed, that is, because the maximum is part of the pre-asserted representation of the potentia there can be multiple maxima, with the number of maxima distinguishing one potentia from another, providing that this does not result in there being more than one realised state. This means that to nature the process of counting must be accompanied by the normalization of probabilities, which in quantum mechanics had to be introduced as an axiom. The potentia retain a label in terms of a unique number of maxima so that the first and last potentia can be distinguished to form the boundaries of the epoch II environment. Because a label must be retained, even though nature's self-definition has evolved to reflect the predictive capabilities of the Axiom of Induction, the counting sequence does not perpetuate eternally but is applied only to actual states available to be counted. Nature, like any child, first learns to count in terms of the natural numbers: 1, 2, 3, … It is interesting to note that this is also historically how humanity developed their number system, with zero not introduced until much later [373].

As we come to understand nature and its evolution more clearly, it will become possible to derive a physical basis for more and more of the fundamental concepts of mathematics and thereby continue to refine this cosmology's resolution of Wigner's dilemma regarding *"…the unreasonable effectiveness of mathematics* [49]*."* In this way a truly fundamental cosmology can clarify and justify the mathematical concepts used in physics.

33. A Finite Space Embedded in an Infinite Superspace

While there are an infinite number of potentia that could have been realised during epoch I, there is a finite number that had actually been realised before the constraints changed so that all the orthogonal potentia were asserted as one composite definition of the initial state. This configuration of the initial state can therefore be characterised as a finite space, the orthogonal potentia, embedded in an infinite superspace, the potentia still to gain a pre-asserted representation. Many cosmologies simply postulate such a configuration without justification as the starting point for their models, with several of the quantum cosmologies [73-75, 78, 79] falling into this category, since they model our universe as coming into existence as a quantum fluctuation in, or as a quantum tunnelling from, a larger superspace. The problem with this however is that it does not overcome the tower of turtles problem, since the superspace simply acts as the lower turtle upon which the finite spatial region rests, since no justification is given for the superspace itself. By contrast the space and superspace of this cosmology are derived from a common source through a single process. The superspace is therefore not the next turtle in the tower, but part of the same initial conditions as the finite space. This space is not defined by reference to the superspace, that is, by a geometric boundary, but is instead self-defined by containing a finite number of orthogonal potentia.

While we have arrived at a point common to many cosmological models, this has required somewhat of an intellectual journey, whereas others have merely postulated the existence of such a configuration. However, a postulated space is generic and can be considered only in terms of the evolution of a simple geometric object. The above considerations allow us to see this space as having originated from a finite series of events and to therefore have a definite substructure.

34. Nature's Attempt to Realise the Intermediate Potentia – Epoch II

Epoch II is a do over of epoch I and therefore involves exactly the same event – the attempted realisation of an intermediate potentia. However the outcome of the assertion of the intermediate potentia in epoch II cannot be predicted based on the events of epoch I since the circumstances have changed. When new potentia were continually being realised in epoch I the only resolution to over-specification was the establishment of a single non-static definition of the initial state. This required the successful realisation of the intermediate potentia in order to establish a causal timeline. But epoch II is based on a different causal schema that takes into account the failure to realise the intermediate potentia in epoch I. New potentia are not constantly generated, instead all the potentia that had been proven to be orthogonal in epoch I are asserted at the same time. In this way the environment of epoch II incorporates every potentia that has as yet been revealed by nature's evolution into a composite definition of the initial state, thereby resolving over-specification and demonstrating that no first cause is required. For this static definition to be maintained as a resolution to over-specification all that must occur is that the attempted realisation of the intermediate potentia once again fails. The first potentia to be realised, *a* and *c*, had no determinable properties and therefore realisation only required that there was no constraint to prevent it. But as evolution progress more specific properties of the potentia are revealed thereby greatly complicating assertion. In epoch II the intermediate potentia is not bounded by the realised states *a* and *c*, but by their pre-asserted representations, which we shall refer to as the orbitals a_j and c_j. Each orbital represents a potential independent definition of the entire initial state, with only the difference schema based on the number of maxima linking them as a single composite definition. The attempted realisation of the intermediate potentia must now take this property into account.

a. The Difference Schema and the Assertion of the Intermediate Potentia

Before we can consider the attempted realisation of the intermediate potentia, it is necessary to settle on a representation for the number of maxima that distinguishes each orbital. It might seem tempting to talk in terms of frequency, but this is not an appropriate term for this evolutionary epoch. Instead we shall simply note that two maxima, one representing x_j and the other $\neg x_j$, can be represented by the principal quantum number *n* with a value of 1, and thereby establish conformity with how atomic orbitals are labelled.

In epoch I intermediate potentia were defined purely in terms of their minimum domain of expression, which was enhanced by the constraints introduced by the boundary conditions *a* and *c*. But now a_j and c_j have as an additional defined property the number of probability amplitude maxima, n_a and n_c respectively. This must be taken into account as an additional boundary condition when determining the pre-asserted representation of the intermediate potentia, b_j. In epoch I the intermediate potentia could not be realised because its pre-asserted representation introduced two-directional time. The pre-asserted representation of b_j in epoch II could also potentially be defined in the direction a_j to c_j or c_j to a_j. However these separate temporal representations must now demonstrate that they are in fact intermediate to a_j and c_j in terms of the difference schema. This means that for the temporal direction a_j to c_j

$$n_b = n_a - n_c \quad \text{where} \quad n_c > n_a \quad \text{therefore } n_b \text{ is negative} \qquad \textbf{E 1}$$

and for the temporal direction c_j to a_j

$$n_b = n_c - n_a \quad \text{where} \quad n_c > n_a \quad \text{therefore } n_b \text{ is positive} \qquad \textbf{E 2}$$

These expressions might seem absurdly trivial but they are not, since they represent the first time nature had a motivation to perform a subtraction. Mathematics evolves as necessity dictates. Both of the above outcomes, n_b negative and n_b positive, are mathematically correct, but as we stated earlier: *Nature does mathematics, like accountants, with a predetermined goal, in nature's case the need to overcome the flaw of having no first cause. There are therefore correct answers and incorrect answers, with each outcome producing different consequences.* But there is a subtle but important difference in the above situation, since whether an outcome is acceptable or not is not exclusively determined by if it overcomes the flaw of there being no first cause, it must also be possible for the solution to be accommodated within the difference schema, that is, it is now essential that the solution can be physically manifest within a specific environment. The answer n_b positive can be considered physically relevant because the property of having a positive number of maxima is already defined within the difference schema. An intermediate potentia can therefore be realised with this positive number of maxima. However the answer n_b negative cannot be considered physically relevant because evolution has not as yet revealed any physical manifestation for the mathematical conclusion that there can be a negative number of maxima and therefore the solution n_b negative cannot be expressed. This means that for the property n_b only the values that relates to the temporal direction whereby $c_j \rightarrow a_j$ can be expressed, given the additional boundary conditions imposed by the difference schema.

b. A More Fundamental Basis for Renormalisation

Nature's determination that the calculated answer n_b positive is physically relevant while the answer n_b negative is not can be considered to be the first example in nature of a process physicists call *renormalisation*. Physics is largely expressed in terms of differential equations such as the Schrödinger equation, but such equations inherently possess an infinite number of solutions and as Hanson pointed out, *"…equations equally well satisfied by any one of an infinity of values hardly constitute an intelligible physics at all…* [374]*."* This situation is addressed by renormalisation, which *"…rejects as unpromising most solutions of any wave equation. But it does this in a manner mathematically objectionable, physically arbitrary and aesthetically inelegant* [374]*."* It is not surprising then that Feynman argued that renormalisation *"…is what I would call a dippy process!* [2]*,"* and that, *"…I suspect that the process of renormalization is not mathematically legitimate* [2]*."*

Feynman is correct in saying that currently renormalisation is *not mathematically legitimate* not merely because there is nothing in the equations themselves to determine which solutions are *unpromising*, but because our conceptualisation of mathematics gives no legitimacy to the concept that a correctly calculated answer might nonetheless be an unacceptable one. However in the re-conceptualisation of mathematics necessitated by this cosmology it is exactly this idea that must be introduced, but as stated earlier: *We must strive to incorporate such fundamental aspects of nature not merely into applied mathematics but into the founding axioms, if not of pure mathematics, of the mathematics of physics*. Renormalisation cannot simply be a *dippy* process tacked on to pure mathematics with little or no justification, since it is clear from the evolutionary history that nature does in fact function in this manner and therefore so must the mathematics of physics at a fundamental level. This is essential because even if we accepted renormalisation as justifiable on purely pragmatic grounds, its application still remains too subjective, with an alternative rejected as unpromising by one physicist included as legitimate by another. Only through the development of a distinct mathematics of physics that formalises the process of assessing whether a calculated answer is acceptable to nature or not can the process of renormalisation be made objective and mathematically legitimate. This process must be guided by a greater understanding of the goals of nature's evolution and by examining instances like the one above where nature itself rejects correctly calculated answers because they can have no physical manifestation. No cosmology reviewed can provide any assistance in this process; it is left therefore to the Flawed Nature Cosmology of this consideration to establish the broad basis for this work. If it is not undertaken renormalisation will remain a *dippy* process with no formal mathematical legitimacy, restricted to separately considering isolated physical situations and providing an inconsistent range of solutions dependent of the variable opinions of different physicists.

c. Realising Individual Properties of the Intermediate Potentia

The enhanced boundary conditions of epoch II provide sufficient constraints to determine that the property n_b has assumed a positive value consistent only with a transition from c_j to a_j, but does this mean that the intermediate potentia has only one probability amplitude curve in this temporal direction? No. The potential to go from c_j to a_j or a_j to c_j still exists; it is just that in this current environment the property n_b can only assume a value consistent with $c_j \rightarrow a_j$. However as we have seen above, nature is willing to patiently wait for future causes to resolve its flaws. But where a state can possess a number of different properties, situations will inevitably arise that can resolve one property while not resolving them all. In such cases nature does not wait for a perfect solution but instead resolves what it can now and continues to wait for future circumstances to resolve the remaining properties. The orbital environment in conjunction with the difference schema allow the resolution of the property n_b but does not provide sufficient constraint to guarantee that some future circumstance will not allow a transition from a_j to c_j by providing a physical basis for the positive values of n_b. This situation results in the intermediate potentia being realised, even though it is only the property n_b that can assume a totally resolved value.

d. The Further Evolution of Time – Epoch II

The orbitals c_j and a_j are part of the static definition of the initial state established as epoch II. But with the successful realisation of the intermediate potentia they become part of the non-static definition sought in epoch I. Therefore c_j is determinably the past state of this limited universe and a_j its future state, with the consequence that $c_j \rightarrow a_j$. Nothing moves here but time.

It must be clearly understood that the number of maxima n_b was not removed from c_j to establish the intermediate state, there was simply the constraint that the intermediate state must be realised with this number of maxima. It is not that c_j has n_b fewer maxima, but that it is equivalent with a_j, where $n_a = n_c – n_b$. You might still want to ask: *What happened to the extra maxima in c_j?* The fact is that providing normalisation is maintained a potentia can be equivalently defined by any number of maxima. Orbitals do not spontaneously change their number of maxima because the realisation of an intermediate potentia is required to establish a causal link between them and thereby establish an instance of temporal progression. The orbitals are temporally static in terms of alterations to their established parameters, but for the realisation of intermediate potentia. The apparent affect on c_j is just the evidence of one instance of temporal progression. Because of the uniqueness of all potentia, the equivalence of the representations of c_j and a_j means that the total definition of epoch II contains one less potentia, one less orbital.

Epoch II is now a mixed temporal environment whereby the orbitals are established from the static composite definition, but this stasis is periodically disturbed by individual events that establish that specific orbital pairs as boundary conditions for a non-static definition. Epoch II was established as an environment characterised as the present, yet epoch I's temporal schema characterised as the future has managed to infiltrate its way into it. Here we can see the intertwining of the present and the future within one evolutionary epoch, the first stage in the evolution of the *block universe* of general relativity where, as we have seen above[20], *the past, present and future all exist seamlessly*. The past, present and future are neither isolated nor abstract. The different levels of time become interwoven into the one evolutionary epoch, the one universe, and are as clearly evidenced there as any material aspect of that environment. We stated earlier that this cosmology could extend the domain of physics to include the direct study of time. As more of nature's evolutionary history is revealed, it becomes even clearer how this can be achieved.

e. The Temporary Nature of Proof

It is an attribute of physics that no matter the number of positive experimental results this cannot prove a theory correct, since some time in the future there may be a result that contradicts the theory. This is why Popper [35] adopted a terminology based on the concept of *falsifiability* rather than proof. But it is reasonable to model physics in this way since nature itself faces the same situation. There had been an astronomical number of events in epoch I where an intermediate state could not be asserted, each proving that a pair of potentia such as *a* and *c* were independent. But in epoch II intermediate potentia are asserted thereby refuting what had been proven in epoch I. This should not be surprising for three reasons. Firstly, nature's evolution is very much a process of trial and error. Secondly, each new evolutionary epoch sets out a new approach to overcoming nature's flaws and therefore should produce different results. Thirdly, nature's evolution is not temporally linear but involves do overs that do not change past results but establish new ones as if this was the first time a resolution of the event was attempted. But, like physicists, nature must base its actions on what is currently considered to be true. Therefore epoch I's proof of the orthogonality of potentia such as *a* and *c* provided the basis for the establishment of the orbital environment of epoch II. But this in turn provided a new set of circumstances in which intermediate potentia could be asserted. Within an evolutionary environment that allows do overs proof is at best temporary.

f. Realising Individual Properties and the use of Measurement Operators in Quantum Mechanics

It is a striking feature of quantum mechanics that it uses measurement operators that resolve individual observable properties that can be manifest for a particular state. In the hypothetical in chapter two the wave family prisms represented these measurement operators. This approach necessitates that a superposition is not simultaneously resolved in terms of all of its properties, but instead each property is measured separately. There are two reasons in this cosmology for this approach to measurement. Firstly, ultimately the initial state is to be defined by a single property so that we must enquire of the wavefunction what its amplitudes would be within a universe defined exclusively by this property. A non-static definition still only provides one definition at a time. A composite definition provides a wavefunction that is the sum of the pre-asserted representation of several potentia, but a measurement must still be made after this composite wavefunction has been decomposed into the wave family of the measured observable, that is, as if the universe was only defined by the property being measured. The second reason measurement operators must be used is the situation we have just discuss above, the

[20] Chapter Two: 10 b. *Retrocausality in Physics*

capacity to realise one property of a superposition independent of the resolution of all properties. Human beings, because they live in a macroscopic world, have gained the impression that all the properties of an object can be simultaneously resolved. But as this cosmology seeks to demonstrate, the struggle to establish existence is more difficult than this and nature therefore more willing to find incremental solutions.

g. The Further Evolution of Physics – Epoch II

In epoch I the specific properties of the bounding states *a* and *c* played no role in determining if the intermediate potentia would be successfully realised. In epoch II because the property *n* is not unique to one potentia but is common to all, thereby providing the basis for a composite environment, the intermediate potentia is constrained to take this property into account. The need to physically manifest the different possible values of n_b provides an additional constraint that allows b_j to be successfully asserted. In this way the assertion of the intermediate potentia takes on more of the properties of an interaction. However, interaction need not involve existent states bumping into each other in a spatial environment, or the physical exchange of some quantity between them, it need only involve complementary constrains operating through a shared property.

Potential is no longer the only arbiter of outcomes. The determination of the next event to occur must involve the specific properties of the bounding states to maintain conformity with the overall environment. It must involve interactions. In this way nature has adopted more of the characteristics of physics, not because the laws of physics either pre-exist or are pre-ordained, but because the process of evolution has demonstrated the benefits of this approach.

h. Concluding Comments on Nature's Attempt to Realise the Intermediate Potentia – Epoch II

The realisation of an intermediate potentia, which had been impossible in epoch I, has been achieved in epoch II by this event assuming more of the characteristics of an interaction. But this has left epoch II expressing two causal schemas, one based on a static composite definition and the other on a changing definition. Nature is rapidly becoming more complex.

35. This Cosmology and Atomic Models

We stated earlier that: *What we are describing, and what nature is establishing in epoch II, is clearly the precedents for the space of atomic orbitals,* it therefore seems prudent to pause at this point and compare our description of epoch II with various atomic models. As we shall see this is possible even though epoch II includes no equivalent to protons, neutrons or electrons to occupy the orbital space. We shall see in the next chapter how these particles become inseparable components of the orbital environment in order to satisfy additional constraints introduced by the causal schema of epoch III, our universe. While it is tempting to equate the successful assertion of an intermediate potentia with an ejected photon this is far too simplistic, instead we shall consider in detail the nature of the asserted intermediate state in the next section. Here we need only consider the intermediate state's role in the causal sequence of this epoch.

It might at first glance seem strange to reconsider models of atomic structure such as Bohr's that have long since been superseded, but what we are seeking here is not to create a better model of the atom but to establish a better understanding of it. This is done to further demonstrate that *evolution cannot be isolated as the sub-discipline of cosmology, but must be incorporated into every aspect of our description of the material world*. We noted earlier Feynman's statement that, " *The more you see how strangely Nature behaves, the harder it is to make a model that explains how even the simplest phenomena actually work. So theoretical physics has given up on that* [2]." What is necessary to set such pessimism aside is to come to a level of understanding of nature's evolution whereby it can be seen that nature is not acting strangely, but exactly as its evolutionary history dictates it must.

a. Comparison of this Cosmology with the Bohr Atom

If classical physics is used to model atomic structure as if an electron were in a planetary type orbital, then because the electron is constantly changing direction to maintain its orbit it is accelerating and therefore should radiate energy continuously and because of this energy loss spiral into the nucleus. To overcome this serious crisis in classical physics' ability to describe microscopic states Bohr simply, " *…assumed that the electrons existed in those orbitals without emitting radiation* [375]." Since no justification was given for this, the science historians John Heilbton and Thomas Kuhn described such an assumption by Bohr as an " *…extra-mechanical fiat* [376]." In the simplified visualization of the finite space of this cosmology it is composed of orthogonal circular orbitals, each of which is the pre-asserted representation of a potentia that could define the entire initial state and therefore must be considered as an independent environment. An electron in an atomic orbital is considered to be accelerating because it is constantly changing direction in order to maintain its orbit. However the orbitals of this cosmology have no space surrounding them to accommodate straight-line motion. Because the orbitals of this cosmology must be considered as isolated environments, the geodesic equivalent to a straight line is the circle itself. Taking the circle as the reference frame, motion along its geodesic path does not constitute acceleration.

But there is a more fundamental reason an electron occupying this space would not experience acceleration. The orbitals are the pre-asserted representations of the potentia, but nature learned in epoch I that such representations cannot be successfully asserted and so no assertion is attempted. The orbitals are not an existent space, not because we have not performed a measurement on them, but because nature has learned that it does not serve its purpose for such a measurement to occur.

While workers in the field of particle physics such as Gerard 't Hooft are comfortable making the statement, " *A single electron can be at many places simultaneously* [158]," for most people this violates their sense of reality. However, it is one of the functions of cosmology to construct a framework within which all the observations of physics make sense. Each orbital defines its own limited universe, with its *pre-asserted representation determining the flow of uncertainty of realisation for the constituents of this universe*. An electron, which itself only maintains existent expression for the finite duration of the present instant of epoch III[21], would have its probability of realisation within this orbital determined by the orbital wavefunction. This you might complain provides a rather simplistic picture of

[21] See Chapter Two 18c. *Predicting the Introduction of a Present Instant with a Finite Duration*

the atom and you would be right. The presence of particles such as protons, neutrons and electrons, with their associated forces, no doubt adds additional constraints that both refine this underlying environment and make it more difficult to distinguish as a separate entity. But this is why it is important to reconsider structures within this universe such as the atom, with reference to earlier and therefore sparser evolutionary epochs. We are not trying to change how the atom is modelled only how it is understood. While there is a determinable regular pattern of probability amplitudes and thereby a pattern of potential locations for the electron there is no realised and thereby fixed location and certainly not the sequence of fixed locations necessary to the definition of acceleration. Heisenberg's statement that the elements of atomic structure do not posses the same order of objective reality as *"…stones and trees…*[65]*,"* but rather reflect, *" …something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality* [8]*,"* is not only true but necessary in the sense that past failures dictate that nature has no choice but to work this way.

Classical physics predicted that the frequency of the light emitted from an atom should be determined by the properties of the electron within an orbital, but this did not agree with the experimental results. Bohr's model of the atom was accepted, despite its use of unjustified postulates, because it predicted that the frequency of the light emitted from the atom would be equal to the energy difference between two orbitals and this did agree with the experimental data. But this was still considered to be an anti-intuitive result. However this would not have been the case if this cosmology were known at the time, since orbital collapse is necessarily modelled as involving the realisation of an intermediate state.

To arrive at the result that the energy of the transmitted light did not come in continuous frequencies but in discrete units determined by the energy difference between allowed orbital states, Bohr was forced to introduce another e*xtra-mechanical fiat*, the concept of *quantum jumps* [377], that is, that an electron jumps from one orbital to another without ever existing in the intermediate space. This concept so violated the tenants of classical physics and was so counterintuitive that Schrödinger was appalled and went so far as to say, *" You surely must understand, Bohr, that the whole idea of quantum jumps necessarily leads to nonsense… If we are still going to have to put up with these damn quantum jumps, I am sorry that I ever had anything to do with quantum theory* [95]*."* This issue was of such concern that one of the founders of quantum mechanics was willing to disassociate himself from the theory if it was not resolved.

But given this cosmology quantum jumps do not *necessarily lead to nonsense* as Schrödinger believed. Firstly, because the classical conceptualisation of space does not apply to atomic orbitals, there is no universal space with the orbitals merely traced out by the path of the electrons. Instead what this cosmology indicates is that each orbital, because it is the pre-asserted representation of an orthogonal potentia, is an independent environment. Secondly, there is no need for an intermediate space or for the electron to have a path through it to satisfy the causality of epoch II, which is based solely on the difference schema and therefore the parameter *n*. Because of the evolutionary epoch in which we live, people are used to determining causal justification in terms of the spatial path of macroscopic objects. However, in epoch II such a causal system has not yet been introduced. We must judge the outcome of events according to the causal system applicable to their environment, rather than mistakenly impose on them expectations only applicable to a later evolutionary epoch. The question therefore is not whether quantum jumps violate our expectations based on our experience of the current spatial environment, but whether they violate the causal schema applicable to the environment in which they occur. The causal schema of epoch II does not involve motion through space, only the realisation of discrete intermediate states, taking into account the difference schema based on the property *n*. If an intermediate potentia is successfully asserted one orbital instantaneously becomes equivalent with another. Any electron occupying such an orbital would not truly go anywhere, always remaining in the orbital it originally occupied; it is just that this space is now equivalent to that of another orbital. In this way the electron does not undertake any motion in the radial direction, still only concerned with the flow of probabilities for its realisation around the original orbital. Therefore the transition of the electron between orbitals as described by this cosmology is a singular action without any transit through an intermediate space and is therefore in keeping with Bohr's postulate of quantum jumps between atomic orbitals. That we can still see such events in the current evolutionary epoch arises because *the initial state of this consideration cannot be influenced by any causal past and therefore its evolution must involve self-exploration rather than progression*. As we have just seen above[22], *Epoch II was established as an environment characterised as the present, yet epoch I's temporal schema characterised as the future has managed to infiltrate its way into it*. This precedent, as we shall see in the next chapter, continues so that not all of the events we see in this universe obey the most recent causal schema, so that the causal schema of epoch II is still applicable in some circumstances even within the spatial environment of this universe. In this way physicists continue to be able to evidence the precedents established by previous evolutionary epochs, thereby bringing all of cosmology within the domain of empirical physics.

Bohr claimed that, " *No language which lends itself to visualizability can describe the quantum jumps* [65]*.*" Yet what we are dealing with in this section is specifically a simple visualization of epoch II. Bohr was not wrong given the conceptualisation of nature prevalent at that time. Similarly, Schrödinger's objections no doubt arose because he felt that quantum jumps violated any reasonable description of nature. But it is the very conceptualisation of nature used by physics that this consideration seeks to re-evaluate. In the context of the cosmology of this consideration quantum jumps are not only comprehensible and visualizable, they are necessitated in order to accurately describe nature.

b. Comparison of this Cosmology with the Schrödinger Atom

Bohr's intuition was truly remarkable, but could not be justified in the absence of a cosmology like the one being developed here. Therefore most physicists at the time were uncomfortable with Bohr's use of " *…extra-mechanical fiat*s [376]*,*" the first and most fundamental of which was to postulate that the angular momentum of the electron had to be given in integer multiples of Planck's constant, *h*. This established Bohr's discrete set of allowed atomic orbitals, in a way similar to the repetition of the same minimum domain of expression, that is, maximum region, modelled by this cosmology. Schrödinger realised that waves provide an inherent mechanism for quantisation that could replace Bohr's postulate that the angular momentum of allowed orbitals was quantised. In his model of atomic orbitals they are therefore composed of standing waves [370]. Schrödinger wrote of his model of

[22] Chapter Three: 34d. *The Further Evolution of Time – Epoch II*.

atomic orbitals that, " *What seems to me to be important is that the mysterious 'whole number requirement'* (in Bohr's model) *no longer appears, but is, so to speak, traced back to an earlier stage: it has its basis in the requirement that a certain spatial function be finite and single valued* [378]." What Schrödinger is referring to is the requirement the waves must join neatly nose to tail, since it is clear that if this were not the case the waves would interfere with themselves and eventually cancel out. This cosmology can trace this requirement back to an even earlier stage, to that point in nature's evolution where the orthogonal potentia adopted a pre-asserted representation based on a self-definition path. As stated earlier the first constraint on repetition *that it cannot introduce an imbalance in the number of* x_j *to* $\neg x_j$ *maxima regions, since this would represent a preference for one over the other.* Combined with the fact that *since what is occurring is repetition the footprint of each maxima region on the circular aa-axis remains constant,* this effectively ensures that the probability amplitude curve must be smooth and continuous. The difference between this cosmology and Schrödinger's orbitals is that he imagined that there were any number of intermediate orbital waves which, since they did not join neatly nose to tail, were eliminated from the orbital schema by self-interference, in this cosmology it is unnecessary to imagine any waves being lost in this way.

Schrödinger's model of atomic orbitals introduced his new form of quantum theory based on wave mechanics. Fundamentally what this did was replace the Newtonian description of nature in terms of the motion of point masses with a description based on waves. This was rationalized by the similarity between the ray depiction of geometric optics and the paths of material points. As Schrödinger stated, " *The point of view taken here, which was first published in a series of German papers* [379-382], *is rather that material points consist of, or are nothing but, wave-systems. The extreme concept may be wrong, indeed it does not offer yet the slightest explanation of why only such wave-systems seem to be realised in nature as correspond to mass-points of definite mass and charge. On the other hand the opposite point of view, which neglects altogether the waves discovered by L. de Broglie* [383] *and treats only the motion of material points, has led to such grave difficulties in the theory of atomic mechanics – and this after century-long development and refinement – that it seems not only not dangerous but even desirable, for a time at least, to lay an exaggerated stress in its counterpart. In doing this we must of course realise that a thorough correlation of all features of physical phenomena can probably be afforded only by a harmonic union of these two extremes* [186]." The Schrödinger equation itself is a partial differential equation, which like other equations of this form, can literally have an infinite number of solutions, so that the general solution need not be sinusoidal at all. Schrödinger did not arrive at the wave mechanics because of any mathematical necessity or through a description of nature that would justify it, but because some alternative to the mechanics of point motion had to be found since this did not give agreement with what was known about atomic physics. Schrödinger's choice of a sinusoidal general solution to the differential equation is no less an " …*extra-mechanical fiat* [376]" than Bohr's postulates, it is simply subtler and like Bohr's postulates accepted because it allows the calculation of results that agree with experiments. But if we are to claim that we truly understand atomic structure, or quantum mechanics itself for that matter, we must be able to justify this use of standing waves in terms of how they arose in nature's evolution. This we have done above[23] in terms of how the pre-asserted representation is maintained.

Schrödinger considered that, *"…material points consist of, or are nothing but, wave-systems …*[186]*,"* and therefore that his waves were in a real sense the electrons themselves. However by reference to this cosmology it can be seen that the orbital environment evolved before particles such as electrons and therefore these two states need to be distinguished. Max Born's probability interpretation [187] did in fact separated these two things – the wave was not the particle but a measure of the probability of finding the particle at a particular location. This is equivalent to this cosmology's statement that *each orbital defines its own limited universe, with its pre-asserted representation determining the flow of uncertainty of realisation for the constituents of this universe.*

That such probability waves are not considered to be a material part of the environment of this universe is largely a human prejudice arising from where we exist along the evolutionary timeline, which has meant that we experienced first the real waves of the ocean and of moving currents of air. People therefore see waves of probability as something unfamiliar and perhaps even unreal. But when we examine the evolution looking forward from the beginning, instead of by looking backwards from the current epoch, we can see that the material waves that we first encountered simply reflect the earlier precedent of the probability waves, which are no less real an aspect of nature. These waves merely represent a view of the pre-asserted states, whereas the material waves people first encountered apply the same precedents to post-asserted states. Nature, because two-directional time unless overcome by specific circumstances prevents successful assertion, prefers the pre-asserted view. As humans we prefer the realised representation and impose this through our experimental apparatus, which forces the attempted realisation of the potentia. In this way we cause a progression from the pre-asserted representation to the post-asserted one. The waveform is how nature sees much of itself, while the measurement product is how we demand to see it. But to understand nature fully we must moderate this preference in our view of it, since much of nature's evolution involves developing the complexity of the pre-asserted representation.

Schrödinger's consideration of atomic orbitals introduced wavefunctions and quantum mechanics as we know it today. But it did not allow any fundamental understanding of what a wavefunction is or why it should occur in nature. This cosmology introduced the wavefunction in epoch I as a natural consequence of the initial state boundary conditions. We can therefore clearly state what a wavefunction is, the pre-asserted representation of an intermediate potentia. The orbital environment simply introduced additional constraints that further refined this pre-asserted representation. However, the wavefunctions of this cosmology are not yet the same as those of quantum mechanics, there are still more details of their development for evolution to reveal.

c. Comparison of this Cosmology with the Atom of Quantum Electrodynamics

As Baggott pointed out, *" Quantum electrodynamics – the quantum field version of Maxwell's classical electrodynamics* [384, 385] *– deals with the forces of electromagnetism. This theory has proven to be tremendously powerful and*

[23] Chapter Three: 30c. *The Pre-asserted Representation of a and c, and Standing Waves.*

successful, but it has done nothing to dispel the difficulties over interpretation. …The progress that has been made over the last 60 years has certainly improved the predictive power of the theory (quantum mechanics), *but it has really been a matter of sharpening the mathematical formalism rather than our understanding of it* [95].*"* QED provides the most recent model of the atom therefore, in looking for an understanding beneath its formalism, let us compare it with this cosmology.

Because QED models the electromagnetic force in terms of the exchange of virtual photons between charged particles, it has the electron held in its orbit by multiple virtual photon exchanges between the proton and electron [2]. In this model, *"…virtual photons of the vacuum interact with stationary states of electrons in atoms. The result of this interaction is a transition of a photon from virtual to real state (with energy supplied by the excited electron of the atom) and the transition of an electron from one excited state to another below it (or to the ground state)* [386].*"* We shall deal in the next chapter with QED's model of the electromagnetic force, here we shall simply outline this cosmology's model of emission and then compare it to that of QED.

The most pervasive and important physical phenomenon in our current universe is the emission or absorption of a photon of light when an electron makes a transition from one atomic orbital to another. Feynman asserted that QED, *"…describes* all *the phenomena of the physical world except the gravitational effect, …and radioactive phenomena…*[2],*"* yet in his lectures on the subject he takes a starting point *"…by just postulating for the emission or absorption of photons* [387].*"* In fact current physics provides no definitive explanation as to why emission and absorption occurs, since simply to say that it maintains the conservation of energy is inadequate as this could be achieved by any number of other methods. No degree of examination of the current evolutionary epoch will allow a resolution of the question of why nature has settled on this process for maintaining the conservation of energy rather than another. This can only be made clear by a study of the evolutionary history of the process. As we have seen above QED does give a phenomenological explanation for emission, but we must ask if this has any justification in terms of nature's evolutionary history.

What this cosmology shows is that a basis for emission is established in epoch II, before the evolution of electrons, protons or photons, either virtual or real. Nonetheless, if for the moment we equate the assertion of the intermediate potentia of this cosmology with the emission of a photon, it is clear that the virtual photon is just its pre-asserted representation. It is also clear that the photon is not emitted from the electron, or from the orbital space itself, but is a newly asserted intermediate state constrained to comply with epoch II's difference schema and thereby take as the value of its number of maxima $n_b = n_c - n_a$. The property n_b is retained even after the effect of the assertion of the intermediate state is complete. This does not involve any physical exchange of maxima between the realised intermediate state and the collapsing orbital, only complimentary constraints that equally result in a conservative system. Therefore QED's statement that emission is related to *a transition of a photon from virtual to real state* seems to have a precedent in the evolutionary history. The emission of a photon as the method for maintaining the conservation of energy when an electron goes from a higher to a lower orbital, maintains a precedent established with the very first event that occurred in nature's evolution, the attempt to assert an intermediate potentia that would allow one of the states that provided the boundary conditions to become equivalent to the other, which in epoch II is evidenced as an orbital transition. The assertion of intermediate states was unsuccessful in epoch I but achieved in epoch II and has simply further evolved with the establishment of the environment of this current universe.

d. This Cosmology and Spontaneous Emission

An anomaly with the standard derivation of atomic orbitals using quantum mechanics is that they are stationary states and therefore should be eternally stable. But in practice this is not found to be true, since as Hoyle and Narlikar point out, *"…we know that the electron jumps 'down' from the state of energy E_m to the state of energy E_n ($E_m > E_n$) even if no external field is present. Such jumps are called spontaneous transitions to distinguish them from the induced transitions caused by ambient electromagnetic fields* [388]*."* Spontaneous transitions are seen as the response of the entire universe to the presence of the electron in a particular orbital, *" It is the nature of the response from the universe which will decide whether there should be transition at all, and, if so, with what probability. Thus the apparently local process of spontaneous transition will turn out to depend on the large scale structure of the universe* [388]*."* This can be simplified by considering only the electron that will undergo the spontaneous transition, labelled *a*, and a particle which will at some future time absorb the emitted photon, labelled *b*, then it is said that *"…the induced transitions of* a *arise from its interaction with the retarding field* b*…*[388]*."* But whether we consider the entire universe or just the final absorber of the emitted photon, this conceptualisation of spontaneous emission involves what Einstein termed as, *"…spooky action-at-a-distance* [389]*,"* which in his view had no place in a scientific theory.

But if there is no obvious physical cause for spontaneous transitions, why do they occur? What this cosmology suggests is that they occur because of the need to assert an intermediate potentia to retrospectively either prove the causal association between the two orbitals, or by the failure of the assertion of an intermediate potentia to reassert their independence. Spontaneous emission occurs therefore not because of a physical imperative that can be causally justified by examining this universe, but by a cosmological imperative that can only be clearly understood in terms of a truly fundamental cosmological model.

The other feature of spontaneous emission that must be explained is that they are only downward. While the above model involving universal interactions does provide a theory about this [388], a far simpler explanation can be gained by reference to this cosmology. Nature works in one of two ways, it either uses precedents established in previous epochs or it uses physical events within the current epoch. Downward transitions can use the precedents established in epoch II and therefore can be spontaneous, that is, this event does not require any physical basis in the current epoch. Upward transitions have no precedent in epoch II and therefore must be based on physical events within the current epoch, that is, they must wait for interactions with incident photons. This again implies that a full understanding of the working of this universe cannot be achieved without a detailed model of its evolutionary history, but this should hardly be surprising, since this epoch is clearly the product of all that preceded it.

Note however that while the basis for spontaneous emission can be most simply understood in terms of the evolutionary history of this process, this does not mean that the large scale structure of the universe does not play a role in this and other localized events. The large scale structure however does not exert a *spooky action-at-a-distance,* but merely provides additional fine-tuning of the boundary conditions for the intermediate state, that is, each intermediate state's pre-asserted representation within this universe is not dependent solely on the upper and lower orbitals, but on the broader constraints imposed by the entire universe. This provides one aspect of quantum mechanics' non-local, universal character. This occurs because the universe is an entangled system whereby individual states can no longer be isolated to provide simple boundary conditions.

e. This Cosmology and Absorption

As Compagno *et al* pointed out, *" It is interesting to remark that while the behaviour of the field in the phenomenon of emission has been discuss in great detail… the absorption does not seem to have attracted much attention… The reason is probably that absorption has been perceived as complementary to emission and that because of this little new information could be obtained from such a study* [390]*."* From the point of view of cosmology nothing could be further from the truth. Emission was possible in epoch II but absorption was not, therefore it represents one of the most fundamental differences between epochs II and our current universe. However, for completeness, we shall give the fundamental basis for the absorption process here, while providing further details of how this is affected by the presence of the electron in the next chapter.

Firstly we must comment that while we have continued to use the terms 'emission' and 'absorption,' it is clear that these are not accurate descriptions of what is occurring. In the rarefied environment of epoch II there are no electrons to emit or absorb photons, instead emission can be equated to the successful assertion of an intermediate potentia, and this, if we wish to relate it to existing theories, can be compared with QED's proposal that emission involves a virtual photon making a transition to a real state.

The difficulty with saying that absorption is simply complementary to emission is that there is no simple complement to assertion. This problem must be reconsidered from first principles. Emission was possible because the pre-asserted representation of the intermediate potentia did not include probability amplitude paths for both directions c_j to a_j and a_j to c_j, since for the latter the number of maxima for the intermediate state was $n_b = n_a - n_c$ where $n_a < n_c$, which was negative. This was the correct mathematical answer but no substantive representation could be given to a negative number of maxima. It is like a mathematician discovering negative numbers before he has conceived how these new abstract entities can be related to real objects of experience, such as a debt that is owed [373]. Similarly for nature there can be correct theoretical answers that must await real objects that can satisfy their properties. As physicists we have already encountered this problem when Dirac suggested that the negative energy solution to his equations implied the existence of real negative energy states [391], an assertion experimentally confirmed by Carl Anderson [392, 393]. Dirac visualized these negative energy states as *'holes,'* that is, regions where the addition of energy would only result in a return to the ground state. But there are no 'holes' in epoch II in the sense that Dirac suggests, just more knowledge than substantive reality can express.

Feynman [394] introduced the concept that negative energy states, or anti-particles such as the positron, are the same as their equivalent particles moving backwards in time, for example, *" An electron travelling backwards in time is what we call a positron* [395]*."* Let us therefore consider what this would mean in terms of this cosmology. Epoch II has a single arrow of time, from higher to lower orbitals, that is evidenced by the realisation of intermediate potentia. As evolution progresses into epoch III, this universe, this arrow of time will be literally visible in terms of emitted light. But this implies that for a photon of light to return to an atom is in a real sense the temporal opposite of the emission. It does not simply add maxima to the atom, it provides a causal justification, the very definition if you like, of negative maxima: *Negative maxima are just positive maxima travelling in the reverse temporal direction*, just as the negative energy of a positron is just the positive energy of an electron travelling backwards in time. Since symmetry suggests that all particles should have anti-particles it is said that the photon is its own anti-particle. What this cosmology suggests is that while there is no physical distinction between the particle and anti-particle photons, so that they cannot be distinguished in free space, their temporal direction is determinable in terms of whether they are being emitted or absorbed by an atom. The incoming photon thereby provides a real state that can be associated with the concept of negative maxima. Physicists could simply reason that negative maxima are just positive maxima travelling in the reverse temporal direction, but nature had to wait for a new evolutionary epoch and a physical event that demonstrated that this could be so. While at first glance this sequence of events may seem strange, is in keeping with how this cosmology has described nature's evolution – a final outcome is asserted and then must wait for a future event to provide causal justification for it. There could be a probability amplitude path from a lower to a higher orbital, but this required a representation involving negative maxima and no such representation was initially available. But a later event, an incoming photon, has provided a causal justification for this representation and thereby made it possible.

The process of asserting the intermediate potentia can now be done over now that an incoming photon has made a realisation of the negative maxima possible. But now the pre-asserted representation of the intermediate potentia is able to include both temporal directions, but as a consequence of this its assertion is no longer possible. No matter its actual source the incoming photon is, in terms of the number of maxima difference schema, indistinguishable from the originally emitted photon. It is its assertion that is no longer possible. The incoming photon is not absorbed, it is as if it never existed at all and therefore neither did the establishment of the equivalence of a higher to a lower orbital. There is never a transition from a lower to a higher orbital as such, just the undoing of the previously valid downward transition.

We have already seen that what was impossible in terms of the realisation of the intermediate potentia in epoch I because possible because of the more complex environment of epoch II. Absorption is just the continuation of this process given the even more complex environment of this universe.

f. Emission, Absorption and the Further Evolution of Time

The establishment of this vast universe from nothing is both difficult to define and for nature to achieve, because nothing is not merely the absence of structure it is also that nothing happens. The full cycle of emission and absorption is a realisation followed by its negation so that in total nothing has happened. Einstein said that, *" The only reason for time is so that everything does not happen at once* [5]*."* This is certainly how nature is compelled to use time in this universe. Ultimately a causal resolution that does not take into account both directions of time is incomplete, but one that does can have no physical consequence. Nature's solution to this problem is both simple and spectacular – it takes both temporal solutions into consideration but at different times. The processes of emission and absorption are the temporal opposites of each other, to the extent that absorption undoes emission. But this universe contains countless equivalent photons and atoms, so that a photon being emitted by one atom and absorbed by another is indistinguishable from it being emitted and absorbed by the same atom. Combined with the vastness and low density of space, this means that a photon may travel for a billion years after emission and never strike an atom and have its existence undone. In this way the motion of particles through space allows these two events to be vastly separated in time, so that both contribute to the physical nature of this universe. It is as if nature is saying: *I'll do emission at one o'clock and absorption at two o'clock and thereby enjoy an hours light.* It is not that anything in net terms has happened it is just that the full cycle of realisation and negation can be experienced.

g. Concluding Comments of This Cosmology and Atomic Models

In a conversation with Heisenberg, Bohr remarked that, *"…there can be no descriptive account of the structure of the atom; all such accounts must necessarily be based on classical concepts which no longer apply. You see that anyone trying to develop such a theory is really trying the impossible. For we intend to say something about the structure of the atom but lack a language in which we can make ourselves understood. We are in much the same position as a sailor, marooned on a remote island where conditions differ radically from anything he can ever know and where, to make things worse, the natives speak a completely alien tongue. He simply must make himself understood, but has no means of doing so. In that sort of situation a theory cannot 'explain' anything in the usual strict scientific sense of the word. All it can hope to do is reveal connections and, for the rest, leave us to grope as best we can* [376]*."* Bohr's opinion is reinforced by Dirac, *" In the case of atomic phenomena no picture can be expected to exist in the usual sense of the word 'picture', by which is meant a model functioning essentially on classical lines* [224]*."* We would agree that a picture of atomic phenomena drawn from classical concepts is impossible, but argue that such a picture drawn from cosmological concepts is not. Bohr instilled in Heisenberg the concept that, *" …atoms are not things…* [196]*,"* that, *" Since an atom was not seen, it was not a meaningful concept* [196]*."* Yet in this section we have stripped from the atom everything that could be seen, its nucleus and electrons, leaving only the temporal space such particles will later occupy and still we have been able to describe things, the very things from which this universe must be derived.

There are many attributes of atomic structure that we have not dealt with in this section, but it must be remembered that this is not a work in quantum chemistry [396] but cosmology. We have commented only on those attributes of atomic structure that this cosmology may be able to shed some light on. It is worth noting however that no cosmology reviewed has anything to say on any of these subjects, since they simply accept physics as it is currently modelled, rather than seeking to understand how its attributes evolved. All we wish to demonstrate in this section is that by taking nature's evolutionary history into consideration, simpler and more consistent interpretations can be given to currently observed behaviour.

36. The Origin of Energy

Energy in general refers to *"…the potential for causing changes* [397]*,"* while in physics it specifically refers to the work done by a particular force. The term 'energy' was first use in physics to denote the product of the mass of an object and its velocity squared by Thomas Young [398] in 1807. The Law of Conservation of Energy was introduced by Hermann von Helmholtz in 1847 [33] and states that: *Energy can neither be created nor destroyed.* The problem is that this dictate makes cosmology itself blatantly absurd. How can we deal with the origin of the universe, which in final analysis is only energy, if we cannot consider the origin of energy itself? The answer is that we cannot in any truly significant sense. Cosmology must be able to derive both the origin of energy and the law of conservation of energy if it is to deal meaningfully with the origin of the universe. However in this endeavor the first thing that we must take into account is that nature initially knew no more about how to create energy than it did about how to create elephants. There is no knowledge of a final design, only the necessity to deal with current circumstances.

a. Energy and the Maintenance of Oblivion

Is the realised intermediate potentia an existent state? As we saw earlier[24], the realised intermediate potentia can be considered to be existent if its assertion takes into account all of the potential within the boundary conditions and therefore elicits no further temporal response in terms of prompting the realisation of further potentia. A temporal response was elicited by the unbounded potentia *a*,*c*,…, since no specific property can express all of the potential of an unconstrained initial state. In the case of the intermediate potentia bounded by the orbitals c_j and a_j, assertion could not take into account the potential for a transition from a_j to c_j because no representation could be given to a negative value for n_b. However this potential remains valid since in this universe an incoming photon gives meaning to a negative number of maxima in the same sense that negative energy particles such as positrons can be considered to be positive energy particles travelling backwards in time. Therefore it cannot be said that the assertion of the intermediate potentia has taken into account all of the potential bounded by the orbitals c_j and a_j and therefore we must conclude that the realised state is not existent. Because the intermediate potentia are realised but not quite existent we shall call them *coexistent units.*

Does this mean that a coexistent unit will elicit an automatic temporal response in terms of the realisation of new unbounded potentia? Epoch I, characterised as the future, involved a sequence of realisations of unbounded potentia. However in epoch II, characterised as the present, this is no longer the case, instead all orthogonal potentia were realised at the same instant at its inception. No further potentia will be realised in the sense of epoch I until the causal schema of epoch II has run its course and a determination can be made as to whether it has succeeded in overcoming nature's flaws or not. The coexistent unit will have a temporal effect but this can no longer be manifest as the realisation of further potentia. Instead to see how this temporal effect will be manifest we must examine in more detail how it arrises. The answer to this is simple - the process of assertion for the intermediate potentia is flawed in that it does not take into account all intermediate potential.

[24] Chapter Two: 18a. *The Origin of Existent States.*

Not even nature can get away with cheating. There has been a temporal event $c_j \rightarrow a_j$, but this has been achieved by not taking into account the potential for $a_j \rightarrow c_j$ because of the physical circumstances of epoch II. But this is an insufficient cause to overcome Lucretius' [70] dictate, often paraphrased as, *'You can't create something from nothing.'* Equivalence with oblivion must still be maintained, and as we have seen above, *nothing is not merely the absence of structure it is also that nothing happens*. The temporal effect that must occur as a consequence of the realised intermediate potentia not being existent is the retention of the capacity for the negation of the temporal event $c_j \rightarrow a_j$. With hindsight gained from our experience of epoch III, this universe, we have seen that this is achieved by a photon that is incoming to an orbital. This tells us how the temporal capacity for a future transition from a_j to c_j is stored – simply by the retention of the property n_b which can later be expressed as a negative value through the physical circumstance of a photon being incoming to an orbital. It is time that causes change, energy is just a stored temporal capacity, just an aspect of time.

The problem with talking about the origin of energy is that people think that this must involve gaining something for nothing. But energy does not add anything; it is merely the retention of the capacity to negate the event of orbital collapse. Therefore energy can be considered to arise from an even more fundamental conservation, the need to retain equivalence with oblivion. Energy enters the description of nature because the realisation of the intermediate potentia did not completely resolve two-directional time, but could proceed regardless because nature is willing to wait for future circumstances to provide the complete expression of its potential. But since the potential for a transition from a_j to c_j was not accounted for in the assertion of the intermediate potentia it therefore must be retained in the post-asserted state. This allows a future event, stimulation caused by an incoming energetic photon, to undo the previous transition from c_j to a_j. The coexistent unit retains the temporal capacity for a transition from a_j to c_j and therefore for the negation of the previous event as if nothing had ever happened. That is all energy initially is. In this universe we see energy as the general capacity for an energetic body to do work on another body during interactions, but when energy was introduced in epoch II there was no capacity for kinetic, or in fact any other type of interactions, there was only orbital transitions. The broader role of energy is introduced with epoch III and an environment that permits a greater range of interactions. But that particles with discrete energy prove useful in the establishment of our universe does not mean that their evolution was sought, no more than the establishment of the orthogonal potentia was sought in epoch I, it is just that nature has no option but to use the residue from the events of the last evolutionary epoch when establishing the next.

In the current universe when an electron jumps from an atomic orbital to a lower one a photon is ejected into space. But in epoch II there is no space beyond the orbitals for a coexistent unit to fly into, instead the 'ejection' is simply that the realised intermediate potentia is no longer a part of the orbital space, but is instead isolated as a discrete state. Therefore there is no actual capacity for the negation of a c_j to a_j orbital transition, since before the introduction of space in epoch III there is no sense in which a realised intermediate potentia can be incoming to an orbital. The temporal capacity for the negation of a c_j to a_j orbital transition is retained but never actually expressed. In epoch III because the events of the transmission of a photon and a photon being incoming to an atom are separated in time because of the finite velocity of light, the negation of the c_j to a_j temporal instant will be evidenced as a separate temporal event, *in this way the motion of particles through space allows these two events to be separated in time, so that both contribute to the physical nature of this universe*.

It is easy to write a cosmology of big bangs, of huge and significant events that in an instant change everything. But this is not how evolution works. In order to understand the origin of the universe we must come to a subtler understanding of just how little has truly changed, how close to oblivion we still stand.

b. The Coexistent Unit and Inertia

We stated earlier that since a truly existent state elicits no automatic temporal response it *will remain as it was realised unless subject to some external stimulus provided by physical interactions*, thereby providing this cosmology's basis for Newton's *Law of Inertia* [29]. The coexistent unit also elicits no automatic temporal response in terms of prompting the realisation of further potentia and can only express its energy in terms of the work it does on another state and therefore must also await future interactions in order to vary from the condition in which it was realised.

c. The Conservation of Energy

That a quantity is conserved does not mean that it cannot have an origin, it simply means that the reason that it originated and the reason it is conserved are different.

In the same way that time arose as a flaw in the capacity to realise unbounded potentia, energy arises as a flaw in the capacity to realise bounded potentia. The realisation of the intermediate potentia, even though it did not take all the potential within the boundary conditions into account, still had a temporal affect on the bounding states evidenced by $c_j \rightarrow a_j$. Energy is no more or less than the retention of the capacity to negate this.

This constrains the coexistent unit to continue to express the property n_b. In this sense the history of energy can be traced back to the most fundamental property of the potentia, that it *represents as a discrete minimum entity a potential that must at some point be realised*. That a potentia has a minimum domain of expression is not a property of the state, it is the minimum nature of the state. But this minimum domain of expression involves no energy just the guarantee that the potentia will at some point be realised. The enhancement of this minimum domain of expression by repetition to provide a difference schema whereby potentia could be distinguished by the property n had absolutely nothing to do with establishing energy, it was simply a necessary enhancement needed to construct a composite definition of the initial state.

As for the conservation of energy through the conservation of the sum of all values of n within epoch II, this involves no imposed law just how this environment was established and a combination of complimentary constraints on how events within it are resolved. The counting process by which the original value of n was established for each orbital terminated with the establishment of epoch II. No new unbounded potentia are added to this epoch. The value of n a newly realised intermediate potentia must assume is determined by the constraint that it must prove itself to be intermediate to its bounding orbitals in terms of the difference schema, e.g. for an intermediate potentia bounded by c_j and a_j, the only expressible value of n_b is $n_b = n_c - n_a$. The affect of realising an intermediate potentia on the bounding orbitals is that $c_j \rightarrow a_j$ and therefore assumes the same value of n as a_j, that is $n_a = n_c - n_b$. An incoming photon in epoch III simply negates the realisation of the intermediate potentia and thereby restores the original orbitals. Therefore the conservation of the sum of the values of n is maintained by the way in which epoch II was established and by complementary constraints affecting the states involved in interactions within it.

As for the current universe, when states interact it is not only in terms of photons incoming to atomic orbitals, since both the environment and the minimum entities within it have become more complex and diverse. There are now many different types of interactions. But in every one the latent temporal capacity, quantified as stored energy, ensures that something happens, that states can affect each other. But while the progress of time is evidenced in such interactions, because they do not represent the negation of an orbital collapse they cannot remove the requirement to retain this capacity. For this reason such secondary events cannot expend energy only exchange it. That energy is conserved in this way leads to an amazing situation, whereby the same temporal potential can be evidenced many different times in many different ways.

d. Energy and the Temporal Environment of the Current Universe

Philosophers and physicists have always seen this universe as progressing into an abstract future, but nothing could be further from the truth. This universe need generate no new temporal potential instead, through the re-utilisation of energy, it continually recycles the same finite capacity for effect and change. New arrangements of the components of this universe require no extension of its temporal extent, no realisation of new potentia.

This is not to say that new potentia are not realised, they are. But in terms of new intermediate potentia realised in orbital collapse the conservation of the sum of n is maintained, as it is with the transition of virtual pair to real particles[25], so that the total temporal extent of this universe is not increased, just new elements of it occasionally exchanged for old.

There are no hidden, abstract levels of time, instead all of time is required to provide the universe that we experience.

e. Concluding Comments on The Origin of Energy

To define the origin of energy has always been considered to be impossible. But within the framework of this cosmology this problem has a quite natural, and in fact necessitated, solution. The only problems humanity cannot resolve are those it refuses to address.

37. The Coexistent Unit and Superpositions

For the first time an intermediate potentia has been successfully realised. However two-directional time has only been overcome in terms of the difference schema, with the result that it is only the property n_b that is completely resolved. This produces a dilemma; the property n_b has a single specific value, while in all other respects the potentia could still equally be realised as either b or $\neg b$. The result is a

[25] We will discuss this in more detail later.

new class of object intermediate to the pre-asserted representation and the fully resolved existent state, which has some of its properties resolved to specific values while others must assume a realised expression that still reflects their unresolved nature. This state is real in the sense that because the property n_b is resolved it assumes a specific place in the environment defined by the difference schema. But for all other properties further causal justification is required for them to be resolved to a specific value.

The nature of quantum states, that they possess as Heisenberg put it, " *…a strange kind of physical reality just in the middle between possibility and reality* [8]," has caused confusion since quantum mechanics' inception. Einstein [226] complained that quantum mechanics could not be describing reality as he understood it. Bohr simply surrendered the concept of objective reality [399]. Schrödinger could not accept this asserting that, " *Discoveries in physics cannot in themselves - so I believe – have the authority of forcing us to put an end to the habit of picturing the physical world as a reality* [65]." What Schrödinger sought was, " *…reality as something independent of what is experimentally established* [227]," a world in which all objects possess well defined properties independent of whether human beings have experimentally established their values. Heisenberg knew it was too late for such concepts, " *Some physicists would prefer to come back to the idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist independently of whether we observe them. This however is impossible* [65]." Given this cosmology we can see both why Heisenberg was correct and why this does not lead to the need to abandon the *habit of picturing the physical world as a reality*. The realisation of bounded potentia is made almost impossible by two-directional time. Physical circumstances can arise that overcome this for specific properties, but this leaves realised states falling short of Einstein and Schrödinger's ideal of having all their properties defined. Human intervention by conducting measurements does provide physical circumstances to clarify additional properties, but this does not mean that, " *You create your own reality* [196]," thereby turning physicists into small gods. The realised intermediate potentia are real enough. They were the best nature could do given the circumstances at the instant of their realisation. The superpositions of quantum mechanics merely provide an adequate description of the properties these circumstances could not resolve and nature's willingness to wait for future circumstances to provide further resolution. A physicist's measurement by its very nature must introduce physical circumstances that can resolve the property being examined, but such circumstances could also occur naturally. Humanity's involvement does not introduce features that were not already present in the natural schema, except for the capacity to choose when and where to apply them. The capacity for reasoned design. Humanity uses this to create technologies. It is interesting to wonder if nature might not have a broader use for it.

a. Graphic Representation of the Coexistent Unit

To understand the structure of the coexistent unit it must first be noted that the boundary conditions by which its pre-asserted representation was defined, the orbitals c_j and a_j, are now equivalent and therefore can no longer provide two distinct boundaries. Nor can this new state simply become another orbital. All that its realisation proved is that it is intermediate to two orbitals, which because of its realisation cease to have any separation. This is not sufficient to become an element of the series of orthogonal orbitals. But most importantly while the orbitals are self-bounded by an *a* to *a* equivalent of epoch I's *ac*-axis, this new state must continue to reflect an unresolved nature that could still result in either *b* or ¬*b* as its final expression. This new state must have a self-definition path that encompasses and binds these two as yet unresolved alternatives, while remaining a single potentia and therefore capable of only expressing a single realised expression. Added to this the property n_b must take a single values distributed over this composite representation.

The only way to gain some comprehension of such a paradoxical state is simply to draw a picture, however it must be noted that this is not meant to be an accurate depiction of the coexistent unit but simply serves as a catalyst to assist our understanding of such an unfamiliar state. We will start by representing *b* and ¬*b* separately by taking two strips of paper that have a line down the centre of both sides with arrows marked on it pointing in the same direction. We now form a circle with these strips so that the one with the arrows pointing in the clockwise direction represents *b*, while the one with the arrows pointing in the counter-clockwise direction represents ¬*b*. These two objects represent self-defined states in the same sense as the orbitals, that its they are defined by *b* to *b* or ¬*b* to ¬*b* paths. Because one potentia must have a single, smooth self-definition path, for both of these aspects of the potentia to be components of a single representation what must be done is to bring these two circles together so that a pen could move around both circles, without being lifted, drawing over the centre line while always moving in the direction of the arrows. To achieve this one strip of paper must be given a half-twist so that its upper surface can be joined to the other strip's lower surface, thereby forming a Moebius strip [400]. By pressing this single strip together two joined circles can be formed one with arrows in the clockwise direction and the other in the counter-clockwise direction. This can now graphically represent the coexistent unit.

Figure 2:

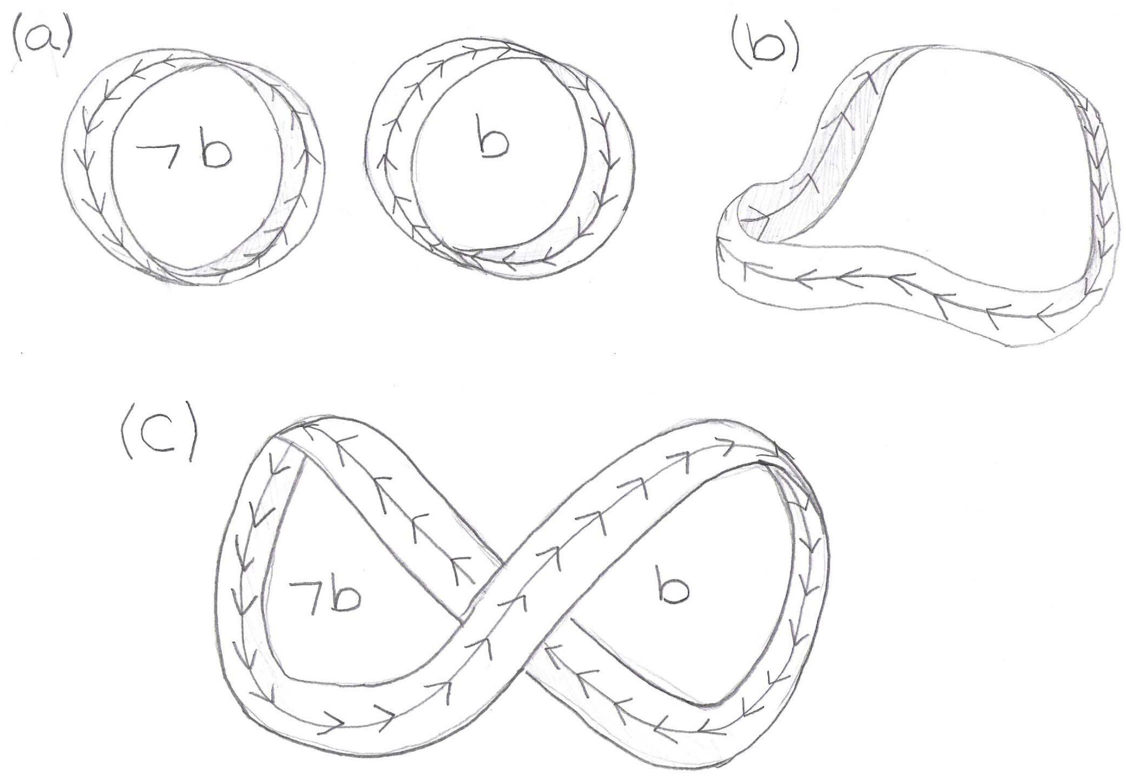

Fig. 2: A graphical visualisation of the coexistent unit. (a) The two aspects of the coexistent unit represented by circular strips of paper with arrows indicating the different temporal directions. (b) The two circles joined to form a Moebius strip. (c) The final visualisation of the coexistent unit.

The realised intermediate potentia is a complex state in two respects. Firstly, it has not resolved it final realised state, that is, whether it will be *b* or ¬*b* and therefore in some sense must maintain an unresolved representation. Secondly, it must carry over the representation of n_b from the pre-asserted to the post-asserted representation in such a way that it spans both *b* and ¬*b*. In epoch I the assertion of the intermediate potentia involved the addition of the two probability amplitude curves in recognition that they were simultaneous representations. In the orbital environment the pre-asserted representation was maintained by the amplitudes ceasing to be simultaneous thereby establishing the standing wave representation. But in the post asserted representation the possible realised states *b* and ¬*b* are geometrically separated so that each occupies a separate extent of the self-definition path. Nature must re-apply the precedent of the standing wave, that is, that one representation follows another rather than being simultaneously expressed, to this new state. But with the coexistent unit the two possible realised states occupy distinct regions of the self-definition path so that not only does no single point represent both *b* and ¬*b*, points representing each different aspect are not adjacent. The non-simultaneous expression of a point defining *b* must persist until a point defining ¬*b* is encountered. We can visualise this by reference to our graphical representation by imagining a pen moving around the centre line of the final paper strip. While the pen is moving around *b* we will consider it to have realised expression to the exclusion of ¬*b* and similarly for when the pen is moving around ¬*b*. In this way both *b* and ¬*b* are never simultaneously given realised expression. As for the value of the property n_b, it can no longer be represented by the number of maxima in the probability amplitude curve overlayed on the potentia's self-definition path, instead it takes a realised representation in terms of the number of times the pen makes one complete circuit of the joined paper strips in one unit of time. This represents a further enhancement to the nature of time in two respects. Firstly, the present instant for the realised intermediate potentia reflects two realised states without breaking the constraint that *a single potentia cannot result in more than one realised state*, since two states are never expressed at the same time. Secondly, the present instant has assumed a finite duration, as previously predicted[26].

The first thing that must be understood about the coexistent units is that they are not the desired end product of an evolutionary progression, but merely residue. As stated earlier: *Such intermediate potentia failed to be asserted in epoch I and if this remains the case in epoch II, there will be no realisation of potential, only an initial state defined by a static pre-asserted representation*. This was the desired outcome. Where the orthogonal potentia were the residue of the failed transitions of epoch I, the coexistent units are the residue of the successful transitions of epoch II, but are no more important for this success. They provide only a partial solution to the flaw of two-directional time, since even after assertion the possibility of the final state being *b* or $\neg b$ must be retained. Rather than being the solution to nature's flaws the realised intermediate potentia is simply the most detailed representation of them. It is the refinement of the question rather than the achievement of an answer.

Nature had sought a first cause that could justify the selection of one potentia as a definition of the entire initial state over all another potentia, but has now learned that this approach must fail – the problem ultimately is not that there are too many different potentia, but that the realisation of any bounded potentia involves alternatives derived from both directions of time. The realised intermediate potentia represents a transition from a choice between two different things to a choice between two aspects of the same thing. In this way the resolution of over-specification has been reduced to a choice between two specific alternatives, encapsulated within one coexistent unit thereby providing nature with the capacity for discrete choices. There need no longer be one all encompassing first cause, instead there can be any number of causes each providing a final resolution of the structure of one realised intermediate potentia. It is because of this that the outcome of individual discrete events becomes important, rather than just the establishment of a single universal first cause.

The coexistent unit represents an evolutionary progression from the unspecified potential preceding the realisation of *a* in epoch I, to a specific question. Such a situation may seem strange, but we are fortunate to be doing cosmology at a time when such states are a common component of physics – the superpositions of quantum mechanics. As we have seen above, the inventors of quantum mechanics could not reconcile the concept that physics had to be described by superpositions with any intuitive conceptualisation of nature. But we can now reassess this problem in terms of this consideration. We compared nature earlier to a sculptor who *need not know in advance what statue lies hidden within the rock, he is a questioner and the refinement of the sculpture no more than the refinement of the question, until the question is so precisely phrased that there can be no other answer but the resultant*

[26] Chapter Two: 18c. *Predicting the Introduction of a Present Instant with a Finite Duration*.

sculpture. Nature is as yet an unresolved state experiencing an evolution that is best described as the refinement of questions. Superpositions are simply the physical manifestation of this refinement, just specific questions. They are perfectly in keeping with the conceptualisation of nature presented by this cosmology. Superpositions are not something that mathematicians introduced into the description of the physical world, they were something that nature was forced to introduce, an ongoing consequence of a flawed initial state that cannot provide an absolute causal progression. Our confusion about the nature of superposition arises because of the belief that nature is perfect and that therefore for a state to be real all of its properties must be precisely defined. But as we have seen in this consideration *nature is not perfect it just does the best that it can.*

b. A Brief Review of Attempts to Realise Macroscopic Superpositions

We contend that quantum mechanics can be given a basis in reality by observing its evolution through a cosmological model. It will retain all its previously bizarre aspects such as superpositions, but they will no longer be states beyond comprehension or visualization, but seen as natural consequences of the evolutionary process. But as Herbert pointed out, *" Since 'reality has consequences' we might anticipate that if one of these quantum realities is 'really real,' we will eventually figure out how to experience it directly* [65]*,"* therefore if the quantum reality given by this cosmology is *'really real,'* and it asserts that a superposition can be a post-asserted state, then we should be able to experience such a superposition state directly. In fact several experimentalists are attempting to do just that by the realisation of macroscopic superpositions, a process not motivated by this cosmology but because it will have significant commercial implications since, *" Bridging the gap between the quantum- and human-scale realms will help in the development of a new generation of electronic, computer and communications security devices* [401]*."* In pursuit of this goal both Friedman *et al* [402] and van der Wal *et al* [403] have performed experiments with macroscopic realisations of superpositions using a SQUID (superconducting quantum interference device), as suggested by Leggett and Garg [404]. In the van der Wal *et al* experiment an underdamped DC-SQUID is used to measure the direction of the persistent super-current flow driven by a small external magnetic field in a micrometer-sized superconducting inner loop with three Josephson junctions [405, 406], with the superposition of persistent currents of opposite sign acting as a macroscopic representation of the superposition. Other schemes have also been suggested to achieve macroscopic superposition states [407-410]. The realisation of such macroscopic entangled states is of such vital importance to quantum teleportation [411], quantum computing [412] and quantum cryptography [413] that, *" It seems likely that the paradoxes of the past are about to become the technology of the future* [414]*."*

Such physical systems are clearly post-asserted representations and yet have all the attributes of superpositions. This is in keeping with what this cosmology reveals – superpositions are not pure abstractions but can be manifest in the physical characteristics of a state where there is insufficient causal justification for that state to be resolved to a single realised expression. Such states can be considered to be intermediate stages between assertion and final resolution, the physical manifestations of Heisenberg's *"… strange kind of physical reality just in the middle between possibility and reality* [8]*."*

Prior to this consideration there was no conceptualisation of nature that included superpositions, in fact according to Bohr there is no reality underlying quantum mechanics itself [156, 157], instead Bohr insisted that, *" There is no deep reality* [65]*,"* and more, *" There is no quantum world. There is only an abstract quantum description* [65]*."* The work of Friedman [402, 415], van der Wal [403, 416] and others [408, 417] which is concerned with whether superpositions can exist at the macroscopic level, goes to the heart of whether quantum mechanics is just an abstract description or whether the states it describes are physically manifest in nature. If as the evidence suggests macroscopic superpositions can be realised [402, 403], then as Bohm and Hiley asked, *" Where, for example, does the non-realistic or veiled realistic quantum level turn into the evidently realistic level? If there is no such point, then it should definitely be possible to have macroscopic quantum phenomena. Would these then be realistic, non-realistic, or veiled realistic? What is involved here is, of course, not the predictions of the theory but the question of the ontological states of the macroscopic level and the relationship of this level with the classical level* [418]*."* A new conceptualisation of nature will be needed to deal with the results of these experiments, perhaps the very one presented in this consideration.

c. Types of Superpositions

If we are to consider superpositions as a real aspect of nature, it is important to realise that they come in several different types. There are three main classifications. Firstly, superpositions of pre-asserted representations, that is, of wavefunctions. This provides the basis for the composite wavefunction or wavepacket. Secondly, superposition of post asserted-representations, involving states that were realised in physical circumstances that could not resolve all their properties. Thirdly, there are imagined superpositions that do not physically exist but are derived from questions posed by an observer. There are also sub-classes within these three main types. For the superpositions of pre-asserted representations it is important to distinguish whether the constituent representations are of multiple potentia or are multiple representations of the one potentia arising from two-directional time. For the superpositions of post-asserted states it is important to know if the superposition is of possible values the property of a single state can take, or if they are superpositions of group properties of macroscopic states. There are two types of imagined superposition. Firstly there are those that are simply due to our ignorance, that is, the state itself may have resolved a particular property but we are not as yet aware of this. Secondly, there are imagined superpositions arising from our anticipation of a situation with indeterminate outcome that has not yet occurred.

As superposition become more accepted as a real aspect of nature physicists will have to be far more precise in classifying the superpositions that are part of the problems they are working on.

d. The Realised Intermediate Potentia and the Origin of Mortality

If evolution is a learning process the coexistent units contain only one piece of knowledge, that every realisation must inevitably incorporate its own negation. Since *while the pen is moving around b we will consider it to have realised expression to the exclusion of ¬b and similarly for when the pen is moving around ¬b,* each aspect of the coexistent unit experiences both realised expression and its absolute absence. As this cycle is repeated innumerable times nature learns something new - a definition need not persist forever to be valid. Previously realisation had always been eternal. When $a \rightarrow c$ the realised state a is not lost it simply becomes indistinguishable from c. But with the elements of the coexistent unit b does not become equivalent to $\neg b$, it is expressed for a time before it fades to allow $\neg b$ its turn. The two elements of the intermediate potentia purchase their realised expression at a price, the specification of a finite duration.

The nature of the coexistent unit falls within human comprehension, since it is no more than the human condition: mortality, a mortality that is not the consequence of a flawed creation, but rather is the inherent cost of overcoming two-directional time. It was the realised intermediate potentia that taught nature that a definition need not persist forever to be valid, that life and death are an acceptable means to express potential. This is as fundamental to the final structure of our universe as nature's acceptance of changing or composite definitions as valid expressions of potential.

All of humanity's experience of this world confirms that our lives are confined to a mortal span, yet we still strive for immortality. This is neither arrogance nor folly but reflects an inherent understanding that our existence would be eternal but for a flaw that might in the future have a better resolution.

These may seem to be strange terms in which to consider the elements of a model in physics, but as stated earlier[27], *we must utilise more than the senses that allow us to observe the external world in order to come to a full understanding of nature's evolution, we must draw also on our own experience of existence. But this is a reasonable approach since to deny that the human experience reflects the evolutionary process is to say that humanity arose independently of natural evolution. This would place human existence beyond the domain of science. Evolution is a cumulative process whereby each new epoch is built upon the consequences of its predecessor, therefore there is no point where earlier evolutionary epochs cease to be evidenced in the nature of the current system. If this were not true, science would be restricted to a study of the present physical system and cosmology would be impossible. While humanity is a recent addition to the evolutionary timeline, it is the cumulative result of the totality of it and as such it is valid to look to human experience to gain an understanding of all that lead to it. Make no mistake about what is sought, it is not the stones or the trees that wish to understand the events of nature's evolution, it is human beings. In this context, there can be no true understanding that does not relate to the human experience, or in fact give credence to its origin and evolution.*

e. Concluding Comments on The Coexistent Unit and Superpositions

The first bounded and therefore specific potentia to be realised is an extremely important state, yet the description given so far is wholly inadequate. However we must re-emphasise that, while this cosmology is a minimum entity model, it is not our intention to postulate a set of properties for our minimum entity designed to solve specific problems. If you are careful enough with the design of such postulated properties, it is easy to be correct. But we are not so arrogant that we would attempt to dictate to nature its design, or even aspire to be correct, instead we simply wish to observe nature's evolution as best we can and struggle to understand. This is an essential first step, since *there can be no comprehension without a process of learning, which we deny ourselves by starting with postulates that are by definition*

[27] Chapter One: 5.*Cosmology and the Process of Learning*.

unquestionably true. Further understanding of the properties of the coexistent units must be gained by examining their role in nature's further evolution. No doubt in this process we will make mistakes. That is to be expected, since most researchers have long abandoned to the *'Too hard'* basket every issue this dissertation considers. We are not seeking to be correct in this preliminary consideration, but simply to offer within the consistent framework provided by this cosmology a demonstration that these issues can be addressed in some manner. As we have stated from the beginning: *What is sought, either by your agreement with the proposals outlined in this dissertation or by your disagreement with them, is to remove these issues from the 'Too hard' basket and place them in the 'Work in progress' basket, where they can again be addressed by the entire scientific community*.

The principal recommendation of this dissertation remains: *Don't rush.*

38. The Coexistent Unit and Particle Properties

If the intermediate potentia had been realised in epoch I it would have existed outside of the flow of time for that epoch and therefore only had instantaneous expression. But both the environment and the realised state have become more complicated in epoch II. The coexistent unit is neither a pre-asserted representation nor a completely resolved and therefore existent state, but truly *"…a strange kind of physical reality just in the middle between possibility and reality* [8]*."* As for the environment epoch II has become capable of expressing two causal schemas, both allowing the expression of multiple states without contradiction through the difference schema and of including instances where intermediate potentia are realised and therefore temporal progression and a changing definition is evident. In order to understand the coexistent unit we must come to grips with both its partially resolved nature and the dual temporal environment within which it has evolved.

a. The Internal and External View of the Coexistent Unit

According to Tegmark [248], the development of relativity theory and quantum mechanics has taught us that we must carefully distinguish between the external and internal views of a mathematical structure. The dual temporal environment of epoch II imposes this condition on the coexistent unit. The internal view concerns its individual, internal properties, which may still be expressed in terms of unresolved superpositions. However it must also assume an external view imposed by the need to take its place in the difference schema of the overall environment. This is possible because the difference schema operates through the property *n*, which was resolved to a single value by the event of orbital collapse. The coexistent unit is not a classical object that has all of its properties resolved, but nor is it a purely quantum object that has no resolved properties before measurement. The coexistent unit, while not truly existent, is nonetheless a real constituent of the environment in terms of maintaining a resolved value of *n*, which as we have seen above will in epoch III represent having a definite energy[28]. The total energy of the universe is not reduced because an electron is in a superposition of possible spin states.

But given that the coexistent unit must takes a place within the difference schema, its other properties must also assume values determined by an external, environmental perspective. Dirac emphasised in his description of superpositions

[28] States of uncertain energy, specifically virtual pairs, will be dealt with later.

that, " *The non-classical nature of the superposition process is brought out clearly if we consider the superposition of two states A and B, such that there exists an observation which, when made on the system in state A is certain to lead to some definite result, a say, and when made on the system in state B is certain to lead to some different result, b say. What will be the result of the observation when made on the system in the superposition state? The answer is that the result will be sometimes a and sometimes b, according to a probability law depending of the relative weights of A and B in the superposition process. It will never be different from a and b. The intermediate character of the state formed by superposition thus expresses itself through the probability of a particular result for an observation being intermediate between the corresponding probabilities for the original states, not through the result itself being intermediate between the corresponding results for the original states* [224]*.*" Not only is this perfectly correct but by reference to this cosmology it is to be expected, since it is simply the maintenance of the constraint that: *A single potentia cannot result in more than one realised state*. However we must distinguish between individual properties that are in a superposition and the group properties of a composite representation such as the coexistent unit, in the same way that we must distinguish between the individual properties of an elementary particle and the group properties of a macroscopic object composed of many such particles. The properties of elementary particles that are known to be composite states, such as the proton and neutron that are postulated to be composed of multiple quarks[29], can be addressed in this way. More subtly, even for elementary particles that cannot be considered to be composed of multiple quarks, we must still consider their particle properties as much in terms of their internal and external view as their final measured values. There is something there even when we do not look; it is just that it is not as resolved as when we do.

b. Elementary Particle Properties and the Coexistent Unit

When the potentia was introduced it was stated that: *If we are to introduce a minimum entity it must be derived from the cosmology, not the cosmology from its postulation*. All we sought was for these states *to become included in a narrative*, a consideration of nature's evolution, since *it is not the function of physicists to try to dictate the structure of the universe by their postulates, but rather to patiently observe and try to come to an understanding that will allow them to describe nature as it truly exists. It is therefore inappropriate to attempt to postulate the properties of the potentia; instead we must trace their development as the evolutionary process unfolds*. But we also noted that as the potentia *is compared to various other states the range of distinctions can become more complex, requiring any number of different degrees of freedom for their expression.* It is this situation that we must now address.

In order for the properties of the coexistent unit to be relevant they must be related to those properties by which elementary particles are currently described. This was the case with strings, which were proposed to give a common basis for all the elementary particles. In order to introduce the most fundamental physical property, energy, to the string Nambu [114] simply postulated that this one-dimensional object had as a fundamental parameter a tension which Nambu set at 15 tons, in this way ascribing a macroscopic property to a microscopic object. But it must be remembered that *when we look at smaller and smaller objects we are*

[29] Why there are three quarks in a proton and neutron will be dealt with later.

looking back along the evolutionary timeline, in much the same way as an astronomer looking at a distant star is looking back into the past state of the universe. Therefore in cosmological terms Nambu's approach is taking properties only developed in a later evolutionary epoch and applying them to an earlier one. While this may have been a perfectly adequate approach to addressing the problems in particle physics Nambu was concerned with, it cannot be carried over to a cosmological consideration. We must start with the properties of earlier epochs and see how these might be related to the properties by which physicists describe this universe. This is very much *the road less travelled* [419] and no doubt more speculative because of this. But we must wonder if any suggestion we can come up with can be more speculative than the heterotic *string* [120] which, as we saw earlier, *has a ten dimensional component circulating in one direction and a twenty-six dimensional component in the other.* Maxwell advised that, " *The first process, therefore, in the effectual study of the sciences, must be one of simplification and reduction of the results of previous investigations to a form in which the mind can grasp them* [420]." Since what we are seeking in this dissertation is to increase understanding rather than refine specific formalisations, we shall apply Maxwell's advice to the properties of elementary particles by associating them with the graphical representation of the coexistent unit. These associations may or may not prove useful in the long run, but for now will simply allow us to discuss the relationship between the properties of elementary particles and the external view of the coexistent unit in an uncomplicated manner.

c. The Coexistent Unit and Energy

As we have seen above energy *is merely the retention of the capacity to negate the event of orbital collapse*, which is achieved through *the retention of the property* n_b which in the post-asserted representation *can no longer be represented by the number of maxima in the probability amplitude curve overlayed on the potentia's self-definition path, instead it takes a realised representation in terms of the number of times the pen makes one complete circuit of the joined paper strips in one unit of time*, that is, the number of cycles of the self-definition path. It is not that the coexistent unit is moving, but that time is moving in such a way that it would impart a definite impetus to any other similar state it came into physical contact with. Until then the energy is passive, that is, present but doing no work. In this way *the present instant has assumed a finite duration*, that is, it gives a more detailed description of the temporal instant in which the potentia is defined, its minimum domain of expression. Whereas the pre-asserted intermediate potentia was defined in terms of the uncertainty of realisation, the post asserted potentia is defined in terms of the capacity to undo a realisation that did not take into account all intermediate potentia.

It was in terms of the property *n* that not all intermediate potential were taken into account and therefore it is in terms of this property that energy is both manifest and quantified. In this way energy is just the visible expression of the difference schema, in the same way that orbital collapse is just the visible expression of the passage of time. Planck's [421] equation as $E = h\nu$, where h is Planck's constant, conceptualises ν as the frequency of a wave, however we also know that frequency can be applied to particles since, "*…the frequency is the number of complete oscillations made by the particle in one second* [375]." The coexistent unit is not oscillating as such; instead, what is in motion is a significant temporal instant within the coexistent unit's minimum domain of expression, so that *the non-simultaneous* *expression of a point defining b must persist until a point defining ¬b is encountered*. The frequency is therefore the number of such cycles of this significant instant per second, with this number of cycles equal to the value of *n*. We shall see shortly how waves evolve from the coexistent unit so that their energy can be given by the same equation. It is only later again, as we shall see, that spatially separated particles evolve that can have their energy given by Einstein's [422] equation $E = mc^2$. Looking at the Planck and Einstein equations in terms of their evolutionary history will give a better understanding of the relationship between them than can be derived from simply looking at how one can be produced from the other by substituting equivalent expressions for physical quantities.

This phenomenological basis for energy in terms of the properties of the minimum entity of this cosmology has introduced no macroscopic parameters such as tension, but only includes properties appropriate to this evolutionary epoch.

The orbitals also possess a definite value for the property *n*, but this does not mean that they are energetic since this enhancement to the significance of this property only occurs because of the nature of assertion and therefore can only apply to realised states. It is worth noting however that the Schrödinger equation from which the wavefunctions of quantum mechanics are derived is just a way to express the total energy of the bounded system. Without an understanding of the relationship between the energy of the system described by the Schrödinger equation and the frequency of the wavefunctions that are the equations solution, this method for modelling nature cannot be truly understood only used as a recipe that is no more comprehensible than a spell read from some grimoire [423].

d. The Coexistent Unit and Spin

The elementary particle property *spin* is described as, " *The intrinsic angular momentum of a particle. It is that part of the angular momentum of the particle which exists even when the particle is at rest, as distinguished from the orbital angular momentum* [424]. " But to have an angular momentum when at rest is not possible classically, as Baggott emphasised, " *Whatever it is, the property of electron spin does not correspond in any way to the notion of an electron spinning on it axis. Here we see the first example of a purely quantum property – electron spin has no counterpart in classical physics* [95]. " However this does not mean that it cannot be understood in the context of this cosmology. Spin is not about the motion of the elementary particle, but the nature of the temporal instant within which this state is defined. Unlike the ac-span of epoch I which must be considered to be *stamped between* a *and* c *in a single action*, the minimum domain of expression for the coexistent unit involves an internal motion which would give significance to individual points along the self-definition path. It is this temporal motion that will impart an impetus that is indistinguishable from adding another element of angular momentum to the interacting system. In turn, that the temporal motion can be interpreted in this way should tell us something about its sequence and geometry. What we are examining when we study spin is the minimum instance of time a state can possess and how this affects external systems. This is, at it purest, the interface between time and structure.

The magnitude of the spin angular momentum, L, is given by [425]

$$L = \hbar\sqrt{s(s+1)} \qquad \textbf{E 3}$$

where s is the spin quantum number, which takes non-negative integer or half-integer values, and $\hbar$ is the reduced Planck's constant, $h/2\pi$. *" The reduced Planck's constant is used because in a wave, a cycle is defined by the return from a certain position to the same position such as from the top of one crest to the next crest. This actually is equivalent to a circle both having 360 degrees. There are 2π radians per cycle in a wave. Therefore, dividing h by 2π describes a constant that when multiplied by the frequency of a wave gives the energy of one cycle* [425]*."* This is what spin is describing, the temporal potential inherent in one cycle of the self-definition path. The coexistent unit would have spin 1, while its two components, if separated, would have spin ½. Feynman noted that, *" So far, no fundamental spin 0 particles have been found* [2]*."* Nor do we anticipate they ever will be[30].

e. Comparison with Strings

For all their strange properties and extra dimensions strings are nonetheless classical objects within fixed properties. In contrast the coexistent unit is a mixed state, with some properties constantly expressible from an external, environmental perspective while it still remains a fundamentally unresolved state with most of its properties only definable in terms of superpositions of possible values.

f. Concluding Comments on The Coexistent Unit and Particle Properties

Have we presented above an alternative minimum entity to the string? Not yet, there are many other properties of particles such as mass that we have not yet encountered in nature's evolutionary history, but this cosmology's minimum entity is starting to come into focus and that is what is important. Throughout this dissertation we have seen that the majority of physicists, with regard to quantum mechanics, agree with Davies' advise that, *" The one thing I would recommend is: don't try to visualise it* [228]*."* In response to this most physicists have followed the path Dirac set out for his students - *to be concerned only with the beauty of their equations and not with the equations' meaning* [46]. But this has lead to a situation where, *" …The progress that has been made over the last 60 years has certainly improved the predictive power of the theory* (quantum mechanics)*, but it has really been a matter of sharpening the mathematical formalism rather than our understanding of it* [95]*."* This discussion of the nature of the coexistent unit is undertaken, in part, in order to challenge this mindset. Even in this preliminary consideration we are starting to see a quantum object directly. It does not matter that we are staring through a muddy pane of glass so that the image is distorted and imprecise, all that matters is that something is being seen. Patience and application will sharpen this visualisation, but what matters for now is that we are starting to be able to see a quantum object directly.

What must be understood of this process is that we do not seek visualisation just to demonstrate that quantum mechanics is giving a direct description of nature, although that is extremely important, but to have the way physicists work be

[30] The only significant theoretical 0 spin particle is the *graviton*, the postulated force-carrying particle for gravity. We shall see in the next chapter that within this cosmology such a particle is not required.

compatible with the way the human brain works, which is in terms of pictures [426, 427]. This is well recognised, with the *11th International Conference Information Visualisation* scheduled to be held in Zurich on 4-6th July 2007 [428]. By rejecting the capacity for visualisation physicists are trying to do significant intellectual work in a way contrary to how their own brains work. We would submit that this makes absolutely no sense. The mathematics can only be formally refined and more narrowly focused. The visualisations can be freely manipulated by the human mind as an entire complex structure [429], thereby making it easier to gain new intuitive insights and pinpoint areas where further clarity is required. The coexistent unit is not merely a new minimum entity it is a new way to do quantum physics.

39. The Collapse of the Orbital Environment

Although epoch II must utilise the residue of epoch I, the orthogonal potentia, it still does not follow on linearly from epoch I but is a do over of it allowing for additional constraints and properties. In epoch I unbounded potentia such as *a* and *c* were asserted but the intermediate potentia b_j could not be. In epoch II exactly the opposite has happened, no new unbounded potentia are asserted but the intermediate potentia can be realised. Nature has learned a valuable lesson by this, that two-directional time can be overcome by a more complex environment which constrains the direction in which outcomes can be physically manifest. This is to a significant degree the driving motivation for nature to continually evolve towards more and more complex environments. But this success came at a high price, a finite duration for the maintenance of the orbital environment, since each time an intermediate potentia is realised a higher orbital collapses into a lower one, thereby reducing the complexity of the environment. The orbital space itself collapses. But it does not disappear completely, since there is a lowest orbital that has no other to collapse into. Instead all of the orthogonal potentia are reduced to a single pre-asserted representation.

a. A Second Failure

Has epoch II succeeded in resolving the potential over-specification of the definition of the initial state? There is a single orbital equivalent to all the original orthogonal orbitals, which has been achieved through the realisation of intermediate potentia and thereby the establishing of a changing definition, a linear timeline. While this reflects the solution sought in epoch I there is a fatal flaw, in epoch I this timeline would have stretched into the future thereby including all of nature's as yet unexpressed potential, but orbital collapse has only included the orthogonal potentia and stopped once there was no longer a pair of orbitals that could exhibit collapse. The limited timeline established by the collapse of the orbital environment of epoch II does not allow the expression of all of nature's potential and therefore cannot resolve the flaw of over-specification. Epoch II has also failed. Not because the outcome of an infinite series of events could be predicted, but because a finite series of events has physically terminated.

But evolution is not ultimately determined by the achievement of successful outcomes, since *the consequences of failure are as determinable as the consequences of success*, all that ultimately matters is the presence of change, that the residue of epoch II is different from that of epoch I, so that the events that have occurred have a retained consequence.

40. The Residue of Epoch II

Whereas the residue of epoch I had been composed of many orthogonal potentia, there is now only one such state, the first orbital, $n = 1$. But to this epoch II has added a totally new type of state, the coexistent units. In epoch I the realised intermediate potentia would not have been retained as residue, since their realisation would have been instantaneous with no capacity for further effect. But because of the nature of their realisation in epoch II, they must retain the capacity to undo the temporal event of orbital collapse. This stored temporal capacity, this energy, ensured that their minimum domain of expression extended over a finite span. Their dual nature perpetuated this as a cycle that expressed b then $\neg b$ then b… But not only are the coexistent units retained as residue, the majority of them have assumed the same value of n since they were intermediate to adjacent orbitals and are therefore indistinguishable from each other in terms of the difference schema. Epoch II has therefore resulted in multiple states that cannot be distinguished using the difference schema. The difference schema has failed. The final act of this epoch is to undo the difference schema altogether. A final collapse from the first orbital, the first instance of the repetition schema, back to the most fundamental minimum domain of expression, a single maximum that would be interpreted as $n = ½$. There is no orbital of this configuration, therefore no transition that could be made through the realisation of an intermediate potentia, instead what is involved is the devolution of epoch II and all that it contains. If there is a question to be answered by this process it is: *Why must nature carry forward the consequences of failure, why can they not be erased so that nature can start again from scratch?*

a. Comparison with a Bose-Einstein Condensate

Epoch II is an unfamiliar, pre-big bang environment but one of the advantages of this cosmology is that it models evolution so that *no aspect of it remains hidden in either the distant past or inaccessible extra-dimensions. Evolution is a cumulative process so that every aspect of it remains evidenced in the final composition of the universe. All that is needed is a sufficiently fundamental cosmology so that this can be understood and individual associations between current interactions and past evolutionary precedents recognised*.

Since in this cosmology we have given a meaning to the property of spin and have established that the coexistent unit, like the photon, has spin 1 and therefore could be considered to be a boson, it is tempting to consider the final collapse of epoch II to the ground state in terms of the establishment of a *Bose-Einstein condensate*. Einstein [430], building on the earlier work of Satyendra Nath Bose [431], proposed in 1925 that at temperature near absolute zero (0^0 Kelvin or -273.15^0 Celsius) a large fraction of the atoms present would collapse into the lowest quantum state and that then quantum effects would become apparent on a macroscopic scale. Such a state, called a Bose-Einstein condensate, was experimentally produced by Eric Cornell and Carl Wieman [432] in 1995, winning them, together with Wolfgang Ketterle, the 2001 Nobel Prize in Physics. However a word of caution must be noted. This universe utilises all the precedents established by the evolutionary process and therefore we expect to find within it physical states that are similar to the conditions found in previous evolutionary epochs. This is ultimately what makes cosmology an empirical science. However within this universe these precedents become mixed, both with those from other points along the evolutionary timeline and with the environment of the current evolutionary epoch. Therefore while these retained precedents can give us insights into previous evolutionary epochs, we cannot model those epochs as if they are the same as the current situations. The earlier evolutionary epochs are sparser and more importantly represent the first time that nature has had to deal with a new situation. We cannot deal with these situations as if they simply involve applying the laws of physics as we currently understand them, but must address them as nature was forced to, without any pre-established precedents for their resolution. Cosmology is not about the application of physical laws, but about gaining some understanding of their development. Therefore while a cosmology as fundamental as the one of this consideration will be able to point out where situations in the current universe reflect precedents set by earlier events it would be inappropriate, for example, to simply apply the formal description of a Bose-Einstein condensate to the residue of epoch II. We shall therefore continue our narrative description, focusing on the issues appropriate to the epoch being described, while using comparisons with a Bose-Einstein condensate in order to both make the pre-big bang environment of epoch II somewhat more familiar and to point out where precedents that continue to evidence its nature might still be experimentally accessible within the current universe.

b. The Fate of the Coexistent Units

A Bose-Einstein condensate describes the state of matter near absolute zero. In what sense is this temperature applicable to epoch II? Nature's evolution to date has involved no direct physical interactions between states, only temporal interactions involving the attempted realisation of intermediate potentia in order to establish an association between boundary states. There have therefore been no kinetic interactions that could establish a high temperature, with the only environmental expression of energy being the isolated spin of each coexistent unit. The last step down to absolute zero temperature is therefore not about interactions between particles but the reconfiguration of the internal structure of individual coexistent units so that this involves only one maximum and no expressed energy. In terms of ordinary bosons this is not a step that could be considered, since there is no conceptualisation of their internal structure available. But the point of doing a blank slate reconsideration like the one of this dissertation is to be able to explore new ideas in cosmology and then see how these might be applied to currently studied situations.

In a Bose-Einstein condensate the atoms are modelled as being reduced to their de Broglie waves, which merge to form a single wavefunction for a *superatom*, the singular form of the previously independent atoms. However in terms of this cosmology to go straight to this Schrödinger representation skips a step. The coexistent units are not represented by linear waves as the ground state orbital would be, but by a sealed self-definition path more in keeping with the closed time curves [433-436] found in some cosmologies. To put this situation in context it is instructive to consider for a moment the differences between the Schrödinger picture of quantum mechanics and that presented by quantum field theory.

The Schrödinger formulation does not allow for the creation and destruction of particles and quickly becomes unwieldy when applied to multiple particle systems, since to describe a system containing N particles requires N! (N *factorial* [437]) terms. Since in typical problems the number of particles is in the order of Avogadro's number [438] ($\cong 10^{23}$) this is unwieldy. Quantum field theory [439], which was developed throughout the 1920's and 30's [440-442], addresses this problem and is therefore widely used in particle physics [443] and condensed matter physics [444]. Quantum fieled theory is defined in a variant of the Hilbert space of standard quantum mechanics called a *Fock space* [445], which is composed of the space of a system with no particles (the vacuum or ground state), plus the space of a 1-particle system, plus the space of a 2-particle system and so forth. In this way each particle occupies its own Hilbert space with the Fock space being the direct sum of tensor products of these single-particle Hilbert spaces for N particles. This space is then acted upon by creation and annihilation operators that can change the number of particles present [446]. Therefore where the Schrödinger picture of the Bose-Einstein condensate would picture it as a single wavefunction, the quantum field theory picture would represent it as a series of individual Hilbert spaces, one for each particle. The quantum field theory representation therefore seems more in keeping with what this cosmology must describe. But the situation is not so straightforward.

The problem is that the conceptualisation of nature under the Schrödinger formulation and that under the quantum field formulation are quite different, which has lead to a long running debate regarding the nature of the photon and the electromagnetic field. In classical mechanics light was treated as a wave and this treatment lead to significant results [447]. However this picture changed with Einstein's study of the photoelectric effect [63] and his assertion that light consists of discrete quanta with particle properties, later called photons, and that the electromagnetic field must be treated as a wavefunction giving the probability amplitude for finding a photon in a small region of space. This is the view taken by Feynman in his path integral approach to quantum electrodynamics, "*The first important feature about light is that it appears to be particles: when a very weak monochromatic light (light of one color) hits a detector, the detector makes equally loud clicks less and less often as the light gets dimmer. …Quantum electrodynamics 'resolves' this wave particle duality by saying that light is made of particles (as Newton* [191] *originally thought), but the price of this great advancement of science is a retreat by physics to the position of being able to calculate only the* probability *that a photon will hit a detector, without offering a good model of how it actually happens* [2]*.*" However Weinberg takes an exactly opposite approach, " *The solution of this problem* (the possibility of negative probabilities arising from the Klein-Gordon-Schrödinger free scalar wave equation [186, 379-381, 440, 448]) *provided by quantum field theory is that neither the ψ of Furry and Oppenheimer* [441] *nor the φ of Pauli and Weisskopf* [442] *are probability amplitudes, which would have to define conserved positive probability densities. Instead, the physical Hilbert space is spanned by states defined as containing definite numbers of particles and/or antiparticles in each mode. If Φ_n are a complete orthogonal set of such states, then a measurement of particle number in an arbitrary state Ψ will yield a probability for finding the system in state Φ_n, given by*

$$P_n = |(\Phi_n, \Psi)|^2 \qquad \textbf{E 4}$$

where (Φ_n, Ψ) is the usual Hilbert space scalar product. Hence, no question as to the possibility of negative probabilities will arise for any spin. The wave fields φ, ψ, etc, are not probability amplitudes at all, but operators which create or destroy particles in the various normal modes [449]*.*" In quantum field theory the fundamental object is the field with particles conceptualised simply as localised excitations of the ground state. Both points of view have compelling arguments in their favour. In fact Freeman Dyson [450] proved these two approaches to be simply different conceptualisations of mathematically equivalent theories. So does it matter which is correct? As Robert Oerter put it, *" In the end, is the field just a calculational tool to tell you where the particle will be, or are the particles just calculational tools to tell you what the field values are? Take your pick* [451].*"* This opinion underlines the growing indifference of physicists to any conception that there is an underlying reality that physics is describing. As long as the calculations come out right what does it matter what reality actually looks like? We would contend that this opinion is only prevalent because there seems to be no choice, since no one has presented a conceptualisation of nature consistent with all the strange facts introduced by quantum mechanics. However what this dissertation seeks to demonstrate is that this need no longer be the case, that human imagination and philosophical insight is indeed capable of formulating a conceptualisation of nature consistent with quantum facts.

In this cosmology the wavefunction defines the flow of uncertainty of realisation for any bounded potentia, with the composite wavefunction consisting of all the potentia that could satisfy the same boundary conditions, thereby reflecting the over-specification of the definition of the initial state. The coexistent units, the photons of this epoch if you like, are clearly not simply perturbations within this field but have their own unique evolutionary history and discrete nature. They are unquestionably particles. But because of their sealed self-definition paths they must be treated as defined in their own unique spaces, in keeping with the Fock space of quantum field theory, rather than being immediately expressed as wavefunctions compatible with the Schrödinger representation of the ground state. The single wavefunction of the Schrödinger picture of the Bose-Einstein condensate as a superatom allows only for interference between adjacent wavecrests, that is, between different particles. What is actually happening within the cosmological model is interference between the two aspects of the one particle, the reconfiguration of its own discrete Hilbert space if you like. The evolutionary history therefore reveals a situation more complicated than that represented by either the Schrödinger or quantum field theory models. It does not provide a way to choose between these representations, but to understand how they are related.

The devolution of the coexistent unit, that is, the undoing of the repetition that established the difference schema, must involve a return to a representation involving only a single maximum. However the coexistent unit remains an unresolved state that reflects two possible final expressions, one for each direction of two-directional time. It is tempting therefore to imagine that the coexistent unit, this intermediate potentia, simply returns to the *ac*-configuration of epoch I. But while devolution definitely drives it along this course, the coexistent unit is a post-asserted state defined in an environment quite different from epoch I. While the pre-asserted representation of the coexistent unit was defined by two orbitals, the post-asserted states, like the orbitals themselves, is self-defined. The coexistent unit is distinct from an orbital in that its self-definition path does not go from *a* to *a*, but instead spans two possible final resolutions of the underlying potential. In epoch II the closest the coexistent unit can come to devolving to the previous *ac*-state is to resolve its geometry to two distinct paths reflecting the *a* to *c* and *c* to *a* paths of epoch I, but each as a self-definition path one *b* to *b* and the other $\neg b$ to $\neg b$. But these cannot separate as such, not just because space is as yet not present, but because it would violate the constraint that a potentia must result in only one realised state. Instead they can be visualised as two circles that are still touching at one point, one with its temporal direction represented by a clockwise progression of its significant point and the other with a counter-clockwise progression. The picture of the progressive significant point must be retained to reflect that the coexistent unit remains energetic. This progression, as we have seen above, is the basis for the property of spin, which simply reflects that the coexistent unit is defined within a present instant with a finite duration, that is, that is not stamped out like the *ac*-curves of epoch I but gives meaning to the individual points along the self-definition path. Therefore the spin 1 coexistent unit has been polarised into two spin ½ self-defined states of opposite temporal orientation.

It was Feynman who first proposed that, *"…particles such as positrons, the antimatter equivalent of electrons, are simply normal particles travelling backwards in time* [108]*."* This is essentially correct, although the situation revealed by this cosmology is slightly subtler. The antiparticle is not travelling backwards in time in the sense so liked by science fiction writers [452], instead this term only describes the direction of progress of the significant instant along its self-definition path, which is an internal property of the state. The reversed time effect that we would see reflects that the antiparticle is derived from the potential to have the opposite temporal affect on the boundary conditions as the particle. It is not so much that the antiparticle is determinably travelling backwards in time in our physical environment, but that it would affect that environment as if this were the case. We can therefore consider that the coexistent unit has resolved its internal geometry to reveal a still contacting particle and antiparticle.

The two separate self-definition paths do not allow the expression of b then $\neg b$, but like the two *ac*-curves of epoch I are simultaneous. In epoch I the pre-asserted representations of the two temporally opposite possible outcomes added and therefore cancelled, allowing no probability that an intermediate potentia would be realised. But the coexistent unit is a post-asserted state, even if not a totally resolved one. The addition is therefore done not in terms of probability amplitudes but in terms of the defining property of the state, energy. Nor can it be done in terms of the entire curve at once, but only at the single point at which they intersect.

While both distinct aspects of the coexistent unit have spin ½, the spin angular momentum associated with this is opposed because of the opposite direction of their 'rotation.' This is a new property, which we do not introduce merely because physicists are familiar with it, but because it demonstrates how the nature of energy evolves. Energy was an environmental property concerned with undoing events of orbital collapse. Spin angular momentum has nothing to do with orbitals, but is nonetheless a manifestation of the finite present instant that is the means by which energy is stored. Time can be used in different ways and with this energy can have different manifestations. It need not do what it was originally stored to do. Energy need not exclusively have an environmental expression, but can have a particle specific manifestation such as spin angular momentum.

The addition of the two distinct aspects of the coexistent unit involves no do over of the event of emission and the collapse of an orbital, allowing for a new interpretation of negative maxima provided by an incoming photon, this is an entirely new situation that cannot undo the event of orbital collapse. The coexistent unit does not have its realisation undone as if it had never occurred, quietly ceasing to exist, but instead energetically annihilate. It ceases to possess a finite present instant that could give it a retained expression, but since no orbital collapse is undone this temporal energy is not expended but expelled into the environment.

Note that while a positron and electron would have a definite mass so that the energy released by their annihilation would be governed by Einstein's equation

$E = mc^2$, for the distinct elements of the coexistent unit the property of mass has not yet been defined by the evolutionary process and therefore the only energy dissipated comes from their spin angular momentum. This is a far less significant event in terms of energy scale, but one that may have already been experimentally noted.

Let us consider for a moment the experiments conducted by Cornell, Wieman and their JILA (Joint Institute for Laboratory Astrophysics) team [453] using a Bose-Einstein condensate of rubidium-85 atoms that are naturally attractive. Using a process called *Feshbach resonance* [454], which involves changing the magnetic field in which the condensate is sitting in order to cause spin flip collisions, they were able to make the rubidium-85 atoms repulsive and thereby established a stable condensate. But what is interesting is that, " *When the scientists raised the magnetic field strength still further, the condensate suddenly reverted back to attraction, imploded and shrank beyond detection, and then exploded, blowing off about two-thirds of its 10,000 or so atoms. About half of the atoms in the condensate seemed to have disappeared from the experiment altogether, not being seen either in the cold remnant or the expanding gas cloud.* [455]." The phenomenon has been named *bosenova*, although the fundamental physics behind the explosion is not understood, as Weiman explains, " *Understand that atoms have been very well studied. Essentially all the behavior of isolated atoms in general and BECs* (Bose-Einstein condensates) *in particular we thought we quite well understood, and could be predicted accurately by theoretical calculations. Even for those features that cannot be accurately predicted, the basic physical processes are still qualitatively well understood. But the theoretical calculations of what would happen in this situation predict behaviors that are totally unlike what we've observed, so the basic process responsible for the Bosenova must be something new and different from what has been proposed* [456]."

Current atomic theory is unlikely to be incorrect in any substantial way; it has been too well studied and experimentally verified for this to be the case. Instead it is far more reasonable to suspect that what is missing is a level of detail that had no affect on previous experimental outcome and has not be theoretically conceived. The coexistent unit is a new theoretical minimum entity to which we have ascribed a substructure. However we would note the similarity between this and the photons of this universe, which will spontaneously decay into an electron and positron, only to recombine again into a photon. This process needs to be understood in more detailed terms than simply saying that both systems contain the same energy and will be addressed in detail later in this chapter. However for the moment we simply note that the photon can undergo a reconfiguration that leaves it equivalently represented by two distinct states each with its own component of spin. For the coexistent unit the lack of separation ensure that the two spin angular momenta will be opposed and interact. The particle will be totally lost but a small explosion of energy noted, in keeping with the unexpected results of Cornell and Wieman's experiment.

The situation is obviously more complex for the rubidium-85 atoms than it would be for photons and so the comparison with the coexistent units is less clear. However what we would suggest is that during the implosion of the rubidium-85 atoms, when the particles *shrank beyond detection*, all spatial separation was lost from some atoms so that their elementary components experienced a reconfiguration that allowed self-annihilation in a manner similar to that described by this cosmology for the coexistent unit. Here the particles and antiparticles involved are not just electrons and positrons but quarks and antiquarks[31].

But what happened to the energy associated with the mass of these particles? The question does not arise for the two components of the coexistent unit because this interaction occurs before that point along the evolutionary timeline where the property of mass was first defined. It is interesting to consider that in Cornell and Wieman's experiment the mass may not have annihilated as such because the environment devolves to a configuration that is sufficiently primitive in a cosmological sense that mass simply cannot be represented. How this occurs will become clearer when we discuss the origin of mass later in this dissertation. However, if follow up experiments continue to give no indication of what happened to the missing rubidium-85 atoms, a serious reconsideration of the nature of both mass and annihilation events will be necessitated. It may therefore not be the big bang but the comparatively insignificant bang of the bosenova that gives us the best insight into the evolution of matter.

c. The Significance of the Annihilation of the Coexistent Units

A zero sum for the addition of the probability amplitude curves in epoch I simply meant that there was no probability for the intermediate potentia to be realised in the span *a* to *c*. In contrast the coexistent units are post-asserted states so that their annihilation removes a potential seen as satisfied. It is not only the residue of epoch II that is erased, but the very potential that it represented. Physicists do not see the annihilation of a single particle-antiparticle pair as a particularly significant event, but in terms of this cosmology every potentia was inherently capable of defining the entire initial state. Rather than a greater range of defined properties expanding their significance, the potentia have been reduced to indistinguishablility and annihilation by this process. Epoch I established two-directional time as the basic characteristic of the pre-asserted representation of the intermediate potentia and epoch II has successfully asserted them as coexistent units that still reflect the characteristics of realisation and negation inherent in two-directional time. However their annihilation has only served to demonstrate that since there can be no net consequence, that there was any potential to begin with was merely an illusion. As a coexistent unit annihilates, this reduces nature itself by one potential definition. All that had been gained by evolution is being lost, and more, the seed from which it grew, the very potential for anything further to happen is being erased. All of nature's evolution has served only to prove beyond doubt that there can only be oblivion. But the most unfortunate thing of all is that this annihilation of all expressed potential is a valid resolution of over-specification. It simply gives justification to what most philosophers and cosmologists had always presumed; that it is most natural for the initial state to be nothing. This cosmology states that no truly initial state can have a cause, but that this also means that it is not constrained so that anything is possible, but to say that the initial state inherently contains all potential and then that the universe is a consequence of that potential is no achievement. What we must instead understand is that all potential can be exhausted without creating the universe.

The lesson being taught by the coexistent unit annihilation is harsh and unmistakable - to strive for more risks losing everything. If there were any eyes

[31] Quarks as well as three quark systems such as protons and neutrons will be dealt with in more detail in Chapter Four.

capable of witnessing this carnage, they would weep for what was lost. But while there could be no catastrophe greater than this, one theory of biological evolution, *Catastrophism* proposed by Georges Cuvier [457], states that dramatic transitions in the nature of life are prompted by such catastrophic events, for example the asteroid impact proposed by Luis and Walter Alvarez [458] to be the cause of the extinction of the dinosaurs and the beginning of the dominance of mammals and eventually humanity.

d. The Significance of the Bosenova Explosions

The bosenova, pictured as occurring within the vacuum wavefunction, somewhat resemble the explosive quantum fluctuations of quantum cosmology. However as Wieman pointed out, *"…the amount of energy contained in the motion of one room-temperature gas atom moving in the air is about 100,000 times larger than the total energy contained in the entire bosenova explosion that we see* [459]*."* This is only enough energy to raise the temperature of the Bose-Einstein condensate by 200 billionths of a degree [460] and is certainly not enough energy to spontaneously create whole universes. However this is not to say it is not important in terms of cosmology.

We can picture the quantum field theory picture of the ground state as a neat crystalline lattice of individual Hilbert spaces, which in terms of this cosmology are the isolated coexistent units. In epoch II the bosenova shockwaves have no space in which to propagate. They are just random instances of temporal activity released within this lattice. This does what we would expect heat to do, it allows an otherwise static state to slightly vibrate. This adds to the chaos of the environment as further coexistent units continue to annihilate, while others are still resolving their sealed geometry to two distinct components. It is inevitable in this environment that two coexistent units will eventually 'collide,' that is, that their finite present instants would overlap so that they can both have realised expression at the same time.

This had never happened before. Even within the composite definition of the initial state established as epoch II, each potentia was to contribute an independent element of definition. When two aspects of the one potentia physically interact, it is as two distinct elements of a superposition for which there can be no mixed outcome only one or the other, or sadly where no choice can be made annihilation and neither. The pre-asserted representations of multiple potentia that satisfy the same boundary conditions can interact to form a composite wavefunction, but what are interacting here are post-asserted representations independent of any shared boundary conditions. They have just bumped into each other. In this universe we see particles interact in this way all the time; such kinetic events are hardly dramatic merely resulting in the particles involved changing their spatial trajectories. But in epoch II there is no space. Nor is it the totally distinct, particle-like manifestations of the coexistent units that interact, instead it is their geometries as they are still undergoing the process of resolving to two distinct states.

Nature's resolution of superpositions, realising one alternative now and another later, applies to superpositions of different potentia and is in keeping with the constraint that every potentia must find expression given the entire extent of nature's evolution. But a superposition of two aspects of the same potentia cannot be independently realised in this way, since this would violate the constraint that a potentia must result in only one realised state. This is why when the intermediate potentia for two orbitals was realised it was as a coexistent state that retained a dual nature. The precedent that one potentia could be realised now and another later was carried over into the internal structure of the coexistent unit, but both aspects remained linked by a single self-definition path. Even when the coexistent units are expressed with both aspects as polarised as possible, they still could not be separated to give two separate realisations of the same potential but instead annihilated. If the present instant for the two coexistent units totally overlaps then this remains a balanced system and annihilation will still result. But if the present instants only partially interact, that is, if only half of one coexistent unit interacts with the other an imbalanced system can be established.

The interaction between one and a half coexistent units cannot be equated with a collision between three particle-like objects. The two coexistent units were defined along independent self-definition paths, as distinct as the x and y axes of Cartesian geometry. The half coexistent unit can neither result in a third particle visible to the other two, nor combine in any way with the complete coexistent unit's aspects to form a larger particle-like state. Instead the only relationship that can be established is the same as that between totally isolated potentia, the foreign aspect must act as a boundary condition. But this is a boundary condition that has arisen as a consequence of an interaction and is therefore unlike the two external boundary conditions of epoch I - it is a single internal boundary condition.

e. The Origin of Wave-Particle Duality

The first direct interaction between two discrete states has not simply resulted in an outcome, such as particles flying off in new directions, but instead has established a whole new class of state, which in turn introduces a new level of complexity to the description of nature. Two external boundary conditions introduced two-directional time to nature's description. We have already seen that a state can be viewed in terms of its internal properties or how an external environment interprets these properties. What a single, internal boundary condition adds is two perspectives from which a state's internal properties can be viewed. This occurs because a single state now possesses two self-definition axes, one associated with the complete coexistent unit and another with the foreign half-coexistent unit, and can be viewed along either. If viewed along the axis of the foreign half-coexistent unit the complete coexistent unit will be seen only in terms of its projection along this axis. If viewed along the axis of the complete coexistent unit, which has now polarised to two particle-like states, the half-coexistent unit will be seen only as a non-common point separating them.

To understand these two views of the same state let us first simply picture the two polarised aspects of the complete coexistent unit as two circles with a significant point travelling in either the clockwise or anti-clockwise directions, each touching at the same point a linear axis representing the foreign half-coexistent unit's self-definition axis.

To understand the projection of the two polarised aspects of the complete coexistent unit onto the linear axis, let us consider for a moment how Dirac's [224] representation of a quantum state as a spinning vector in a complex space is related to Schrödinger's [186] wave representation. The tip of Dirac's rotating vector, which is of fixed length, traces out a circle in the imaginary plane, with the real axis bisecting this circle, as in the Figure 3 below. Figure 4 illustrates the relationship between the real sinusoidal wave and its complex rotating vector representation by showing 'snapshots' of the physical wave alongside a series of vector diagrams of the complex amplitude, with varying phase, of the complex wave. While the magnitude of the complex wave is independent of *x*, its orientation with respect to the *x*-axis rotates counter-clockwise as its position advances along the *x*-axis. By giving the amplitude vector in each of the cycles the clockwise angular velocity ω, we can visualize the behaviour of the wave as time increases [461].

Figure 3

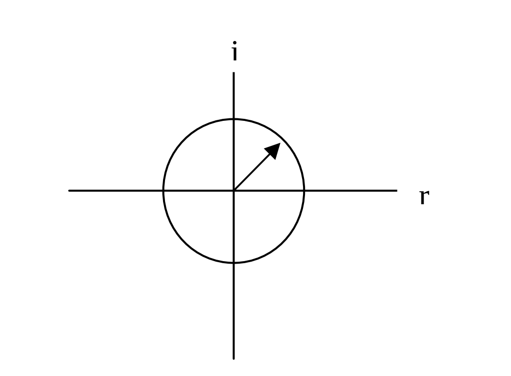

Figure 4

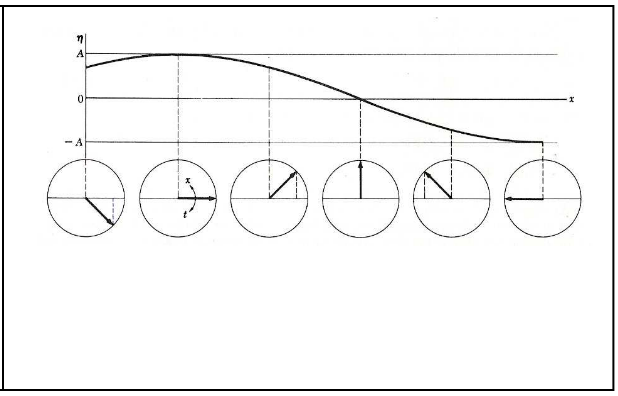

Fig. 3 Dirac's spinning vector represented in the complex plane. **Fig. 4** [462] The actual physical wave is the projection on the real axis. At any time t, the complex vector rotates counter-clockwise with increasing *x*. At any position *x*, it rotates clockwise with increasing t, with the angular velocity ω.

In terms of this cosmology there are two such circles, each representing one aspect of the complete coexistent unit, so that the resultant waveform has two orthogonal components in keeping with electromagnetic radiation. The waves are orthogonal to represent that the two aspects of the complete coexistent unit are independent and that while the two vectors are running clockwise and anti-clockwise they are both being drawn onto the linear axis at the same time and in the same direction. With electromagnetic radiation the amplitude of the electric wave is much greater than that of the magnetic. With regard to this cosmology we simply note that while potentia such as *a* and *c* were orthogonal, intermediate potentia that resulted in the coexistent units are by contrast largely indistinguishable. The intersection between the two coexistent units need not be orthogonal and could therefore be such that the projection of one aspect of the complete coexistent unit onto the resultant linear axis may be of a greater magnitude than the other.

Now we must consider the view along the axis of the complete coexistent unit. For the unresolved coexistent unit there was no actual point of intersection between its two aspects, which was represented by a half-twist in the earlier visualisation of them. The significant point was in one instant within the range of *b* and in the next $\neg b$. When the coexistent units polarise to two particle-like aspects, each has its own significant instant which collide at a shared point that must express both at the same instant, leading to annihilation. However with the interacting system the projection of the foreign half-coexistent unit affects the nature of this common point. Instead of there being *b* and in the next $\neg b$, there must be *b* and then the projection of the foreign half-coexistent unit and then $\neg b$. It is as if instead of there being a shared point, this point belongs to neither *b* nor $\neg b$, thereby providing a separation between them. The result is a particle-like coexistent unit that has two distinct self-definition paths, which share no common point of intersection, no instant where they must be simultaneously expressed and can annihilate. They are separated by one point that belongs to neither, the tiniest extent of space.

However it must be noted that neither the wave nor particle views of the complete coexistent unit represent the final resolution of the potentia, merely a new way to express it as a superposition, a further refinement of the question to the point where the two possible answers are already distinct.

As we saw earlier[32], when Schrödinger introduced his wave mechanics stated, *" The point of view taken here, which was first published in a series of German papers* [379-382], *is rather that material points consist of, or are nothing but, wave-systems. The extreme concept may be wrong, indeed it does not offer yet the slightest explanation of why only such wave-systems seem to be realised in nature as correspond to mass-points of definite mass and charge. On the other hand the opposite point of view, which neglects altogether the waves discovered by L. de Broglie* [383] *and treats only the motion of material points, has led to such grave difficulties in the theory of atomic mechanics – and this after century-long development and refinement – that it seems not only not dangerous but even desirable, for a time at least, to lay an exaggerated stress in its counterpart. In doing this we must of course realise that a thorough correlation of all features of physical phenomena can probably be afforded only by a harmonic union of these two extremes* [186]*."* Much of the controversy surrounding quantum mechanics is encapsulated in this statement by Schrödinger made at the very time he introduced his interpretation of it. There are two issues that troubled Schrödinger. The first was that the particles and waves were considered to be so different that he could conceive of no conceptualisation of nature that could include both as compatible descriptions of the same underlying reality. However within this cosmology wave-particle duality is as determinable a consequence of a single, internal boundary condition as two-directional time is of two external boundary conditions. The evolutionary sequence that leads to this dual representation of the same state can be understood and the single states described by either waves or particles clearly visualised. In terms of the wave and particle representations of the same state this cosmology does provide *a harmonic union of these two extremes*. The second issue that Schrödinger could not reconcile was that he could *not offer yet the slightest explanation of why only such wave-systems seem to be realised in nature as correspond to mass-points of definite mass and charge*, that is, why measurement results seem to reveal particles rather than waves. The Copenhagen interpretation of quantum mechanics is correct in that there are experiments that will reveal the wave characteristics of a state and others that will reveal its particle attributes. But this can be clearly understood given the conceptualisation of wave-particle duality provided by this cosmology. When a measurement is performed in a very localised region of space, this can be idealised as observing just one point of the linear axis provided by the half-coexistent unit. In this case only the view provided by the self-definition axis of the complete coexistent unit can be seen, since it is inherently focused at one point along the linear axis. This view will always reveal particles. Waves determine the evolution of the state and this may be evidenced in certain experiments, but the realised state at a specific location will always be revealed as a particle.

f. The Fate of the Partially Interactive Coexistent Unit

As evolution progresses that description of nature becomes more complex. The coexistent unit *represents a transition from a choice between two different things to a*

[32] Chapter Three: 35 b. *Comparison of this Cosmology with the Schrödinger Atom.*

choice between two aspects of the same thing. In this way the resolution of over-specification has been reduced to a choice between two specific alternatives, encapsulated within one coexistent unit thereby providing nature with the capacity for discrete choices. There need no longer be one all encompassing first cause, instead there can be any number of causes each providing a final resolution of the structure of one realised intermediate potentia. It is because of this that the outcome of individual discrete events becomes important, rather than just the establishment of a single universal first cause. Is the cross-coexistent unit interaction the future event that is to resolve the superposition introduced by two-directional time?

We have seen above[33] that for superpositions involving multiple potentia, each of which retains the guarantee that it will be at some point realised, nature's solution is that *one outcome is realised when a measurement is done and another when an indistinguishable system is measured at some future time*. But we have also previously pointed out[34] that we must be careful to distinguish between different types of superpositions. The coexistent units do not involve two potentia but two aspects of the same potentia. Here the constraint is that one potentia must result in only one realised state. The precedent of realising one aspect of a superposition now and one later applied to the coexistent unit cannot resolve it, but instead merely allows the realised state to continue to be expressed as a superposition of two possible final outcomes, where it would annihilate if both aspects were expressed simultaneously. The same precedent applied to a different state has had a different consequence. Nature need not learn more to produce a greater variety of outcomes, it need only apply a solution developed to deal with one situation to a different situation. However, this does not change the fact that for a superposition of two aspects of the same potentia to be measured requires a choice of one alternative over the other, so that only one realisation is evident.

The cross-coexistent unit interaction cannot produce such a true choice, however it can produce a pseudo-choice whereby one element of the superposition is not eliminated but it is effectively isolated. As the interacting half-coexistent unit becomes a component of a new state it is as if it had been realised in one of Everett's [201, 202] parallel universes. Although a more appropriate comparison could be made with Hawking radiation [463, 464], where one half of a virtual pair is trapped within a *black hole* [465], the super-dense remnant of a collapsed star, thereby releasing the other as an independent particle. The interacting half-coexistent unit is indeed trapped within a foreign environment, leaving its other aspect to break free as an independent state.

What is most fascinating about this event is that it combines characteristics that would be associated with both classical and quantum physics. The event is prompted by a physical collision between two real states, a distinctly classical event. But these are not the billiard ball type point masses of classical physics, but two superpositions that must rightly be associated with quantum mechanics. There are no classical forces at work here or kinetic interactions; instead there is the first realisation of a measurement process. But there is nothing conceptual or strictly mathematical about how this measurement process works; it is physically manifest as if the not completely interactive coexistent unit had been physically torn apart, with one part of it trapped within the foreign coexistent unit and the other flung from the interaction region. There is no separation between classical and quantum physics here. In

[33] Chapter Two: 18f. *Predicting the Nature of Measurement.*
[34] Chapter Three: 37c. *Types of Superpositions.*

examining this interaction physics' demarcation between these two aspects of nature's behaviour seems arbitrary indeed.

g. Entropy in this Cosmology

Entropy has been given many interpretations since Lazare Carnot [466] first introduced it in 1803. Carnot's son Sadi [467, 468] framed the first theory of the conversion of heat into mechanical energy, which Rudolf Clausius [469] later formulated into the second law of thermodynamics, which in general states that, " *Heat cannot pass from a colder to a hotter body* [470]," Mathematically the law states that the integral of the differential of a quantity of heat, *Q*, divided by its temperature, *T*, must be greater than or equal to zero for every cyclical process [259]

$$\int \frac{dQ}{T} \geq 0 \qquad \textbf{E 5}$$

But even Clausius found this description somewhat abstract commenting that, " *Although the necessity of the theorem admits of strict mathematical proof if we start from the fundamental proposition above quoted it thereby nevertheless retains an abstract form, in which it is with difficulty embraced by the mind, and we feel compelled to seek for the precise physical cause, of which the theorem is a consequence* [469]."

The practical consequence of an increase in entropy is that the system becomes more chaotic, with less of its energy available to do work. G. N. Lewis writing in 1930 stated that, " *Gain in entropy always means loss of information, and nothing more* [470]." The relationship between entropy and information was formalised by Ralph Hartley [471] and Claude Shannon [472] and lead to the concept of *information-theoretic entropy* [473]. However this theory's applicability to quantum mechanics has been questioned by Caslav Bruckner and Anton Zeilinger [474], although this argument was in turn challenged by Chris Timpson [475]. At this point the ultimate nature of entropy remains an open debate [476, 477].

The interactions between the elements of the residue of Epoch II were to answer the question: Why must nature carry forward the consequences of failure, why can they not be erased so that nature can start again from scratch? In the context of the current cosmological consideration entropy has both a general and specific meaning. In general it relates to the inability to erase the residue of epoch II, the coexistent units, the failure of devolution itself. The intermediate potentia realised as coexistent unit never simply lose the attributes gained in epoch II, they either annihilate altogether thereby completely erasing the underlying potentia or they continue to evolve into new states. This is at the heart of what entropy is, the inability to roll the clock back and return to the original starting point. This occurs because the events that establish new states such as the coexistent units also establish new properties, in this case energy. These new properties cannot simply be erased so that the devolution event need not deal with them. Instead they affect the temporally reversed events in a way that was not possible when the forward-looking events initially occurred. Evolution marches on in such a way that there is no going back.

The specific meaning of entropy must be given in terms of its relationship to energy, which arises simply because everything costs something. Entropy is the cost of being able to apply energy to a variety of consequences rather than just to the task it was originally to perform. Energy arose specifically as the stored temporal capacity to undo orbital collapse. But energy can have consequences beyond this intent. However each transmutation takes it further from this intent, making its application less obedient to design and therefore less capable of doing any specific work. Entropy is not so much about a loss of information, as Lewis suggested [470], as it is about an increasing disassociation of energy from its original intent.

h. Concluding Comments on The Residue of Epoch II

The residue of epoch II cannot simply be erased, instead it either annihilates not just the coexistent units but also the underlying potential from which it evolved or produces new states whose implications must be considered.

41. The End of Evolution?

The coexistent unit, definable as $x_i\ OR\ \neg x_i$, is the most concise manifestation of the over-specification that resulted from there being no first cause. This flaw is not simply a matter of there being many alternative potential definitions of the initial state, but that for any individual definition there are two temporal directions producing negating alternatives. For there to be a single definition of the initial state this temporal duality must be broken so that such a definition can exist independent of the capacity for its negation. This is exactly what has occurred due to the cross-coexistent unit interaction, for the first time a future event defined by an interaction between two discrete states has provided an enhanced causality that could resolve a superposition. We could reasonably surmise that many more similar events will occur. But where in epoch I the realisation of *c* immediately followed that of *a*, these physical interactions must wait for circumstances that allow their occurrence. There is a pause. Perhaps we would now measure it in terms of billionths of a second, it does not matter, for nature at this instant along the evolutionary timeline there is just this singular potentia. One definition isolated from its negation that could be applied to the entire initial state. Nor will the realisation of this potentia prompt an immediate temporal response as *a* did in epoch I, since it is an existent state having satisfied all the potential inherent in the event that established it, a physical event that provides it with a cause. Nature has achieved its goal; there is a first cause and a single definition of the initial state as a result of this. Is this the end of evolution?

In order to understand the answer to this question we shall first take Bacon's advice that, " *Truth is so hard to tell, it sometimes needs fiction to make it plausible* [5]." So let us borrow from the works of Douglas Adams [478] whose fictional computer *Deep Thought*'s answer to the *Ultimate Question of Life, the Universe, and Everything* was 42 [479]. Perhaps, unlikely as it seems, this was the right answer, but if so it was still not an acceptable one. This simple answer could no longer satisfy the needs of a new, more sophisticated generation that had grown up in the seven and a half million years since the question was first posed. Just producing the correct answer is not enough; it must be relevant to the historic period to which it is delivered.

Like the people who built *Deep Thought* nature has matured over the intervening period since the question was first posed. We saw earlier[35] that despite the fact that the lack of a first cause meant that *anything that can happen will*, nature could not spontaneously create entire universes, as quantum cosmology would have it do, because *the limiting factor is knowledge*, which *only comes from the actual occurrence of events, not from an overabundance of untested potential*. But after the

[35] Chapter Two: 11. *Nothing and Evolution*.

evolution of epochs I and II nature has gained such knowledge, encapsulated in its generalised memory. The singular potentia, since it is existent, need not express all of nature's unbounded potentia, but it must express what nature actually knows. What is presented through this random physical interaction as an answer to the *Ultimate Question of Life, the Universe, and Everything* is not sufficiently sophisticated to reflect the sum of nature's memories. The answer is less than all that has lead to it. The ultimate definition of the initial state must be derived from more than the lack of restraint, or current random events, it must reflect all of nature's past. The singular potentia is rejected as the definition of the entire initial state.

a. From Questioning to Being

In the section *Consciousness and Cosmology*[36] it was stated that with respect to epoch I: *If nature itself has a consciousness that can evolve from its self-definition algorithm it is very slow to act and then only produces outcomes that can be considered to be derived from the determinable refinement of the algorithm. Nothing is happening here that cannot be understood in terms of simple evolutionary processes. It would only be the rejection of an outcome produced by these natural processes that would distinguish an event as being the consequence of an emerging sentience*. The rejection of the resolution provided by the singular potentia is just such an event.

What has been demonstrated by the resolution of nature's original question and its rejection is that the questioning itself is more important than the answer. It is not an answer derived from a random physical event that is desired but the perpetuation and refinement of the process of questioning. Evolution need not end while ever the motivation that drives it can itself evolve.

b. Limiting the Application of the Singular Potentia

The consequences of the cross-coexistent unit interaction cannot be assimilated into nature's self-definition algorithm without overwhelming and erasing everything that came before it. The knowledge that the singular potentia exists and defines everything must be stored elsewhere. This is what it means for it to have been rejected.

That the singular potentia exists and defines everything is stored within the singular potentia itself, that is, it becomes the first generalised memory for this discrete state's own self-definition algorithm. But as we have already seen such generalised memories do not take the form of statements but of questions. In this way it is not that all of existence is defined by the singular potentia, but that for the first time there is a discrete state with an individual self-definition algorithm driven by its own questions. There is a singular state that could define everything but instead only defines itself, not as a statement but as a question. The consequence of nature having both found a resolution of the first cause and rejecting it is a discrete state defined by the question: *I am?* The first expression of being is the all too human experience of knowing that we exist but not knowing why.

You may ask: *Is it appropriate for physics to attempt to deal with something as abstract and fundamental as the origin of being?* It was appropriate for Wigner [49] to ask why the mathematics of physics so accurately describes nature. The answer to

[36] Chapter Two: 22. *Consciousness and Cosmology*.

this question and the basis for the evolution of being are the same. The reason why the mathematics of physics is applicable to a description of nature is that in the absence of the capacity to retain specific memories, the generalisation of nature's self-definition takes the form of an evolving algorithm that is best described as a self-directed question. The origin of being is simply the consequence of this being an element of nature's evolution.

We must therefore consider two types of states: inanimate objects distinguished by the consequences of their interactions being assimilated into nature's self-definition algorithm, and conscious states that assimilate the consequences of their interaction into their own self-definition, their own discrete memory. But this produces a schism in nature, a fracturing of intent. Because nature did not assimilate the fact that a singular definition of the initial state had been realised it proceeds with its initial intent of establishing one. Whereas the discrete self-aware state knows that a first cause has been found, itself, and therefore has no need to seek one but instead seeks self-development, that is, the answer to its own question: *I am?* This is not done by setting goals, such as overcoming specific flaws, but by simply experiencing the process of evolution itself.

c. Of Human Ego

Nothing is coincidence; nothing is folly, not even the existence of the human ego. Ego would have us see ourselves as more than our physicality would warrant, not just as the most important but as the only thing in existence. So in essence we are. Each self-aware being potentially defines all existence, but in a manner confined to their own consciousness. We are indeed small cosmoses, the equal of the universe entire, and thereby entitled to our pride. But beyond consciousness we have developed an intelligence that can understand our state of being, both its origin and contradictions. We who are everything stand in the midst of a multitude of beings of equal authority. It is indeed a strange world in which we live. It allows us to both take pride in the extent of our authority and temper it with the understanding that we are not unique.

d. Physics, Consciousness and Being

Sir James Jeans declared that, *" The universe begins to look more like a great thought than a machine* [196]." So it might seem given this cosmology. Is it a case of *" A bridge too far* [480]" for physics to even consider the origin of being? Pragmatism might delay this process but it cannot stop it, since it is human beings that would understand the origin of the universe, and as we have already seen[37], this has lead Penrose to acknowledge that, *" A scientific world-view which does not profoundly come to terms with the problem of conscious mind can have no serious pretensions of completeness. Consciousness is part of our universe, so a physical theory which makes no proper place for it falls fundamentally short of providing a genuine description of the world* [269]." However Penrose recognized that, *" For physics to be able to accommodate something that is as foreign to our current physical picture as is the phenomenon of consciousness, we must expect a profound change – one that alters the very underpinnings of our philosophical viewpoint as to the nature of reality* [269]." There is no easy way to do this, but what must be

[37] Chapter Two: 22. *Consciousness and Cosmology.*

sought is a consistent approach, one that does not try to address this issue in isolation but as part of an overall schema, which is broad enough to be able to seek experimental or observational verification with regard to several aspects of the total model. The more profound the change the greater the need for caution and periodic verification, this is what a broadly based cosmology offers. It will no doubt take quite some time and effort to be able to fully integrate the concept of consciousness into the framework of physics, but if the fundamental model that sketches out the basic approach to this problem, also addresses other issues in a way that can be subjected to experimental scrutiny, credibility can be built up for the overall approach. This, we believe, will allow work in this controversial area to be better understood and supported.

Penrose asked with respect of our quest to find a basis for consciousness, *" How far down, then, are we to go* [269]*?"* We would suggest that the roots of consciousness can be traced back to before the advent of the physical universe and can therefore be understood in terms of cosmological evolution. Consciousness is not an afterthought added only to the most recent products of evolution such as humanity, but is a fundamental aspect of nature that remains intimately entangled with the resolution of its physical interactions. A complete physics must grow to become capable of dealing with these entanglements. What better goal for science to aspire to.

e. The Origin of DNA

Nothing in nature's evolution occurs without process, if nature has determined that the final definition of the universe must be causally justified not just by individual random events, but must take into account all of its memory, this should be physically manifest in the current universe. It is, through the influence of DNA (Deoxyribonucleic acid) on biological evolution. DNA contains the genetic instructions for the development of all life on earth and thereby provides the interface between physics and biology. Physics is incomplete unless it can explain the nature of biology. Cosmology is incomplete unless it can explain its origin.

It is now known that a final solution to the definition of the initial state can be found, but that this must be made sufficiently sophisticated to reflect the entirety of nature's evolution rather than just the consequences of one isolated, random physical interaction. We have already seen[38] that the presence of nature's memory may provide a common databank that can allow the sharing of evolutionary enhancements on a universal scale. Only the abstract, algorithmic nature of this memory can provide a basis for such universality. This is also the case for this cosmology's resolution of the anthropic principle[39]. But we have also seen that DNA *may act as a counterbalance to the conformity that could otherwise result from a universal shared memory*. It also has the advantage of breaking up the universal memory into smaller, more manageable segments. DNA manifests nature's generalised memory as a physical entity that can have a determinable influence over physical causality, thereby ensuring the resultant states are sufficiently sophisticated to reflect all of nature's memory. However the DNA molecule itself is a very complex physical structure, its double-helix form only revealed in 1953 by Watson and Crick [481], somewhat controversially assisted by data from Rosalind Franklin [482]. It is not possible for it to be introduced into the causal schema of this universe at the level of

[38] Chapter Two: 29a. *This Cosmology and Astrophysics – The Shape of Alien Life*.
[39] Chapter Two: 29. *The Anthropic principle and this Cosmology*.

sub-atomic interactions, but only at the other evolutionary extreme of biological life forms.

This cosmology provides a new perspective on the workings of DNA. It is not that the DNA develops as the plant or animal does, but that the plant or animal evolves to express all aspects of the DNA. This would explain why DNA contains so much *white noise* strands that appear to serve no function. DNA does not initially say, for example, *'Make an eye,'* but simply remembers some distinct interaction. The function of biological evolution is to express this segment of DNA as a macroscopic, physiological property that through natural selection can be refined and incorporated into the ecosystem as a useful trait, a compatible and purposeful aspect of the definition of the entirety of nature. In this way the physical interactions of inanimate matter become expressed through living organisms. This process will go on until all of the white noise within DNA acquires a specific expression through the catalyst of biological evolution. Then nature will have a definition the equal of all its memory.

f. Concluding Comments on The End of Evolution?

Davies stated that, " *If life follows from* (primordial) *soup with causal dependability, the laws of nature encode in a hidden subtext, a cosmic imperative, which tells them: 'Make life!' And, through life, its by-products: mind, knowledge, understanding. It means that the laws of the universe have engineered their own comprehension. This is a breathtaking vision of nature, magnificent and uplifting in its majestic sweep. I hope it is correct. It would be wonderful if it were correct* [483]*."* In this cosmology nature has indeed brought forth life and consciousness, but this has not arisen due to any *causal dependability* or because *the laws of nature encode a hidden subtext …which tells them: 'Make life!'* If this were the case humanity would never be able to comprehend the root cause of their existence, it would forever remain a *hidden subtext* laid down before the first event occurred. Life emerges out of this cosmology not because it was preordained but because it is required. Life arises for specific reasons at a specific time, as part of an evolutionary sequence that humanity can comprehend.

The evolution that we have examined in this consideration, while it must produce the massive galaxies of our experience is not fundamentally about this. It is about the internalisation of evolutionary developments rather than their external expression. It is this trend that provides the ultimate basis for the concept that evolution is about *looking in the box,* examining the initial state in greater detail rather than progressing beyond it. What we can understand even from this preliminary consideration is that for conscious beings, such as the humans of this planet, to exist is not an aberration but a natural consequence of the general direction of evolution.

S.E.T.I. [339, 340] expends large amounts of money searching for extra-terrestrial intelligence, but this simple consideration is the best evidence that this expenditure is not wasted. If the general trend in all of evolution is towards the internalisation of evolutionary developments, and if the evolution of individual beings is a natural consequence of this, there is no reason to believe that the evolution of such beings is anything but universal.

42. Do the Concepts of Consciousness and Being Represent too great a Personification of Nature?

We started earlier[40], in agreement with Gross [1], that *physics has matured to the point where its next challenge is addressing the question: Why?* This cosmology allows this issue to be addressed within physics because evolution takes it starting point from a flawed set of initial conditions. *We can therefore determine the purpose of an evolutionary progression if we can see the flaw it would overcome. Such flaws are a determinable part of the physical makeup of the system, as open to empirical examination as any other aspect of it.* In this way we have seen that nature's evolution can be purposeful without being pre-ordained or intelligently guided.

This dissertation has gone on to consider the origin of consciousness and being. While it has been shown[41] that such issues are starting to be addressed by many eminent scientists [271, 273, 275, 276, 290] including Penrose [269], with Feynman even willing to entertain the concept of, " *Atoms with consciousness…*[289]," we nonetheless acknowledge that this is very much new and dangerous territory to tread. But because this consideration suggests that these issues may not be restricted to recently evolved biological life forms but have some basis in nature's fundamental evolution, they cannot be ignored by cosmology. The insights offered so far into the possible origin of consciousness and being are rudimentary and do not give as clear cut a resolution to these issues as is provided by this cosmology for the question of whether nature's evolution is purposeful. However if physicists do not have at least a basic awareness of the possible affect on evolution of these issues, the overall structure of the universe will not be comprehensible.

The use in these discussions of terminology that may seem like personification simply indicated that these considerations are still in their infancy. This is merely a broad terminology that can most quickly express general concepts. As the processes underlying these concepts are better understood the terminology will become more formal. This is a perfectly normal sequence often encountered in the expression of new ideas.

a. The Implications of the Fracturing of Intent for the Structure of the Universe

Nature found its answer but rejected it, hiding it away as the first self-aware discrete state. The questioning itself was found to be more important than the answer. What is desired is not an answer but the perpetuation of the process of questioning. Without this choice there would be no universe. And without understanding this physicists cannot hope to model the universe in a comprehensible way, since this determines its structure at the most fundamental level – that this universe is composed of maintained superpositions, which we evidence as particle-antiparticle pairs or even waves, questions that do not seek immediate answers. The function of this universe is not the resolution of such simple superpositions but the exploration of their evolution, both in terms of the complexity of structure that can be composed of them and the complexity of interactions between such states, so that the final solution offered by the evolution of this universe might be equal to the totality of nature's evolution.

[40] Chapter One: 7. *A Physics Beyond How?*
[41] Chapter Two: 22. *Consciousness and Cosmology.*

b. Evolution by the Reapplication of Process

This universe is the first evolutionary epoch that must reflect a division in nature's intent, it must still overcome its flaws by providing a clear causality that can maintain a single definition of the initial state, but now it is also driven to express all that has been learned through the evolutionary process and to experience all the events involved in its further evolution. For an impersonal nature what this means is simply that it will explore all possible consequences of the processes it has learned. As we have seen above[42] when a superposition contains multiple potentia *one outcome is realised when a measurement is done and another when an indistinguishable system is measured at some future time*. But when this precedent was reapplied to the coexistent unit, which involves two aspects of the same potentia, this process *cannot resolve it, but instead merely allows the realised state to continue to be expressed as a superposition of two possible final outcomes, where it would annihilate if both aspects were expressed simultaneously. The same precedent applied to a different state has had a different consequence. Nature need not learn more to produce a greater variety of outcomes, it need only apply a solution developed to deal with one situation to a different situation.* Both the previous evolutionary epochs failed to achieve their stated goal, yet the precedents learned through the events they involved have been retained in nature's memory. This vast and complex universe allows nature to explore what the processes in themselves might achieve independent of pre-determined goals.

Let us examine a simple visualisation to make this clearer. Imagine a piston being driven up and down with the purpose of finding the final state, *up* or *down*. While this is conceptually an easy question, if the piston is given an endless supply of fuel it becomes in practice unsolvable. What nature does instead is learn that a piston while going up and down to discover the final state of the system, an unattainable goal, can in the interim power a car. Nature comes to understand that even if the original goal of the process will never be achieved, the process itself can be put to other uses.

Physics has come to accept the equal opposite nature of material particles, that is, for every particle there is an anti-particle, and that if these two states of matter are brought together they annihilate. But a similar situation exists for events. As we have seen above[43], the event of atomic emission has a negating event, absorption, such that the net consequence of both is as if nothing had happened at all. *Nothing is not just the absence of net structure it is also the absence of net events*. We have never drifted far from oblivion. Yet in this universe all of chemistry and much of physics utilise these negating processes.

This universe could contain no net structure and no net events; no first cause and no final determination of definition and only involve processes that fail to achieve the goal that motivated them. This is the harsh reality that cosmologists must confront and still be able to explain how this vast universe came to be. This situation has always been considered to be too difficult, so cosmologists have chosen a lesser starting point. This is not necessary; the problems of cosmology can be confronted at their most difficult and still be overcome. The trick is that the establishment of this universe did not wait for the final resolution of nature's flaws, but instead reapplied

[42] Chapter Three: 40f. *The Fat of the Partially Interactive Coexistent Unit*.
[43] Chapter Three: 35e. *This Cosmology and Absorption.*

all the processes that throughout nature's evolution have attempted to resolve these flaws, whether they had proven to be successful or not[44].

To understand this universe it is necessary to divide evolution into two aspects, the processes that work towards an ultimate goal, which may in fact be impossible to achieve, and the utilisation of these same processes to achieve a secondary goal such as providing the structure and functionality for this universe. Without understanding this dual stranded evolution you might ask the question: *Why did this process evolve to do this useful function?* The fact is that for fundamental processes they did not evolve *to do this useful function*, but instead initially evolved to serve nature's primary function, find a first cause, but where then reapplied. There are of course perfectly valid physical explanations as to why each process came to be applied in a certain way, but there is more understanding to be gained by using a more humanistic terminology since this allows us to understand that much of the evolution of this universe is about experiencing the process rather than just valuing the final result. Part of the purpose this universe serves is to experience life.

c. Bashing the Rocks Together

Science is not about trying to support a particular point of view, but struggling to understand a complicated truth. There are perfectly valid reasons why Weinberg should have comment that, *"…the more the universe seems comprehensible, the more it seems pointless* [89]*,"* and for Geller's assertion, *"…Why should it have a point? What point? It's just a physical system, what point is there?* [90]*"* This cosmology has revealed how nature comes to rely on physical interactions, such as the cross-coexistent unit interactions, for the determination of cause. This precedent is used extensively in this universe and it is therefore this that physicists principally encounter in their study of it. Initially the capacity of this vast universe to provide huge numbers of indistinguishable events allows nature to sate over-specification by allowing all possible outcomes of an event to be expressed over time. Here the physical interactions define the potentia to be included in the composite wavefunction and may even affect the probability weighting associated with each possible outcome, but does not causally determine the outcome of individual events. But as nature evolves towards macroscopic structures these effectively reflect a consensus of consequences that can allow the ultimate physical manifestation of an event to evolve. Now nature does have Newtonian rocks to bash together, which can in themselves causally determine the outcome of events. Such causal determinacy does make nature more comprehensible but it should not make it seem pointless. This represents the fulfilment of nature's purpose, to overcome the flaw of having no first cause, rather than demonstrating a lack of purpose. It is *just a physical system*, but the *point* is the provision of Newtonian causality. The simple fact is that nature is quite happy to let the rocks bash together in order to provide causal determinacy. But it is only ignorance of a cosmology as fundamental as that presented here, which has prevented scientists from understanding that this simple process is purposeful. As we have just seen, this universe is not about the provision of ultimate answers, but exploring all possible consequences of physical interactions.

There need not be two opposing arguments, one that says that evolution is purposeful and another that says that this universe is just a collection of material objects randomly bashing together, instead we offer one cosmology that explains

[44] We shall consider a specific example involving the electro-weak force later in Chapter Four.

both points of view. If physicists are to understand this universe they must set aside petty prejudices and come to terms with the fact that both these attributes are necessary elements of nature's evolution.

d. Concluding Comments on Do the Concepts of Consciousness and Being Represent too great a Personification of Nature?

An initial state devoid of a first cause encompassed all potential, but to resolve the over-specification resulting from this nature sought a cause to select a single potentia to provide its definition. But when this was achieved this solution was too simplistic to express all that had arisen as a consequence of evolution. Instead this singular potentia was rejected allowing evolution to continue.

Do the concepts of consciousness and being represent too great of a personification of nature? The physicists may say: *We do not want the presence of consciousness to be part of our definition of the origin of the universe*. With the same indignation the theologian may say: *We do not want physical interactions to be part of our definition of the origin of the universe*. But it does not matter what any of us wants, the truth is independent of our prejudices or the artificial way we wish to compartmentalise knowledge. The birth of consciousness and the birth of the universe from physical processes are intertwined. If in defining the origin of the universe we do not reveal the seeds of consciousness, then as conscious beings we must conclude that such a definition is either incomplete or incorrect. But if we cannot also understand the physical processes involved in both the origin of consciousness and the universe we have only belief and not knowledge.

43. Concluding Comments on Chapter Three

The first evolutionary epoch ended because no single definition of the initial state could be found. The second has ended because a singular definition was found, but is so simplistic that it is inadequate to express all that nature has learned through the process of evolution. It is no wonder that the next evolutionary epoch, the universe of our experience, is such a vast and complex place.

Chapter Four:

The Origin of the Past

and of the Universe

“ In the beginning the Universe was created. This has made a lot of people very angry and been widely regarded as a bad move [479]*.”*

44. The Origin of the Past

We have marked the beginning of each evolutionary epoch with a description of the origin of one aspect of time, in terms of the establishment of the predominant causal mechanism that defines that epoch. Even though we shall give more details below, we shall continue this precedent here.

The different aspects of time arise as a consequence of specific approaches to overcoming the flaw that there is no first cause. In epoch I nature sought to overcome the lack of a first cause by simply realising any random potential as the definition of the initial state, an approach which we characterised as the future, since it involved the realisation of nature's potential before any causal justification was provided. But this approach failed because it leads to the over-specification of the definition of the initial state. In epoch II nature sought to work around this over-specification by incorporating all elements of it into a single composite definition of the initial state, an approach that we characterised as the present, because all the elements of this composite definition needed to occupy a single present instant of time. But this failed because it involved only the finite number of potentia that had been realised, and proven to be independent, in epoch I and therefore this environment was incapable of expressing all of nature's potential. However while these two approaches failed, they provided environments that allowed events and even interactions to occur. One physical interaction between two coexistent units provided a causal basis for the selection of a singular potentia as a resolution of over-specification. But this method produces a cause that is given at the instance of resolution. Things bash together and there is some consequence, cause and effect at the same time devoid of any predetermination. To find an answer without rhyme or reason did not prove a satisfying resolution. More was still needed, one last aspect of time – the past.

Nature did not initially have a past, but out of the new environment of this universe, particles separated by space, it could create one – a past derived from the finite time it takes for a particle to move from one spatial location to another. If this spatial trajectory could then provide a causal basis for the resolution of the next event involving this particle, then past causal justification would be established. In this approach over-specification is not resolved by the realisation of an intermediate potentia but by the past history, in terms of spatial trajectory, of each element of the over-specification. If all interactions between the discrete elements of the definition of this universe are causally deterministic in this way, then the entire environment provides a consistent composite definition of the initial state. This approach we shall characterise as the past.

It does not matter that the universe has not yet achieved the ideal of strict causal determinacy based on past spatial trajectory, since this universe remains a work in progress that is clearly moving towards this goal through the aggregation of elementary particles to form composite macroscopic states, for which past spatial trajectory does provide the basis for the causal resolution of future interactions.

This universe is not the end product of the evolutionary process it is the next step in nature's attempts to overcome its flaws and even in this respect very much a work in progress.

45. How to Describe the Origin of the Universe?

The universe is an immensely large and astonishingly complex place. To deal with its study, science and then physics has needed to be broken up into a number of specialist sub-disciplines, with scientists devoting their careers to specific aspects of its description. But even given this Wigner complained that, *" Physics is becoming so unbelievably complex that it is taking longer and longer to train a physicist. It is taking so long, in fact, to train a physicist to the place where he understands the nature of physical problems that he is already too old to solve them* [5].*"* No individual could either have the longevity or intellectual capacity to learn all of the specialist skills and intricacies of every branch of physics, therefore for one individual to attempt to define the origin of the universe in a way that would be acceptable to all disciplines is absurd. The task is just too great. But what can be done through this preliminary consideration is to provide an overall framework that can suggest directions for specific research within the various specialities, by introducing new concepts based on this cosmology that may help make seemingly intractable problems addressable.

What physics has taught us more than anything else is that nature works in some pretty bizarre ways. What this consideration seeks to illuminate is why nature must have these characteristics. To say that our universe is just one of an infinite number, so why should there not be one of this design, is both too cheap and too expensive a solution to explaining this universe's seemingly bizarre characteristics. It is a cheap solution because it has required little thought, but in consequence said nothing about why this specific universe is as it is. It is too expensive because, as we stated in Chapter One with regard to accepting quick fixes to the problem of defining a first cause, *if our universe is merely one of an infinite ensemble then physics is reduced to the examination of an infinitesimally small fraction of the totality of nature that despite our self-interest, since it is the universe we inhabit, may be totally insignificant. The laws of physics that we have spent centuries unravelling may be repeated nowhere else and have no deeper basis than – 'Why not?'* But this cosmology traces the evolution of the one universe of our experience, leaving us no choice but to seek to understand why this universe is as we observe it. Most cosmological models are solely concerned with following the big bang through different energy epochs and attempting to model the particle interaction applicable at that time. Later in this chapter we will give this cosmology's account of the big bang, addressing there the issues of inflation, the missing antimatter, the origin and nature of dark matter and the acceleration of the universe, but these are issues that will require further research to formalise and validate the approaches offered. This is to be expected since the stated goal of this preliminary consideration is simply to remove seemingly intractable problems from the *'Too hard'* basket and place them in the *'Work in progress'* basket. In terms of providing an immediate benefit we stated at the outset of this consideration that: *Apart from new concepts we hope will reinvigorate the debate on cosmology and lead it to address more fundamental issues, the most significant immediate benefit this dissertation offers is a totally new conceptualisation of nature and its evolution consistent with all that has been learned since the introduction of quantum mechanics*. Therefore what we shall emphasise in our description of the origin of the universe are the ways in which the pre-big bang evolution we have been considering affects the final structure of the universe and therefore allows us to understand it. What is sought is for the reader to be able to look out their window and say: *Yes, it's all starting to make sense*.

46. A Brief Review of the Current State of Cosmology

Before we explore the Flawed Nature Cosmology of this dissertation further it is necessary to review the current state of cosmology, since much has changed since the original big bang theory was proposed.

a. A Brief Review of the Big Bang Theory

Albert Einstein's first application of general relativity to cosmology [484] included an *a priori* term, the cosmological constant, which ensured that his universe was static, extending infinitely into the past and future. In this way the question of the origin of the universe was avoided. Even when in 1927 Georges Lemaître [485, 486], based on a consideration of the recession of extragalactic spiral nebulae, concluded that the universe began with the explosion of a *"…primeval atom* [487]*,"* Einstein rejected this conclusion. The conception that the universe was static could not easily be overthrown since it had too solid a historical basis, dating back to Aristotle [488], and had been violently defended by the Roman Catholic Church throughout the middle ages, most notably in the trials of Galileo [489], for his support of the Copernicus' [490] earth centred solar system [491]. Galileo's observations through an early telescope [492] revealed to him a universe of change not in keeping with the church's static Aristotelian model. Einstein's static universe also fell to observation, when Edwin Hubble's 1929 study of red shifts [493] indicated that the galaxies were moving away from each other, that the universe was expanding. This gave observational support to Lemaître's theory and prompted Einstein to proclaim that his introduction of the cosmological constant was his greatest scientific mistake [494].

Alexander Friedmann showed that Einstein's cosmological model was not unique, but one of an infinite series determined by the value given to the cosmological constant, which could take values such as 1, 0, -1 [495]. However no matter the value of the cosmological constant, all Friedmann models that agreed with Hubble's discovery that the universe was presently expanding began at a finite time in the past with a superdense singularity. Hoyle [496] coining the term *big bang* to describe the violent expansion of the universe from this singularity, when he somewhat sarcastically referred to Lemaître's theory during a 1949 BBC broadcast as *"…this big bang idea…*[497]*."*

Contrary to Einstein's original assertion, the universe appeared to have a finite past. The age of the universe can in fact be calculated using Hubble' law [498]

$$V = H_o D \qquad \textbf{E 6}$$

where V is the velocity of recession of the galaxies, D is the distance to the galaxy and the constant of proportionality, H_o, is called the Hubble constant. H_o is a measure of the rate of expansion of the universe. The time that the universe would take to expand to its present size is given by the Hubble time, t_H [498]

$$t_H = H_o^{-1} \qquad \textbf{E 7}$$

While there is not a universally accepted value of H_o due to the difficulties with determining D exactly, if we take a commonly accepted value of H_o = 72 km s^{-1} Mpc^{-1} [45], then t_H = 15 billion years [498]. The Hubble time is related to the age of the

[45] Mpc = Megaparsec

universe through a model of its expansion. Based on WMAP data [499] the current age of the universe is calculated to be $(13.7 \pm 0.2) \times 10^9$ or 13.7 billion years.

George Gamov modelled the evolution of the universe as a consequence of this big bang [500] and this was used by his colleagues Ralph Alpher and Robert Herman to predict that there should be a residual radiation background with a current temperature of 5^o K [501]. When Arno Penzias and Robert Wilson, almost by accident, discovered background radiation at 2.7^o K [502], and it was shown to have a blackbody spectrum [503, 504], the evidence for the big bang seemed conclusive. The big bang theory was soon presented to the wider community [505-508], with few detractors [62], and became widely accepted, if not totally understood.

The problem is, as Alan Guth put it, *" In spite of the fact that we call it the Big Bang Theory it really says absolutely nothing about the Big Bang. It doesn't tell us what banged, why it banged, what caused it to bang. It doesn't even describe, doesn't really allow us to predict what the conditions are immediately after this bang* [125] *."* The problem is that our models cannot penetrate the singularity Friedmann found at the initial instant of all physically relevant models. As Neil Turok put it, *" Nobody has a solution for the singularity problem other than essentially by hand starting the Universe at a certain time and saying let's go from there and let's not worry about what happened before and that's very unsatisfactory. This is the deepest problem in cosmology. If you can get through the singularity you're on your way to a complete theory of the Universe* [125] *."* This leaves us with a cosmology that ultimately fails to define the actual origin of the universe, since the big bang is only a theory about the location of matter and says nothing about its origin. It presupposes the existence of all the matter of the universe and merely extrapolates its location back in time, predicting that at the beginning it existed at a single point. This point would then be immensely dense, hot and energetic and as a consequence of this would experience an explosive expansion. But no matter the protestations of physicists that, *'This will have to do,'* as we pointed out at the beginning of this dissertation[46], there are questions that Quine referred to as *"…perennially present…* [45]*" - the determination of the origin of the universe from nothing is one such question*. Whether the big bang model is correct or not, it is simply not enough.

b. A Brief Review of Inflation Theory

Inflation theory originated from a cosmological consideration of grand unification theory, through the suggestion that in the extremely early universe 10^{-36} s after the big bang, when the density was 10^{78} grams per cubic centimetre and the temperature 10^{28} K [509], all the forces of nature were unified. This is in keeping with Einstein's vision, as a search for such a unification of the forces of nature was the focus of his later research [510]. Einstein stated, with regard to his equation of general relativity: *curvature of spacetime = constant × matter*, that, *" The right side is a formal condensation of all things whose comprehension in the sense of a field is still problematic. Not for a moment, of course, did I doubt that this formulation was merely a makeshift in order to give the general principle of relativity a preliminary expression. For it was essentially not anything more than a theory of the gravitational field, which was somewhat artificially isolated from a total field of as yet unknown structure* [509]*."* It was this total field, encompassing gravity, the strong and weak nuclear forces and electromagnetism, that grand unification theory

[46] Chapter One: 3.*Mathematics*.

proposed existed 10^{-36} s after the big bang. What is explored by grand unification theory is a series of symmetry breakings and phase transitions by which the forces that we now see as separated are isolated from the total field.

Sydney Coleman [509] suggested that in the extremely early universe a phase transition occurred from a state dominated by the hyperweak force (the unification of the electroweak force and the strong nuclear force) to a state of lower energy consisting of quarks and leptons dominated by the separated electroweak force and strong nuclear force. At the grand unified epoch, 10^{-36} s, a delay in the hyperweak phase transition causes supercooling that Coleman called the *false vacuum*. This is analogous to the process in the water-ice phase transition whereby the water supercools to a temperature lower than freezing point before transforming into ice. The false vacuum is not the lowest energy state of the system but is nonetheless stable for some time. In the case of the early universe the false vacuum is the lowest energy state available to the hyperweak force. When the phase transition does occur the false vacuum releases its enormous latent energy.

Guth [39] realised that the false vacuum was in a state of negative pressure that would act in a manner opposite to gravity, and therefore this environment would approximate a de Sitter space, that is, a space containing no ordinary matter but with a positive cosmological constant producing rapid expansion of physical spatial distances. In Guth's model this causes a brief period, from 10^{-36} s to approximately 10^{-34} s, when the expansion of the universe is enormously accelerated. Guth coined the term *inflation* to describe this period of exponential expansion and recognised that it could provide a solution to the horizon and flatness problems then troubling the big bang theory.

The horizon problems arises because the temperature of the universe is nearly the same even in regions which, according to the standard big bang model, had never been in causal contact [511]. The cosmic microwave background was formed some 300,000 years after the big bang and shows that the universe had a substantially uniform temperature. The problem is that even then the universe was so large that photons emitted from two spatially separated atoms could not reach each other given the 300,000 years that the universe had existed and therefore there could be no causal contact between them. How could the temperature of the universe be so consistent if different regions of it could not be causally connected? Inflation solves this problem because the universe could have been causally connected before the brief period of exponential expansion, which is much greater than that predicted by the original big bang model.

The flatness problem arises because the current universe is almost flat but for this to be so today the ratio of the density, ρ, and the density at which the expansion rate of the universe will tend asymptotically towards zero, the critical density ρ_c, in the early universe must be very close to 1. If this value, labelled Ω, is just slightly above 1 in the early universe it would quickly re-collapses into a *big crunch* and if slightly below 1 the early universe would have expanded so quickly that stars and galaxies could not have formed. In fact to avoid these catastrophes Ω must have been within one part in 10^{15} of unity when the universe formed. Inflation solves this problem by stating that the exponential expansion would have smoothed out any non-flatness originally present [512].

Guth's model has a false vacuum with regions of true vacuum within it established through nucleation [513, 514]. Since the true vacuum bubbles are at a lower energy than the surrounding false vacuum their walls have surface tension. The bubbles quickly expand and may in consequence of this collide. In Guth's model material particles are established from the energy of the walls of these bubbles during collisions. But this model failed because in order to solve the horizon and flatness problems the bubble nucleation rate must be too low for bubble walls to collide and because a homogeneous and isotropic universe could not be preserved through the violent tunnelling between the false and true vacuum. Andrei Linde [512] as well as Andreas Albrecht and Paul Steinhardt [515] proposed new models of inflation based on a scalar field slowly rolling down a potential. These models had the advantage that features of them could be related to data extracted from the cosmic microwave background [516] and have constraints imposed by it [517]. But these models predicted an inflation that, while it could end in some regions, was fundamentally eternal [518, 519]. But inflation cannot be eternal into the past and therefore these models could not solve the problem of the initial conditions of the universe [71, 520, 521]. Therefore inflation theory did not overcome Guth's own objections to the big bang theory, as Hawking pointed out, " *Even if inflation works, it won't tell us why the universe is as it is,*" since it cannot give a clear description of the initial conditions, " *It simply shifts the problem from 13.7 billion years ago to the infinite past* [522]."

c. The Accelerated Expansion of the Universe

Recent astronomical observations of the light-curves of distant type Ia supernovae suggest that the universe is undergoing accelerated expansion [135-139]. As Caldwell rightly pointed out, " *If the observational evidence upon which these claims are based are reinforced and strengthened by further experiments, the implication for cosmology will be incredible* [523]." Accelerated expansion would bring into question the standard big bang model since it failed to predict it and even when re-examined given this observation cannot be made to explain it. In fact, as Albrecht and Skordis point out, " *There is simply no compelling theoretical framework that could accommodate an accelerating universe* [524]." However supporting evidence has been forthcoming, leading Parker and Raval to conclude that, "*…the evidence from the cosmic microwave background radiation (CMBR) power spectrum that the universe is spatially flat, together with the relatively low density of matter, including cold dark matter (CDM), implies that there is a significant nonmaterial component of energy and pressure in the universe* [525]," presumed by some physicists to provide the impetus for the accelerated expansion[47]. Michael Turner [526] coined the phrase *dark energy* to describe this *nonmaterial component of energy and pressure*.

d. Dark Matter and Dark Energy

It was the Norwegian explorer and physicist Kristian Birkeland in 1913 that first expressed ideas that could be related to the concept of dark matter, writing that, " *It seems to be a natural consequence of our point of view that the whole of space is filled with electrons and flying electric ions of all kinds. We have assumed that each stellar system in evolution throws off electric corpuscles into space. It does not seem unreasonable therefore to think that the greater part of the material masses in the universe is found, not in the solar system or nebulae, but in 'empty' space* [527]."

[47] A range of proposed theories to explain the accelerated expansion of the universe will be examined in Chapter four: 54a. *A Brief Review of Current Theories to Explain the Accelerated Expansion of the Universe*.

Twenty years later Fritz Zwicky's [528] 1933 study of galactic clusters showed that only about 10% of the total gravity of the cluster could be accounted for by the visible matter. At first it was thought that this missing matter could be made up of hard to detect baryonic matter, but this has now been discounted [529]. Even the discovery that neutrinos have a small mass [530] could not account for the missing galactic mass [531]. Whatever this missing matter is, it participates in the gravitational effect, but cannot be easily detected since it does not readily absorb or transmit light. This has made it necessary to simply postulate the existence of *weekly interactive massive particles* (WIMPs), that have been named *dark matter*, as a totally new constituent of the universe [532]. However, the existence of dark matter can be observationally verified by strong *gravitational lensing* [533] in the halo region around galaxies [534] and the nature of the clustering of far off galaxies [535]. In the Virgo Cluster a galaxy named VIRGOH121 has been observed that is claimed to be composed primarily of dark matter, having approximately 1000 times more dark matter than hydrogen [536]. In fact if the predictions based on galaxy models are correct, the universe contains approximately six times more dark matter than baryonic matter.

Further diluting the baryonic matter's contribution to the total energy density of the universe is the dark energy mentioned above. Besides the problem of explaining the accelerated expansion of the universe, there is another reason to postulate the existence of dark energy related to the flatness problem. In the same way that Zwicky's [528] study of galactic clusters indicated the need to postulate the existence of dark matter to account for the missing mass needed to provide the galaxy's evidenced total gravity, recent data from the WMAP satellite [222] on the cosmic microwave background radiation have indicated a deficiency in the amount of matter in the universe as a whole. The data shows that the universe is substantially flat a situation that, as we have seen above[48], requires the energy density of the universe to equal a specific critical density. Even taking into account the dark matter detected through gravitational lensing in galactic haloes, the total observable mass of the universe only account for about 27% of this critical density, leading to the conclusion that, " *This flat universe model is composed of 4.4% baryons, 22% dark matter and 73% dark energy* [222]."

The missing mass ascribed to dark energy is required to have a density of only 10^{-29} grams per cubic centimetre and to uniformly fill otherwise empty space. In contrast the dark matter must have an appreciable mass and is clustered around galaxies. However, dark matter and dark energy are similar in that they interact significantly only through the gravitational force.

Dark matter and dark energy account for some 96% of the energy density of the universe and yet their nature has not yet been adequately explained. The original big bang model does not include them at all. Even if the model is updated to include them, without some details of their structure, what role they might play in big bang nucleosynthesis, or what equivalent evolution they might undergo, is totally indeterminable.

e. The Missing Antimatter

The big bang singularity, in order to maintain the conservation of energy, needs to have contained an equal number of particles and anti-particles. However when

[48] Chapter Four: 46b. *A Brief Review of Inflation*.

astronomers look out into the current universe they see galaxies that are composed almost exclusively of matter and therefore cosmologists are forced to ask: *What happened to the corresponding antimatter from the big bang singularity?* While we will examine some suggested approaches to solving this problem shortly[49], no definitive answer has yet been found.

Even when dealing with only baryonic matter, a mere 4% of the total energy density of the universe, the big bang model has so far failed to explain the most striking astronomical observation concerning it – the predominance of matter over antimatter.

f. Concluding Comments on A Brief Review of the Current State of Cosmology

The total energy density of the universe is composed of approximately 75% dark energy, 22% dark matter and a mere 4% baryonic matter. The nature of dark energy and dark matter has not been determined, so that the current models of the big bang can only deal with baryonic matter and therefore only 4% of the composition of this universe. Even then the big bang model says nothing about the origin of any form of matter. Nor does the current big bang model account for the two most striking features of our observations of the universe, that the galaxies are composed almost exclusively of matter rather than an even distribution of matter and antimatter and that the universe seems to be undergoing accelerated expansion. To believe that we can use the current cosmological models and the available observations to state: *Yes, it's all starting to make sense*, is a fallacy.

Mike Disney's opinion of cosmology's current standard model is that, " *It's as if someone's put Humpty Dumpty together and covered him all over with bits of elastoplast, and one's not convinced that Humpty Dumpty looks like that at all, if you took all the bits of elastoplast off he'd fall apart and might look like something completely different. So we have this situation where the whole thing's held together by entities* (dark matter and dark energy) *which we don't know exist at all and they have no physical basis,"* and that, " *Some of these cosmologists pretend that the subject is nearly over, we've just got to do a few more observations, a few more computer calculations. But I think they're missing the whole message of scientific history, which is: The greatest obstacle to progress in science is the illusion of knowledge, the illusion that we know already what's going on when we don't* [537]*."*

The circular orbits of Claudius Ptolemy's [538] earth centred cosmology were for centuries modified by small corrections, *equants* [539], as more data became available reflecting the true elliptical nature of planetary orbits. But eventually there were so many small corrections that the model became unwieldy and increasingly unlikely to be correct. Copernicus [490] did not modify Ptolemy's model further but reconsidered the problem from scratch, placing the sun not the earth at the centre of the solar system.

The purpose of a blank slate reconsideration like the one of this dissertation is to be able to look at fundamental issues like the big bang from a completely different perspective, so that new concepts might be introduced to broaden and reinvigorate the debate. In this way cosmology might start to be able to address those issues currently beyond the scope of the big bang model - how the initial conditions for the big bang where established, how to model through the big bang singularity and the

[49] Chapter Four: 50. *The Flawed nature Cosmology and the Missing Antimatter Problem*.

origin of the material substance of the universe. We can then examine how these concepts may provide new mechanisms for driving inflation. In re-examining the hot big bang we will not seek to further expand the original Alpher-Bethe-Gamow theory [540] of big bang nucleosynthesis, which has been extensively studied both in the context of standard big bang cosmology and newer alternative cosmologies [134, 541], since while this deals with the evolution of baryonic matter it does not explain its origin nor has it yet successfully explained the predominance of matter over antimatter. Instead we shall consider a new approach both to the origin of baryonic matter and the missing antimatter problem. We shall also seek to incorporate into the big bang model the remaining 96% of the universe composed of dark matter and dark energy, by attempting to give some cosmological insight into their origin and nature. With respect to dark energy this consideration directly addresses the issue of explaining the accelerated expansion of the universe.

Each of the above topics could be the subject of a dissertation in itself, we therefore make no apology for the fact that the consideration we are able to give them here is both preliminary and speculative, but it is a necessary part of the process of learning emphasised in chapter one[50]. What we wish to demonstrate by these suggestions is that all of these problems can be dealt with by this cosmology without the need to add any new elements to it. No other cosmology reviewed has the potential to address so many long outstanding problems within a consistent framework. It is quite possible that the final resolutions found may be quite different from the preliminary suggestions given here, but the role of these suggestions is merely to provide some starting point for research into these issues within the framework of this cosmology.

47. A Reconsideration of the Initial Conditions for the Big Bang

It was stated earlier[51] that with regard to establishing the initial conditions for a cosmology: *If we are simply to use all encompassing postulates, it is doubtful that any one postulate is more scientific than another.* What shall be examined in this section is whether the Flawed Nature Cosmology can provide a determination of the initial conditions for the big bang that reduced the weight of postulates that would otherwise be required to establish this model.

a. A Brief Review of Opinions Regarding the Big Bang Initial Conditions

We have already reviewed[52] opinions regarding the difficulty of determining the initial conditions for any cosmological model, where we concluded that *we cannot accept on the arguments of either Valchurin et al* [83] *or Guth* [84] *that any credible cosmology can be presented that ignores a description of the initial conditions. Nor do we accept that evidence of these initial conditions will be lost due to the effects of inflation. For cosmology to be an empirical science we must understand the initial conditions sufficiently to be able to find residual evidence of them within the current experimentally accessible environment.* However we must

[50] Chapter One: 5. *Cosmology and the Process of Learning.*
[51] Chapter One: 6. *A Brief Review of Quantum Cosmology and the Problem of Defining the Initial State and First Cause.*
[52] Chapter One: 6. *A Brief Review of Quantum Cosmology and the Problem of Defining the Initial State and First Cause.*

note here that this is clearly not the position adopted by Hawking and Hertog [321] in their *top-down* approach to cosmology where the model is not built up from a set of initial conditions, but modelled as if the final state of the universe as we observe it today selects from a quantum ensemble average a past history for the evolution of the universe[53]. But as Paul Steinhardt stated, " *It's kind of giving up on the problem. We've always been hoping to calculate things from first principles. Stephen* (Hawking) *doesn't think that's possible, but I'm not convinced of that. They might be right, but it's much too easy to take that approach; it looks to me like throwing in the towel* [320]."

b. The Flawed Nature Cosmology and Big Crunch Models

Epoch II has failed and therefore evolution must start again. Each new epoch is a do over from $t = 0$ that takes into consideration all of the precedents and constraints established by the previous failed attempts to resolve nature's flaws. This cosmology therefore does provide some justification for Weinberg [80]and Davies' [78] agreement with Saint Augustine's assertion that, " *The world was made, not in time, but simultaneously with time.* [60]." Except that it is not all of time that is made with the establishment of this universe but a new level of it called the past. Therefore Saint Augustine's assertion does not excuse cosmologists from considering nature's pre-big bang evolution, since this involved establishing the other aspects of time, the future and the present. This is especially true because each new epoch *takes into consideration all of the precedents and constraints established by the previous failed attempts to resolve nature's flaws.* Therefore a cosmology that refuses to consider nature's pre-big bang evolution will be totally incapable of justifying the initial conditions from which this universe evolved.

This is precisely the situation with the big bang model which must simply presume the existence of all of the fundamental particles that make up this universe, as well as the laws that govern their interactions and the space that provides the stage on which their drama is played out. The big bang's initial conditions simply state that all the matter of the universe was once located in a superdense, superheated singularity, which exploded because this is not a state that could be maintained. But even if we ignore for the moment the fundamental issue of the origin of the matter in the universe, this still leaves the question: *If the superdense, superheated singularity could not be maintained, how did all the matter of the universe get into this configuration in the first place?* Attempts have been made to explain this using a *big crunch* model [542], which is much like the original time reversal of Hubble's [493] observation that the galaxies were moving away from each other that lead to the big bang theory, but modelled as a physical collapse. However there are three problems with this concept. Firstly, it says nothing about how the first big bang singularity formed, unless the model starts with a universe of galaxies and has this collapse to form the first singularity. But if we must start by simply postulating the existence of the universe why bother doing cosmology at all. The second problem is that the big bang initial conditions require a low entropy environment. This can never be reproduced by a big crunch since entropy increases whether the universe is expanding or contracting [543]. Thirdly, recent evidence that the universe is undergoing accelerated expansion [135-139] contradicts the original assumption on which the big crunch cycle was based, that the original impetus provided by the big

[53] See also Chapter Three: 28a. *Comparison with Hawking's Flexiverse.*

bang would be exhausted over time so that the expansion of the universe would slow down and, if the universe contained sufficient mass, stop and start contracting under the influence of gravity. However universal expansion does not appear to be slowing down but accelerating. Perhaps this will not remain the case forever, however because what is driving this accelerated expansion is currently not known there is no way to determine this. All that we can be certain of is that the big bang theory, on which the big crunch scenario is based, did not predict this behaviour and therefore will undoubtedly require serious modification before it could be trusted to make as long term a prediction as that incorporated into the big crunch model. While acknowledging that cyclic universe theories are still being explored using the exotic multi-dimensional environment of M-theory [132, 544, 545], we would look elsewhere for a clear understanding of the initial condition for the big bang.

Even though time restarts with the big bang, cosmologists must consider pre-big bang scenarios such as the one given in this dissertation in order to be able to understand and justify the complex initial conditions for the big bang. Otherwise science must simply accept not only that all the material substance of this universe always existed, but that all the complexity of nature also either always existed or was preordained, which in either case would leave it forever beyond any true comprehension. Physics can either accept that its role is merely to observe and establish the relationship between aspects of nature that can themselves never be truly understood, or risk expanding the domain of cosmology in an attempt to establish a fundamental understanding of all aspects of nature in terms of their derivation.

In this dissertation, through the consideration of pre-big bang scenarios, it has been possible to arrive at the instant of the big bang with a perspective and a set of initial conditions quite different from anything that has been previously considered. We are not looking back from this universe to the big bang, but forward from the origin of all things. Nothing is presumed to exist, as always this evolutionary epoch is based on the precedents set, and the residue left, by what came before it. Such a fresh perspective is required if we are to fill the current gaps in the big bang model.

c. Is this Universe the End Product of Nature's Evolution?

What this cosmology offers that has never been available before is a way to determine what stage of nature's evolution this universe represents: *Is this universe the end product of nature's evolution or just an interim stage?*

It is clear that nature's flaws were not resolved prior to the establishment of this universe so that epoch III, like epoch I and epoch II before it, is an attempt to resolve them using another, as yet untested, causal schema. This vast universe is not the end product of nature's evolution but instead set the task of developing the tools to allow nature's flaws to be overcome and a final definition of the initial state determined.

But nature learned a harsh lesson at the end of epoch II – such an experiment can produce an immediate and simplistic singular definition of the initial state that could stifle evolution without expressing all the complexity and knowledge that has been gained through the process of evolution. However there is another consequence of the cross-coexistent unit interaction that is not singular. Here there is simply a coexistent unit expressed as a new form of superposition through the incorporation of a foreign axis provided by the second coexistent unit. This new superposition represents a further refinement of the question, x *OR* $\neg x$, which makes the alternatives more distinct prior to resolution, and is therefore in keeping with the general trend of nature's evolution. It is this precedent that nature adopts for the establishment of this universe.

Interactions between discrete states has been demonstrated to be an important aspect of nature's evolution, but they cannot be allowed to produce another immediate and overly simplistic singular definition of the initial state. This constraint determines the most striking feature of the big bang initial conditions, that this universe does not directly involve the residue of epoch II but only their projection onto the non-singular consequence of the cross-coexistent unit interaction. Interactions between these projections can be made to produce more mundane consequences contained within the environment of this universe, where they can have no immediate impact on nature's further evolution. Far from being the end product of the evolutionary journey this universe is more like nature's sand box, just a place to play. Because the elements of this universe are only the projections of fundamental states, no consequence of an individual interaction within this universe can provide a final resolution of the definition of the initial state, instead what can be explored is all the ways the residue of epoch II might evolve to provide a definition of the initial state complex enough to express all that nature has learned through the process of evolution.

At the end of epoch II all of nature's expressed potential was annihilating, but for the consequences of a single cross-coexistent unit interaction. The initial conditions for the big bang are therefore a do over of the cross-coexistent unit interactions within a new temporal environment, the past, which must prevent them from resolving to a singular potentia, instead assuming a more mundane consequence. This universe is not the end product of evolution but a place to learn without the consequences of interactions having an immediate affect on the course of further evolution.

d. The Establishment of the Past and the Origin of Space

The epoch II environment has been derived in this cosmology from first principles, the only thing that needs to be added to it in order to establish the initial conditions for the big bang is the temporal environment of the past. The nature of the past was pre-empted in the first section of this chapter[54]: *Nature did not initially have a past, but out of the new environment of this universe, particles separated by space, it could create one – a past derived from the finite time it takes for a particle to move from one spatial location to another. If this spatial trajectory could then provide a causal basis for the resolution of the next event involving this particle, then past causal justification would be established. In this approach over-specification is not resolved by the realisation of an intermediate potentia but by the past history, in terms of spatial trajectory, of each element of the over-specification. If all interactions between the discrete elements of the definition of this universe are causally deterministic in this way, then the entire environment provides a consistent composite definition of the initial state. This approach we shall characterise as the past.* What we must examine now is how this is achieved.

[54] Chapter Four: 44. *The Origin of the Past*.

e. A Brief Review of Current Theories Concerning the Origin of Space

Penrose [112] attempted to construct a space from minimum entities which he developed from the mathematics of quantum mechanics and general relativity – *spinors* and *twistors*. The spinor is a mathematical object that is used in quantum theory to describe the spin properties of the elementary particles. Twistors are derived from the null lines of general relativity, but treated as quanta of curvature and thereby elevated to a status equivalent to elementary particles. Penrose was working on the problem of uniting quantum theory and spacetime. *" Our familiar space-time may not in fact be the background in which the elementary particles play out their lives; rather quantum systems may define their own space-times! Penrose's speculation was a particularly bold one, for it suggested that somehow quantum particles are not born into a background space-time, but rather this space-time is created out of quantum processes themselves at a subatomic level* [7]," as Peat put it. Einstein had been greatly influenced in his considerations of the nature of space by the philosopher and physicist Ernst Mach [510], paraphrasing him in his early writings on general relativity, *" What, Mach had asked, would it mean to say that a planet is rotating in space if there were nothing else in the universe against which this rotation can be measured?* [7]" Similarly, Penrose asked what meaning could be given to the spin up and spin down states of an electron in an empty space. To answer this question Penrose constructed a network of spinors and then theoretically brought an additional spinor up to this giant spin network. This did allow Penrose to give a meaning to direction, but not distance. To solve this problem he progressed to considering a network of the more complex twistors.

At the same time Green was expressing the opinion, as Peat reported, that, *" ...all these* (string) *theories are fundamentally flawed because they still regard strings as moving in a fixed, background space-time. Such an approach just has to be wrong; a proper string theory cannot treat space time in this way* [7]." The problem is that, *" A proper superstring theory should generate its own space-time, since space and superstrings are irreducibly linked. But the best that physicists have been able to do is to put the strings in a flat, inert background space* [7]." String theorists such as Witten [7] consider that Penrose's [112] work on twistors may be able to address this problem, but no satisfactory solution has yet been found. We would add to these endeavours the consideration undertaken here, since as Peat noted, *" …present attempts to link twistors to superstrings involves attempts to join the two theories, but it is also possible that essential features of each could emerge out of some deeper theory* [7]."

f. The Flawed Nature Cosmology and the Origin of Space

It has been pointed out that with Feynman's [225] sum over histories interpretation of quantum mechanics, *"…the calculations only come out right if the calculations are done in imaginary time …a time dimension that is expressed using complex numbers* [320]." Hawking showed that the consequence of this for cosmology was that where time would usually come to an end at the big bang singularity a new dimension of space appears instead [94]. But whereas looking back from within this universe Hawking saw this as showing that there were originally four spatial dimensions, when we look forward from before the big bang using this cosmology it is clear that we must commence with only the time dimension of general relativity reduced to a spatial dimension as Hawking has shown. The origin of the three traditional spatial dimensions is a consequence of the projection of the coexistent unit onto this single point space. Therefore that there are three spatial dimensions is not pre-ordained but determined by the dual orthogonal waveform projection of the coexistent units onto an intervening space, as examined earlier[55] in terms of the non-singular consequence of the first cross-coexistent unit interaction. While it may be hard to visualise, if a more complex state were projected the spacetime of this universe could have had a higher dimensionality.

g. The Flawed Nature Cosmology and the Big Bang Singularity Problem

As seen above[56], Turok stated that, *" Nobody has a solution for the singularity problem other than essentially by hand starting the Universe at a certain time and saying let's go from there and let's not worry about what happened before and that's very unsatisfactory. This is the deepest problem in cosmology. If you can get through the singularity you're on your way to a complete theory of the Universe* [125]*."* To Turok, *" The existence of branes[57] before the singularity implies there was time before the Big Bang. Time could, can be followed through the initial singularity* [125]*."* The problem is that the big bang singularity is modelled as if it already contains all the matter of the universe, which makes its description extremely complex. The only physical system that even approximated this state is a black hole [465], the super-dense remnant of a collapsed star. But black holes do not explode as the big bang singularity does and therefore this comparison is of only limited use. But with the Flawed Nature Cosmology the big bang singularity is just the time dimension of general relativity expressed as a minimal spatial dimension, while the big bang itself is just the projection onto this space-time[58] axis of all the remaining residue of epoch II. This greatly simplifies the modelling of the big bang singularity, since the problem can be reduced to a series of individual projective interactions between the residue of epoch II and the space-time axis. This has the additional advantage that, since the nature of the space-time axis itself will change with these events, the model can examine in detail the changes in the big bang process that occur at the Planck energy scale of 10^{16} TeV, where it must be noted that, *"…most theorists expect new physics beyond the Standard Model to emerge at the TeV-scale, based on some unsatisfactory properties of the Standard Model* [546]*."*

The big bang singularity can be understood by reference to this cosmology in terms of its origin, function and why it progressed beyond the configuration in which it was established. It is not necessary to seek to write cosmologies that avoid the big bang singularity, as Hawking's complex time cosmology [94] does, this is a problem that can be directly addressed.

h. Wave-Particle Duality and the Big Bang Initial Conditions

Hawking and Penrose [547] proved a theorem which showed that our universe must have emerged from a singularity. As Hertog pointed out, *" The real lesson of*

[55] Chapter Three: 40e. *The Origin of Wave-Particle Duality*.
[56] Chapter Four: 46a. *A Brief Review of the Big Bang Theory*.
[57] See Chapter Two: 13b. *A Brief Review of Brane Cosmology*.
[58] The terms *space-time* will be used to denote the time axis of general relativity, while the term *spacetime* will be used to denote the entire four-dimensional environment.

these so-called singularity theorems is that the origin of the universe is a quantum event [320].*"* This is indeed the lesson of the Flawed Nature Cosmology where the singularity provides a foreign axis onto which all the remaining residue of epoch II is projected. We have already seen[59] that *within this cosmology wave-particle duality is as determinable a consequence of a single, internal boundary condition as two-directional time is of two external boundary conditions*. The space-time axis provides this *single, internal boundary condition* for this universe. The particle represents the projection of a coexistent unit onto a single point, that is, where the state is in space-time. The wave is the same state's continuous projection onto the space-time axis, its temporal evolution, which is rightly modelled by quantum mechanics as unitary evolution. Wave-particle duality arises simply because there are two projections of the same state into this universe, with the particle giving its instantaneous location while the wave plots its continuous evolution.

Nature is seeking to establish a new causal schema based on the past spatial trajectory of particles, however the rudimentary space of the big bang singularity does not provide the complexity or extent for this to be possible, instead it satisfies the more rudimentary requirement of necessitating interactions. Until the environment necessary to fully implement the new causal schema develops nature simply continues to use the precedents already set by epochs I and II. Therefore the causal resolution of subsequent events involving the projected states is dominated by the purely temporal waveform evolution modelled by quantum mechanics, rather than the point particle trajectory evolution of classical mechanics. However as evolution continues and macroscopic states evolve to occupy an expanded spatial domain, the new causal schema can become predominant. Human history shows that quantum mechanics replaced Newtonian mechanics. However in the history of nature's evolution exactly the opposite is true. Therefore in modelling the expansion of the universe from the big bang singularity we must be careful to take account of the incremental shift in the relationship between these two causal schemas.

i. The Cosmological Significance of the Pauli Exclusion Principle

Epoch II and this universe are similar in that they are to provide a composite definition of the initial state, that is, many states that each contributes one element of definition within a consistent difference schema. For the orbital environment of epoch II this was relatively easy, requiring only that each orbital possessed a unique value for the property *n*. This schema however ultimately failed because the environment was not temporally static, but instead enabled new intermediate states to be realised that predominantly had the same values of *n*. For a composite definition to be maintained in this universe the difference schema must be extended to account for the presence of countless particles with the same energy. In general terms, two particles with the same energy can be distinguished if they are at different spatial locations at the same time or the same spatial location at different times. More specifically the refinements to the difference schema are encapsulated in the Pauli exclusion principle [548], which states that no two fermions of a given type can simultaneously occupy the same quantum state. This is not simply a feature of atomic structure, but has a cosmological basis in terms of the necessitated extension of the epoch II difference schema. There must be a way in which every state can uniquely contribute to the definition of this universe.

[59] Chapter Three: 40e. *The Origin of Wave-Particle Duality*.

We have already seen[60] that bosons do not obey the Pauli exclusion principle and can occupy the same energy levels as demonstrated by Bose-Einstein condensation, however as Cottingham and Greenwood explain, "*The Standard Model asserts that the material of the universe is made up of elementary fermions interacting through fields, of which they are the sources. The particles associated with the interaction fields are bosons* [549]." Therefore the fundamental constituents of the universe do obey the Pauli exclusion principle.

j. Virtual Pairs

Matts Roos stated that, "*It is a property of the* vacuum *that particle-antiparticle pairs such as e^+ and e^- are continuously created out of nothing, to disappear in the next moment by* annihilation *which is the inverse process. Since energy cannot be created nor destroyed, one of the particles must have positive energy and the other one an equal amount of negative energy. They form a* virtual pair*, neither one is real in the sense that it could escape to infinity or be observed by us* [550]." The non-scientist would no doubt be somewhat surprised, and perhaps even amused, that physics so calmly accepts that matter is *continuously created out of nothing*, but physics is an observational science and this is what our observations indisputably tell us. But what we seek from cosmology is an understanding of why nature behaves in this manner, and how this behaviour can be accounted for in a consistent physical model. Fritzsch expresses physics' standard explanation, "*Uncertainty relations are responsible for the appearance of virtual particles in physics* [551]." However while the time-energy uncertainty, first formulated correctly by Mandelshtam and Tamm [552], is almost exactly the same as the position-momentum uncertainty in form and application, because time in quantum mechanics is only a parameter rather than an operator, this uncertainty relation cannot be derived from a commutation relation [553] and therefore must ultimately be considered as an additional postulate. Since a postulate cannot be considered to provide an explanation for the appearance of virtual particles, but that such vacuum fluctuations occur can be verified because of their association with the Casimir effect [554, 555] and Lamb shift [556], it is widely accepted that this, "*…is a concept that would benefit from a deeper understanding than currently available* [557]."

While many cosmologies start with virtual pair production [79], in the Flawed Nature Cosmology it has yet to appear. It must be clearly understood that when the coexistent units geometry unravels to be expressed at two polarised, particle-like halves their projection into this universe is not as a virtual pair. The coexistent units are participants in the epoch II difference schema on which energy is based and are therefore real, if quantum states. Virtual pairs are introduced with the establishment of this universe for reasons that can be clearly understood given this cosmology.

For any definition of the initial state to be acceptable it must be capable of expressing all of nature's potential. The epoch II orbitals incorporated all the potentia that had to date been realised, but such a static definition could only be acceptable if further attempts to realise intermediate potentia failed. But the coexistent units were realised proving that more of nature's potential could still be expressed. While it was pointed out that: *No further potentia will be realised in the sense of epoch I until the causal schema of epoch II has run its course and a determination can be made as to*

[60] Chapter Four: 40a. *Comparison with a Bose-Einstein Condensate.*

whether it has succeeded in overcoming nature's flaws or not, at this point epoch II has failed. Whatever comes next must be able to express all of nature's potential.

It was stated earlier[61] that: *At the beginning of all things there is only the potential inherent in the lack of constraint, with no realisation at all. The initial state has no constituents prior to the realisation of some potential in the form of a specific definition of the initial state. The potentia are not pre-existing elements of the initial state but become discrete states because no specific definition can encapsulate all the potential of an initial state devoid of the constraint of a first cause, so that there must be further definitions added. There are multiple potentia because as soon as any potential is made at all specific, it becomes non-inclusive of all possibilities so that no matter how many attempts are made to give the potential of the initial state a specific realisation, this can never represent everything that is possible. The potentia therefore arise as discrete states because of a limit on the effectiveness of the realisation of potential. The initial state is not composed of multiple, pre-existent potentia it is simply that the well of potential can never be emptied. If there is one specific potential realised, there must be another to compensate for the fact that the first cannot possibly give expression to everything that is possible.* However it must always be kept in mind that evolution is not a headlong progression away from the initial state but a continual re-examination of it. It is the initial state itself that changes. There is still no background sea of potentia as such, but with the failure of epoch II there are a huge number of already realised states that do not satisfactorily express all of nature's potentia, this restarts the realisation of unbounded potentia on a massive scale. But this process must now take account of all the evolutionary developments that have occurred since epoch I. When epoch II was established the orthogonal potentia that were the residue of epoch I assumed the precedent of taking a pre-asserted representation. With the establishment of epoch III when unbounded potentia are realised they assume the precedent of the coexistent unit's structure. This is necessary because epoch III is to be dominated by interactions which require all states to have compatible properties.

Let us now consider the time-energy uncertainty relation [558]

$$\Delta E.\ \Delta t = \tfrac{1}{2}\hbar \qquad \textbf{E 8}$$

As it relates to virtual pair production this equation states that since the total action, energy multiplied by time, is given by Planck's constant that if E is increased t must be decreased and vice versa. This means that the larger the virtual pair's energy is the shorter the time it is present. In this cosmology energy is an extension of the epoch II difference schema that utilises the parameter n. Because virtual pairs are derived from unbounded potentia they are not constrained to assume a particular value of n as the potentia intermediate to orbitals were. By extension they can therefore also assume any value for E. However these are freshly asserted potentia that did not participate in the process of repetition that established epoch II and therefore retain a minimum domain of expression involving only one maximum, which has already[62] been associated with h. The time-energy uncertainty as it applies to the generation of virtual pairs simply reflects that the unbounded potentia are asserted with all the properties of coexistent units but with the parameter n free to assume any value, provided the total action does not exceed h, that is, the action applicable to a minimum domain of expression with only one maximum. But despite their assertion the virtual particles cannot automatically become full participants in the energy difference schema of this universe, because their realisation did not involve orbital

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[61] Chapter Two: 13c. *Potentia*.

[62] Chapter Two: 35b. *Comparison of this Cosmology with the Schrödinger Atom*.

collapse and energy is ultimately the retention of the capacity to undo a specific event of orbital collapse as specified by the value of *n*. For the duration of its virtual existence a pair can mimic all of the properties of a real particle pair, but to become a permanent participant in this universe it must acquire energy from it. This can be supplied, for example, through the annihilation of a real particle-antiparticle pair. As Veltman described it, " *An antiparticle can be defined by the fact that if taken together with the particle one obtains something that has no properties except energy. No charge, no spin, nothing* [64]." What this says is that while annihilation is possible in terms of other properties, in terms of energy it is not – *n* is always positive, just a count of repetitions. What the physical system adds is that instead of this energy disappearing it can be passed on to another asserted potentia to make it real. This conservation of energy and its transmission to virtual pairs to make them real is necessary in order to compensate for the true annihilation of elements of nature's potential experienced at the end of epoch II. Because of the uniformity of the expression of potential nothing is truly lost, it is just that one potential that has already experienced a finite duration of expression has given way to the realisation of a fresh potential. In this way as virtual pairs acquire energy from the annihilation of real particle-antiparticle pairs, or from some other source, this provides a mechanism that involves different potentia in existent expression, while maintaining a present instant in this universe that is static in terms of the conservation of energy, its difference schema.

Nature includes virtual pairs in its description not because of any uncertainty, but because of the necessity to maintain the capacity to express all of its potential. Such an explanation, given in terms of why this phenomenon should exist, may seem superfluous to those who are only concerned with whether the mathematics works, or who think that saying *'It's all just part of the non-intuitive nature of quantum mechanics,'* represents an explanation. This is valid, though not very expansive, science. Ultimately more fundamental explanations are essential if we are to make any claim that physics is providing a direct description of nature. Over the last eighty years physicist's expectations that this is possible has been undermined, but this need no longer be the case if a general framework can be provided by a truly fundamental cosmology such as that of this consideration.

k. The Nature of the Ground State

The ground state is not a wavefunction either in the sense of this cosmology or the Schrödinger picture. In terms of this cosmology the ground state is not a wavefunction in the same sense as an orbital, that is, it is not the self-bounded pre-asserted representation of a single potentia. Instead it gives structure to the most primitive form of the initial state, the total lack of constraint that is a consequence of there being no first cause. The unbounded potentia that give rise to the virtual pairs have no pre-asserted representation. As was the case in epoch I they are either expressed as realised states or not at all. In terms of the Schrödinger picture the ground state can have no boundary conditions that would allow the definition of a wavefunction for the same reason no initial state boundary conditions could be specified - there is no way to get outside of it to determine boundary conditions. This is to be expected since the ground state is the initial state and as such is in fact an unbounded environment.

This is important in terms of the previously mentioned[63] debate between Feynman and Weinberg regarding the different interpretation of the ground state provided by quantum electrodynamics and quantum field theory respectively. Quantum field theory would have virtual pairs, and all particles for that matter, appear simply as localised perturbations in a real field [449]. In this way the energy of the ground state is a fundamental property of the field. Quantum electrodynamics in contrast holds that the ground state energy arises solely because of the appearance of virtual particles [2]. On this issue the Flawed Nature Cosmology clearly comes down on the side of Feynman and quantum electrodynamics.

l. The Residual Orbital

The other aspect of the initial conditions for the big bang is the sole remaining orbital from epoch II. While the coexistent units represent all the intermediate potentia that have ever been successfully asserted, this single orbital represents all the unbounded potentia that had been realised in epoch I. All the residue of nature's evolution to date is carried forward into this universe. However two things must be noted about this orbital, firstly that being a pre-asserted representation it is non-energetic and secondly, it does not represent the ground state orbital but the first excited level.

m. Schrödinger Cheated!

So much of our physics is currently dependent on the Schrödinger equation that it seems almost to be a sacrilege to point out that Schrödinger cheated when he constructed it, in that he used a presumption that was not physically justifiable. It is not that this is unknown; it is just that it is untaught, in case it instils any sense of doubt in the new student of quantum mechanics. But in doing this lecturers remove from their consideration a problem whose solution holds the key to resolving the reality interpretation of quantum mechanics. But let us start at the beginning, with a simple reconstruction of the Schrödinger equation.

We must start by considering de Broglie's statement regarding his relationship between wavelength, λ, momentum, p, and Planck's constant, h, " *In a region where* K (the kinetic energy) *is constant, the velocity and hence the momentum, p, are constant. The matter wave, ψ, is then a sinusoid with wavelength* $\lambda = h/p$ *(hence, with wave number* $k = 2\pi/\lambda$*). This is*

$$\psi = A\sin\left(\frac{2\pi}{\lambda}\right) + B\cos\left(\frac{2\pi}{\lambda}\right) = A\sin(kx) + B\cos(kx) \qquad \textbf{E 9}$$

The amplitudes A and B are not determined. The extent of the waves is indefinite. The polarization of the wave is unspecified [559]."

A differential equation that has as its solutions the de Broglie waves is therefore [559]

$$D^2\psi = -k^2\psi \qquad \textbf{E 10}$$

where in considering a problem defined along the x-axis D^2 denotes the second derivative with respect to x.

By noting the relationship between wave number and kinetic energy [559]

[63] Chapter Two: 40b. *The Fate of the Coexistent Units.*

$$k = \frac{(2m)^{1/2}}{\hbar}\sqrt{K} \qquad \textbf{E 11}$$

the differential equation can be re-written as [559]

$$D^2\psi = -\frac{2m}{\hbar^2}K\psi \qquad \textbf{E 12}$$

Now given that the total energy is [559]

$$E = K + U \qquad \textbf{E 13}$$

where U is the potential energy, this becomes [559]

$$D^2\psi = -\frac{2m}{\hbar^2}(E - U)\psi \qquad \textbf{E 14}$$

This then is Schrödinger's non-relativistic time-independent equation in one dimension. It can be considered to be based on de Broglie's derivation of $\lambda = h/p$, but as de Broglie clearly stated this applies only to a *"…region where K is constant…*[559].*"* Schrödinger's cheat, or stroke of intuitive brilliance if you prefer, was that he assumed that his equation would hold, *" …even in a region in which the kinetic energy is not constant* [559].*"* As has been pointed out by Grometstein, *" There is no theoretical justification for this conjecture, but it has worked magnificently* [559].*"*

The Schrödinger equation produces a wave packet composed of the de Broglie waves that are its solution, given the specification of E and U and the boundary conditions. But even if this defines a situation that would produce a variable momentum in the region of the x-axis under consideration, each de Broglie wave spanning this region is presumed to have one specific frequency. Whereas, if we were to cut this region into small segments and simply apply the formula $\lambda = h/p$ to these segments taking into account the variation in p, the entire region would be spanned by a reconstructed de Broglie wave of variable frequency. However, it is the former arrangement that gives agreement with experiments. But it is because this cannot be derived strictly from the physical situations, which would produce the latter result, that no clear physical interpretation of what the Schrödinger wavefunction represents could be given.

What we suggest is that if the Schrödinger waves having a single wavelength cannot be justified on the grounds of the physical situation under consideration, it must be based on a precedent establish earlier in the evolutionary history. That precedent was the repetition that established the orbitals of epoch II. In this cosmology each acceptable component of the wavepacket represents the definition of the limited universe defined by the boundary conditions as if this was provided by one and only one potentia. Resolution of the inevitable over-specification of acceptable wavefunctions is resolved by their summation to form the composite wavefunction or wavepacket. This then defines the uncertainty of realisation for the constituents of this limited universe. These wavefunctions based on the pre-asserted representations of potentia need not be reinvented but are a tangible element of the big bang initial conditions. Even if a totally new potentia is required for a particular set of boundary conditions, in the same way that unbounded potentia are realised using the precedents established by the coexistent units, intermediate potentia would be expressed using the precedents established by the orbitals, that is, repetition and therefore non-variable frequencies.

This consideration provides support for Penrose's belief that the wavefunction is *"…completely objective* [160]*,"* and Weinberg's statement that, *"…the wave function really is out there in nature* [161]*."*

n. The Speed of Light and the Establishment of the Past

As Baggott explained, *"…Einstein, faced with the problem of explaining a fixed speed of light, raised that fact to the status of a postulate and used it to deduce the special theory of relativity* [95]*."* However by reference to the Flawed Nature Cosmology why a maximum velocity should be an attribute of this universe can be clearly understood. As the big bang singularity expands particles can be projected onto a larger number of locations in spacetime. If there were no constraint on the velocity with which particles could move interactions could be instantaneous, thereby providing no past history in terms of spatial trajectory to be used for the causal resolution of events. A maximum velocity is required for this universe to establish a past that nature never previously possessed. This maximum velocity is provided by the constant rate of projection of the waveform onto the space-time axis.

o. Time and the Big Bang Initial Conditions

Much of this dissertation concerns the evolution of the nature of time. There is no going back, no recourse to excessive reductionism. Therefore in considering the temporal environment for the big bang initial conditions we must look for far more detail than simply considering time to be evidenced by the first motion of a material object through space. In fact the temporal environment must be broken down into three aspects – the continued realisation of nature's potential, the three schemas for establishing causality characterised as the future, present and past, and the evolution of individual states, both microscopic and macroscopic.

Firstly let us consider time in terms of the realisation of nature's potential. When saint Augustine wrote his *Confessions* [60] he had no choice but to conclude that the future was abstract and invisible, and that ultimately the progress of time from the future through the present to the past is beyond human comprehension. But this need no longer be the case. Nature's evolution, as we have seen in this cosmology, is fundamentally about the evolution of time. It should not be surprising then that the establishment of this material universe makes the passage of time manifest. We can literally see the transition from future to present and from present to past. The future is manifest, even before it becomes truly real, as virtual pairs. In epoch I the future was expressed as the random realisation of unbounded potentia. The virtual pairs are just this same process done over to take account of the precedent established by the structure of the coexistent units. They are elements of nature's unbounded potential that have not yet found sustainable existent expression, but that can nonetheless be seen. They cannot immediately become real, that is, part of the present instant of this universe because the present instant itself, as it was in epoch II, is meant to be a static, composite definition of the initial state. In epoch II this was expressed through intermediate potentia having to assume a value of n intermediate to the value assumed by the orbitals that bounded it, which was balanced by orbital collapse so that the sum of n was conserved. In the epoch of this universe the difference schema is manifest as energy and the constraint that this must be temporally static as the conservation of energy. But while this places constraints on the flow of time it does not stifle it. As particles and antiparticles collide and annihilate they fade from existence leaving only the energy that cannot be taken from the present instant. This energy can be taken up by virtual pairs to make them legitimate participants in the present's difference schema and therefore real particles. In this way as part of nature's potential fades from existence, having exhausted its turn at expression, fresh elements of nature's unbounded potential are given their turn at existent expression. The passage of time in terms of the realisation of nature's potential is no abstraction but clearly visible. As this dissertation has repeatedly emphasised – nature does nothing without process.

Secondly let us consider time in terms of the three schemas for establishing causality characterised as the future, present and past. We have already seen[64] that general relativity models time in terms of the concept of a *block universe where the past, present and future all exist seamlessly*. It has also been shown[65] how this situation evolved: *Epoch II is now a mixed temporal environment whereby the orbitals are established from the static composite definition, but this stasis is periodically disturbed by individual events that establish that specific orbital pairs as boundary conditions for a non-static definition. Epoch II was established as an environment characterised as the present, yet epoch I's temporal schema characterised as the future has managed to infiltrate its way into it. Here we can see the intertwining of the present and the future within one evolutionary epoch, the first stage in the evolution of the block universe of general relativity*. This process is simply extended to include the past, which is a causal schema based on the past spatial trajectory of particles. When we look out at the world what we see in terms of the causal schemas that determine how events within it are resolved is all levels of time, that is, the precedents established by the entirety of nature's evolution.

Thirdly let us consider time in terms of the evolution of individual microscopic states. This is complicated by the fact that each state has two projections into this universe. *The particle represents where the state is in space-time, a single point. The wave is the same state's continuous projection onto the space-time axis, its temporal evolution, which is rightly modelled by quantum mechanics as unitary evolution*. This is how the state would evolve in isolation and remember that this is what the potentia seek to do, provide a single definition for the entire initial state. But there are more directions in space than there are in time and so unitary evolution does not trace a specific spatial trajectory but the heartbeat of the state itself. In the final analysis it moves only in its own mind's eye. However this can be interrupted by consecutive interactions that provide the boundary conditions for a causal gap. The big bang singularity is the first measured location of all particles, the first boundary condition for subsequent causal gaps. Remember that a state's projection as an individual elementary particle does not persist beyond the duration of the finite present instant of this universe. Therefore an individual elementary particle cannot maintain existent expression long enough for its spatial trajectory to determine its evolution over any significant distance. Therefore if there is an interaction that could potentially determine the location of a specific elementary particle at significantly more than the Plank length from the last location where the particle's location was fixed in four-dimensional spacetime, what nature has is a problem, a causal gap that it must resolve in order to maintain this universe as a consistent composite definition of the initial state. But there is no single definition of this limited universe, every waveform that satisfies the Schrödinger equation represents one potentia that could provide its definition. The wavepacket in the spatial region of the second

[64] Chapter Two: 10b. *Retrocausality in Physics.*
[65] Chapter Two: 34d. *The Further Evolution of Time – Epoch II.*

measurement determines the uncertainty of realisation taking into account the potential within the bounded region. As we have seen[66] *when Schrödinger introduced his wave equation interpretation of quantum mechanics he believed the wavefunction to be the electron itself, stating that, "…material points consist of, or are nothing but, wave-systems…*[186]*." However Born's probability interpretation* [187] *separated these two things – the wave was not the particle but a measure of the probability of finding the particle at a particular location*. In terms of the Flawed Nature Cosmology probability arises because while a potentia is guaranteed realisation given the full extent of nature's evolution, an attempt to realise a potentia within limited boundary conditions may indeed fail. The particle is not the wave but an instantaneous realisation with an uncertainty of success determinable from the amplitude of the wavepacket.

Penrose pointed out that in quantum mechanics, *" …systems are described as evolving according to one or other of two apparently incompatible procedures: deterministic unitary Schrödinger evolution …and probabilistic state vector reduction…*[68]*,"* and that, *"…the unquestionably impressive experimental support that quantum theory continues to have is not for the Schrödinger evolution of a quantum state. It is for that absurd concoction of Schrödinger evolution on the one hand and state-vector reduction on the other which defines the standard Copenhagen interpretation. That is where the support lies and it is that with which we must come to terms in our attempts toward an improved theory* [160]*."* Given this cosmology there is no incompatibility between these two schemas. The *deterministic unitary Schrödinger evolution* is the continuous projection of the underlying state onto the space-time axis of this universe. It defines its temporal evolution, although because of the complexity of space this cannot be expressed as a specific trajectory but instead determines the flow of uncertainty of realisation to be applied along any path. The *probabilistic state vector reduction* is simply an attempt to realise the underlying state at a specific location along the space-time axis, the second method by which it is projected into this universe. The projection of particles onto the space-time axis is inherently a discontinuous process, with their location only fixed for the finite duration of the present instant of this universe. Wavefunction collapse occurs because the causal gap that defined the limited universe is resolved. Thereafter the potentia evolve independently and the wavepacket dissipates. Everything that is true will eventually make sense in terms of a direct description of nature.

Lastly let us consider time in terms of the evolution of individual macroscopic states. While macroscopic states are simply composed of a large number of microscopic states, interactions within the group objects ensures that sufficient elementary particles are always realised for the macroscopic object to be continually existent and therefore maintain an unbroken spatial trajectory. Time for macroscopic objects is determined by their motion through space. Two objects separated by a distance, s, have a minimum time between kinetic interactions given by $s = ct$ and an actual time given by $s = vt$. This is the extent of the past that can be utilised to determine their causal association if they come into contact. In this way time and space become interrelated.

It must be noted that not all interactions involve contact and so the forces that provide long distance contact between states also form part of the temporal character of this universe, but we shall deal with this when we consider the origin of the forces shortly. For the moment we simply note that these forces are also constrained so that

[66] Chapter Two: 18e. *Predicting the Consequences of Having Multiple Intermediate Potentia.*

they do not act instantaneously but have influences propagated at the finite speed of light.

p. The Dispersal of the Wavepacket and the Evolution of Nature's Memory

When a measurement is performed the probability of a particular outcome being realised is calculated from the amplitude of the superposition of all the wavefunctions that satisfy the Schrödinger equation, which is called the wavepacket. While Schrödinger wanted to state that the wavepacket was the particle itself, Hendrik Lorentz pointed out that, *" When confined to a small region of space, such a wave packet is expected to spread out rapidly, dispersing or 'dissolving' into a more uniform distribution. This is obviously not what happens to sub-atomic particles like electrons* [95]*."* Instead the wavepacket has become associated with a sharply defined piece of knowledge. But as Wolf pointed out, *" The Schrödinger equation is the only mathematical tool we have to keep track of such* (quantum) *objects. But it doesn't do a good job; it simply tells us how we lose information. Once we actually perform an observation, we gain back some of what we lost. This process of gaining back is a discontinuous process* [196]*."* When we do a measurement the wavepacket represents a sharply defined piece of information about the physical system, but immediately after measurement the wavepacket starts to disperse because the individual waves have different frequencies and therefore different velocities and this information is rapidly lost.

In this cosmology *wavefunction collapse occurs because the causal gap that defined the limited universe is resolved. Thereafter the potentia evolve independently and the wavepacket dissipates.* However if a second measurement is done almost immediately after the first and before the wavepacket has had time to disperse, we can predict accurately that the outcome of a single measurement will be the same as the last measurement. Given this the loss of information need not be considered as a failure either in our understanding of nature or of nature's capacities. Instead it is a marvellous achievement by which nature, at least partially, has managed to overcome the lack of capacity for specific memory. Admittedly nature's memory fades quickly, but at least it has gained a physical capacity to retain it for a time. The Schrödinger equation is not flawed in giving the prediction that information will be lost in this way, it is simply modelling the imperfect nature of this cosmology and its struggle to overcome its flaws.

q. The Arrow of Time and the Big Bang Initial Conditions

As previously noted[67], *much has been written in the literature of physics* [315-319] *about the fact that time has two intrinsic directions while our universe seems to possess a single forward directed arrow of time. But this is not surprising since the dual direction of time represents the introduction of a new flaw that nature has striven to overcome.*

Most physicists approach the arrow of time problem in terms of entropy, with the thermodynamic arrow of time given by the direction of increasing entropy, which in turn is dependent on irreversibility. Elitzer and Dolev [560] argue that indeterminism and time symmetry are incompatible, stating in a paper co-written

[67] Chapter Three: 26. *Non-Linear Evolution*.

with Hemmo that, “ *To say that a process can be microscopically reversed, one must profess absolute determinism* [319],” and that, “ *…genuine indeterminism at the micro scale enforces a macroscopic time arrow that has nothing to do with initial conditions. Rather, it seems to be intrinsic* [319],” noting that a similar conclusion was reached by Albert [561, 562]. However, their paper [319] does not tell us why nature is indeterministic but only gives a classification scheme, in terms of patterns of indeterminism. This cosmology by contrast does point out why nature’s evolution is fundamentally indeterministic. But it goes much further than this by pointing out exactly where along the evolutionary timeline two-directional time was introduced. Therefore while we agree with Elitzer and Dolev that indeterminism has a role to play in providing a basis for the thermodynamic arrow of time, we suggest that the fundamental resolution of the arrow of time problem must be given in terms of how nature seeks to overcome the original flaw of two-directional time. This resolution of the arrow of time problem must be given in two different ways, one for each of the methods of projection into this universe.

For the waveform projection two-directional time is overcome by taking the coexistent unit superposition, *x OR* $\neg x$, and giving it a linear representation as a continuous wave, *x then* $\neg x$. But this is only a partial resolution as evidenced by the way a probability must be calculated using the wave. This is done by taking the amplitude of the wave Ψ and multiplying it by its complex conjugate Ψ^*. This is a real number that with normalization is in the range 0 to 1. This equation is taken from an analogy with the equation for the intensity of light passing through a region of space, which is given by the square of the amplitude of the waves emitted from the source. The association with probability arises when this intensity is interpreted in terms of the number of photons passing through this region. If of one hundred photons emitted from the source, five photons pass through this region, the probability of finding one of the original photons in the region is 0.05. As Feynman and Hibbs [563] put it, “ *We* compute *the intensity (i.e., the absolute square of the amplitude) of waves that would arrive in the apparatus at x and then* interpret *this intensity as the probability that a particle will arrive at x.*” But note that this is purely an arbitrary interpretation. Ultimately the use of the expression $\Psi\Psi^*$ to calculate the probability of a particular outcome occurring is only justified by the fact that it works.

However in this cosmology that probability is determined by $\Psi\Psi^*$ simply reflects the fact that the waveform is only a partial solution to the flaw of two-directional time. It defines the temporal evolution of the projection of the coexistent unit into this universe but does not introduce any capacity to resolve the superposition itself, instead merely providing an alternative representation of it. In the epoch I *ac*-superposition the two waves of opposite amplitude spanned the same temporal gap and so were simultaneous and added, or in the terminology of probability theory, the two aspects of time represented two alternative ways for the same event to occur and therefore were added. This addition always results in a wave with zero amplitude everywhere and therefore no probability of realisation. The waveform representation of the superposition does avoid this cancellation of the two temporal aspects of the potentia by ensuring that they do not both span the same temporal gap but are expressed one after the other. The two temporal aspects are no longer two ways the same event can occur, but two consecutive events that would have their probabilities multiplied. Every point along the space-time axis therefore either has a positive or a negative amplitude projected onto it, never both for a single potentia. But because the superposition is never resolved, two-directional time must still be accounted for in the determination of the uncertainty of realisation of a particle projection. Therefore if the amplitude of the wave is Ψ at the spatial location where a measurement is conducted, the probability of realising the particle is given by $\Psi\Psi^*$, which both accounts for two-directional time, that is, that the superposition has not been resolved and the nature of the waveform projection of the superposition into this universe. In so doing it provides a means for resolving interactions between discrete states in terms that are independent of the resolution of the underlying coexistent unit superpositions and therefore independent of whether this individual event resolves nature's flaws or not. Nature has learned patience.

The missing antimatter is often considered to represent a flaw in nature's design, a broken symmetry that shatters nature's perfection. But nature was never perfect and so instead must struggle to overcome its flaws, both the initial flaw of having no first cause and new flaws introduced by the evolutionary process such as two-directional time. Particles and antiparticles are the projection of the coexistent unit superposition, $x\ OR\ \neg x$, where the superposition is maintained by spatial separation. If the particle and antiparticle are ever at the same place at the same time, and therefore not distinct in terms of this universe's difference schema, this will violate the constraint that a potentia must only have one realised expression and they will annihilate. The particle and anti-particle reflect the two possible temporal directions just as Feynman [108] suspected. When an astronomer looks out into the universe and sees galaxies made only of matter, this demonstrates that the flaw of two-directional time has been largely overcome in terms of particle projection. While the waveform projection provides no capacity to resolve the coexistent unit superposition the independent evolution of the two aspects of the superposition as particles and antiparticles does. Since the disparity of matter and antimatter was established during the big bang, it has a material role to play in resolving one aspect of the resolution of the flaw of two-directional time and thereby providing a single arrow of time for this universe.

However it must be noted that these resolutions of two-directional time are not absolute. New virtual pairs will continue to express both aspects of time, but this is to be expected since they did not undergo the events of the big bang. When a limited universe is established by boundary conditions the causal resolution of this event will still reflect two-directional time since it represents the reestablishment of the conditions that introduced it. But while this means that all waveforms within the boundary conditions will be considered to be simultaneous, spanning the same temporal gap, and therefore added, these will now be the new linear waveform representation of the potentia which can produce a composite wavefunction that does not have zero amplitude everywhere. This will then provide the single linear waveform overlaid on the space-time axis from which the probability of realisation will be determined in terms of the formula $\Psi\Psi^*$.

r. Concluding Comments on a Reconsideration of the Initial Conditions for the Big Bang

Currently the big bang model must simply postulate all its initial conditions, with the existence of matter, space, the laws of physics including the postulates of quantum mechanics simply presumed and applied from the outset. This is a huge weight of postulates. By contrast the Flawed Nature Cosmology simply flows into the big bang as a continuous model based solely on the proposition that no truly initial state can have a first cause and that this is a flaw that nature will strive to overcome. The initial conditions for the big bang are still complex, but they are comprehensible given this cosmology's consideration of nature's pre-big bang evolution. While this cosmology is still in its infancy we would reiterate that *the test of Ockham's razor is not concerned with our comfort, but purely with the number of assumptions required as a basis for a theory*. We cannot postulate everything and call that science, but must instead continually struggle to develop new theories that reduce the need for all-encompassing postulates.

Less than a heartbeat ago all the coexistent units were annihilating, erasing all that had been achieved by nature's evolution as well as the potential from which it sprang. Then there was one random event, a physical interaction between two coexistent units that established two new states, a new type of superposition composed of one and a half potentia and a singular potentia that could have provided a definition for the entire initial state, but a definition so simplistic that it would be incapable of expressing all that nature had learned from the evolutionary process. But this answer cannot be erased only isolated by not allowing the knowledge of its existence to be part of nature's memory but instead making it the first element of its own. The first evolutionary epoch ended because it could be predicted that no matter how many times the *ac*-events were repeated they could produce no resolution to the flaw that there was no first cause. The second evolutionary epoch ended because it can be predicted that any further cross-coexistent unit interactions will produce a single definition of the initial state that is causally justified by the physical event of interactions, but too simplistic to express all that nature could become given what has been learned through the evolutionary process. To explore everything that evolution could establish is more desirable than to find an answer that would render nature static and dead, erasing any memory that more is possible. This is the state of knowledge at the point when nature must attempt a new approach to resolving its flaws. The big bang is just what happens next.

48. The Big Bang and the Establishment of the Past

This cosmology promised to provide *a physics beyond: How?* that could explain nature's actions in terms of why they occur. Why the big bang occurs is clear – it is to establish a past that nature has never possessed and from this a causal schema based on the past spatial trajectory of discrete states. In order not to be blinded by the complexity of the physical interactions involved in the big bang it is necessary to first gain a general understanding of how this broad objective is to be achieved.

a. The Establishment of the Past and Quantum Mechanics

The initial conditions for the big bang, like those for the initial state itself, are not perfect. However they are more complex both in terms of the physical residue established by earlier evolutionary epochs and nature's state of knowledge, which can be applied even to the previously unasserted potentia. What nature seeks to establish with the advent of this new evolutionary epoch is a causal schema whereby a state's past history in terms of spatial trajectory determines the resolution of interactions in a consistent way, so that despite the presence of change this universe can remain a consistent composite definition of the initial state. This will overcome the shortcoming of epoch II where change and the maintenance of a composite definition were in conflict. However nothing can occur without process. What must principally be understood about the big bang is that it is the process whereby this universe is established. This may seem self-evident but it is not actually reflected in the way the big bang is currently modelled, which tends to simply presume the existence of all the attributes of the current universe. Instead the big bang must be modelled from primitive initial conditions that are only moderately different from those at the end of epoch II and that therefore are insufficient to achieve an ideal outcome, through the development of the environment to the point where causality based on past spatial trajectory has been established. It is this, not the formation of galaxies, which marks the completion of the big bang. Therefore to understand the big bang at a fundamental level is not principally about understanding how matter acts in an environment of extremely high density and temperature, but must involve recognition of the difficulties nature must overcome in order to establish a causal schema based on past spatial trajectory.

Before the spatial trajectory of discrete states can be used as the basis for a causal schema there is a problem that must be overcome, the most fundamental characteristic of an initial state devoid of a first cause is that anything that can happen will. In terms of the motion of a discrete state through space this means that it cannot be constrained to take a single path but must in a real sense take all possible paths between two points in space. This would be impossible for a Newtonian point mass that is constantly existent, since it would mean being in multiple places at the same time. However the quantum discrete states of this cosmology are only temporarily realised. When a measurement event occurs that could determine if a particular discrete state is in a new spatial location, this establishes a causal gap that must be retrospectively resolved. This situation is only different from the *ac*-environment of epoch I in two respects. Firstly, instead of establishing a new pre-asserted representation of an intermediate potentia the causal gap is to be closed using the timeline of the discrete state. Therefore the pre-asserted representation that spans this causal gap is the em-waveform for a photon or the de Broglie wave for an elementary particle. When describing the failure of the *ac*-events of epoch I[68] it was stated that: *It is as if we are trying to establish a point matrix to define a space, but every time two point locations are specified and an attempt made to establish their relationship in terms of a transition from one to another, it is instead proved that, "You can't get there from here* [232]*," and these points are lost to inclusion in a common space*. However two spatial locations can be proven to be elements of a common environment if they are linked by successive realisations of the same discrete state. The second way in which the situation within this universe is different from the epoch I *ac*-environment is in terms of the complexity of the environment between the two boundaries of the causal gap. There was no space in epoch I and therefore only one path was possible between *a* and *c*. However the three spatial dimensions of this universe allow multiple paths, and since anything that can happen will, all of these paths must be treated equally. This would seem to remove any possibility of establishing past spatial trajectory as the causal schema for this epoch. However this problem is overcome by using the timeline of a single discrete state rather than any possible intermediate potentia to close the causal gap, since this ensures that while there are unlimited spatial paths the frequency of the wave that travels these paths is fixed. Earlier[69] it was stated that *while the various flavours of quantum mechanics are mathematically equivalent, they may not be cosmologically equivalent. Therefore we would contend that a preference can be determined in*

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[68] Chapter Two: 20. *The Consequences of Failure*.
[69] Chapter Two: 18j. *This Cosmology and the Different Flavours of Quantum Mechanics*.

terms of which comes closest to providing a direct description of nature. It is clear at this point that in terms of the motion of discrete states Feynman's sum over histories interpretation of quantum mechanics provides the best direct description of nature. This is emphasised by the fact that, as applied to quantum electrodynamics, Feynman's approach describes only three basic actions, " *Action #1: A photon goes from place to place. Action #2: An electron goes from place to place. Action # 3: An electron emits or absorbs a photon* [2]*,"* yet as Feynman emphasises, " *…the theory describes all the phenomena of the physical world except the gravitational effect …and radioactive phenomena, which involve nuclei shifting in their energy levels* [2]*."* With respect to the motion of photons through space Feynman has shown [564] that while all possible paths must be taken into account, crooked paths have a nearby path of considerably less distance and therefore much less time and that the amplitudes of these paths tend to destructively interfere. By contrast paths near the path of least action, that is, where $(x_2 – x_1)^2 + (y_2 – y_1)^2 + (z_2 – z_1)^2 – (t_2 – t_1)^2$ equals zero, have similar final amplitudes that constructively interfere. Therefore only spatial paths near the path of least action contribute to the amplitude for finding a photon in the second spatial region. In this way the specific waveform of the photon overcomes the fact that any path can be taken and establishes a narrow column of space around the path of least action as the only significant spatial trajectory for the photon. Note that this does not establish the path of least action as the actual past spatial trajectory of the photon, in fact all possible paths are taken into account when determining the probability that it will be realised at the second spatial region, however this is rendered almost indistinguishable from having the path of least action as its past spatial trajectory by the physical characteristics of the waveform for the discrete state. Quantum mechanics itself provides the first evolutionary step towards establishing a classical causal schema based on the past trajectory of discrete states, a process that is completed with the evolution of macroscopic group states that can be considered to be permanently existent and therefore maintain true trajectories through space.

But note that Feynman's sum over histories interpretation of quantum mechanics only deals with one of the flaws introduced by the initial state having no first cause, that anything that can happen will. There is also the flaw that the definition of the initial state is hopelessly over-specified. With respect to this universe over-specification is the problem that must be overcome with regard to the definition of any specific environment, while that anything that can happen will is the problem that must be overcome with regard to the motion of discrete states. The selection of a preferred flavour of quantum mechanics must still be dealt with on a situational basis. Feynman's sum over histories provides the best conceptualisation for the motion of discrete states, while Schrödinger's wave equation provides the best description with regard to specific limited environments, since each solution to this equation specifies another potentia by which the limited universe under consideration could be defined. The universe really is a complicated place and must be dealt with by physicists as such. Only a fundamental cosmology can fit all the aspects of this complexity together to provide a consistent conceptualisation of nature.

b. The de Broglie Wave and the Wavefunction

If a student of quantum mechanics were to ask their lecturer, " *What is the relationship between the de Broglie wave and the wavefunction?"* they would no doubt be told that this is not a proper question, that there is no relationship between the de Broglie wave and the wavefunction; it is simply that the wavefunction is the set of de Broglie waves that satisfy the Schrödinger equation for a specific set of boundary conditions. But as we have seen earlier[70], given the standard ensemble average interpretation of the wavefunction, this does not satisfy the issue raised by Ord and Gualtieri, " *How can a single particle have an associated wavefunction* [183]*?"*

In the Flawed Nature Cosmology the de Broglie wave and the wavefunction while related are not exactly the same thing. The de Broglie wave represents one of the two ways a discrete state can be projected onto the space-time axis. It is an attribute of a single state independent of external boundary conditions. However no wavefunction can be defined without boundary conditions, which for a discrete state are the self-boundary conditions either in the sense of orbitals or coexistent units. The de Broglie wave is the projection derived from the motion of the significant point of the individual state's self-definition path onto the space-time axis of this universe. It is not an ensemble average but the flow of uncertainty of realisation as defined by the state's own self-definition. In the context of this universe the uncertainty of realisation relates to the instantaneous projection of the state onto a specific location on the space-time axis, which produces the particle representation. The de Broglie wave determines the temporal evolution of the state in isolation, that is, within a universe where it is the only projection. It is appropriate therefore that the de Broglie equation gives a single answer, a single waveform representation for each discrete state. The complexity that arises in terms of determining the evolution of the discrete states comes from the fact that for an initial state without a first cause anything that can happen will, which ensures that a particle can take any path between two points in space.

The wavefunction as defined between two spatially distinct boundary conditions is quite different in that it is not a property of a discrete state but of the limited universe established by the boundary conditions. Each component of the composite wavefunction is a potentia whose waveform representation could define this limited universe. These can be selected by the Schrödinger equation together with the boundary conditions. This is a manifestation of the fact that the lack of a first cause leads to the over-specification of the definition of the initial state. It is therefore appropriate that the Schrödinger equation, being a partial differential equation, can have an unlimited number of solutions since the limited universe, like the initial state itself, is still subject to over-specification.

A particle that no longer evolves in isolation but as part of a limited universe will be affected by the wavefunction definition of this limited universe. It must take account of its environment, but this must be done in a way that is compatible with its evolution in isolation, that is, not in terms of a classical description of the geometry and constituents of the environment, but in terms of how this affects the flow of uncertainty of realisation. The composite wavefunction is in a real sense all that can be known about the environment expressed in a terminology compatible with the state's own evolution.

The de Broglie wave defines the state's free evolution, while the composite wavefunction adds to this a compatible definition of the environment of the causal gap between the last spatial location where it was realised and the next location where an attempt at realisation will be imposed by a measurement. This definition of

[70] Chapter Two: 17d. *The First Wavefunction and Probability.*

the environment appears to be just a set of de Broglie waves because this is how all potentia, whether already realised as particles or just potential definitions of a limited universe, are specified. What this cosmology adds is clarity in terms of understanding why this is a valid direct description of nature, as well as an answer to Ord and Gualtieri's question, " *How can a single particle have an associated wavefunction* [183]*?*"

c. The Establishment of the Past and General Relativity

The function of this universe is to establish a past that nature has never previously possessed. At the beginning of epoch III the residue of epoch II was focused on one place, in a manner similar to having all the residue of epoch I realised at the same time in order to establish epoch II and the present. But if the present instant was not simply asserted at its establishment, what is it within this universe? Again we must deal with this question separately for the waveform and particle projections. However the temporal evolution of this universe is dominated by the projection of the waveform representation of the coexistent units onto the space-time axis, which occurs at a constant rate that is evidenced as the speed of light, *c*. For the waveforms there is no static present instant, instead the present instant is shared by all states that propagate at the speed of light. Physicists use the second as the standard unit of time, but Feynman has already pointed out that this was a very poor choice, instead recommending that *"…the time it takes light to go one meter…*[2]*,"* is a more natural unit of time. This is in fact more in keeping with how nature would count time, which is in terms of the rate of projection of the waveform onto space. Therefore an object that cannot traverse a meter of space in this unit time is out of step with nature's definition of the present. Such objects lag behind this universe's present instant and are in a real sense constituents of its past. All massive objects fall into this category, all the components of galaxies and worlds and the ecosystems that may evolve upon them. The function of this universe is to establish a past that nature has never previously possessed, but time is no abstraction instead the past is where all of the tangible structure of our universe resides, illuminated by the evidence of a consistent present that perpetually races ahead of it.

Particles such as electrons are not permanently existent but must be reasserted with each new measurement. The present instant for the particle projection is therefore the time during which it can maintain it realised expression. This is initially determined by one maxima region of the waveform, which defines both its minimum and maximum domain of expression. A situation only slightly blurred when the particle's location within a limited universe is defined by a wavepacket that can momentarily persist, a physical situation that serves as nature's memory and that would result in the same particle being found in the same place if measurements were repeated rapidly enough. However there are two types of particle projections, those that occur on the space-time axis and those that occur off axis. The projection of the waveform representation of the coexistent unit onto the space-time axis established the potential for the three normal spatial dimensions of this universe. However the first particle projection resulting from these waveforms was on the space-time axis, where the dual nature of the coexistent unit is maintained as a single particle, the photon. However there is an equivalent off axis projection, where the dual nature of the coexistent unit is expressed as a particle-antiparticle pair. Such a realisation has the same location in terms of the space-time axis, but is offset into three-dimensional space. They now have a location in four-dimensional spacetime, with the principal space-time axis coming to specify the time of realisation while the off axis dimensions give the particle pair's location in the three normal dimensions of space in terms of their separation. In this way a particle-antiparticle pair separated by three-dimensional space establishes a new representation for a maintained superposition. They cannot be considered to be two realisations of the same potentia unless they are expressed at both the same time and the same place, in which case the particle-antiparticle pair would annihilate. However separated by three-dimensional space each aspect of the superposition can evolve in an almost independent manner. Such off axis particles travel at a velocity less than that of light and therefore cannot be said to be experiencing a purely temporal evolution. They are not evolving purely within the present instant of this universe, but lag behind this to also evolve in terms of their three-dimensional spatial location. But this is what is required for there to be a past spatial trajectory.

49. A Brief Review of Particle Physics

Before we can effectively consider the big bang it is necessary to briefly review particle physics. As we have seen earlier[71], as Cottingham and Greenwood explain it, *" The Standard Model asserts that the material of the universe is made up of elementary fermions interacting through fields, of which they are the sources. The particles associated with the interaction fields are bosons* [549]*."* Fermions are broken up into two types *leptons* and *quarks*, all of which have spin ½ in units of $\hbar$.

Leptons do not interact through the strong force but instead interact through the weak force and, if they are charged, through the electromagnetic force. Quarks interact through the strong force, but can also interact through the weak force, and, if they are charged, through the electromagnetic force. There are three families of leptons, the electron family, *e*, the muon family, μ, and the tau family, τ. Each family includes a corresponding neutrino, for example the electron family includes the electron-neutrino, ν_e. Neutrinos have no charge and were originally considered to be massless, however there is now evidence that they have a small mass [565-567]. For all of these particles there are corresponding antiparticles. The muon and tau families are similar to electron family in having negative charge although they are more massive - the electron mass is 0.511 MeV/c^2, the muon 105.658 MeV/c^2 and the tau 1,777 MeV/c^2. As Donoghue *et al* noted with regard to the lepton masses, *" They fit no evident pattern* [568]*."* The muon and tau can decay into other particles whereas the electron cannot. As Jonathan Allday pointed out, *" Aside from making the number of leptons equal to the number of quarks, there seems to be no reason why the heavier leptons exist* [569]*."* In fact muons had not been theoretically predicted before their discovery in collision experiments, prompting Isidor Rabi to exclaim, *" The muon – who ordered that* [551]*?"* While the particle zoo continued to grow through the 1950's and 1960's, there is now evidence based on the decay of the Z^0 boson that there are in fact only three lepton families. The Z^0 can decay into a neutrino-antineutrino pair of any flavour. That only the three flavours already discovered have been evident in Z^0 decay indicates that there are only three families of leptons.

The families, or *flavours*, of quarks are called *up*, *down*, *charmed*, *strange*, *top* and *bottom*, designated respectively *u*, *d*, *c*, *s*, *t* and *b*. Quarks have fractional electric charge of either + 2/3 or –1/3. The six quarks are broken up into three families with

[71] Chapter Four: 47i. *The Cosmological Significance of the Pauli Exclusion principle*.

one quark in each family having charge + 2/3 and the other having charge – 1/3. An isolated quark has never been observed instead they are confined to compound systems called *hadrons*. *Baryons* such as neutrons and protons are three quark systems. The proton is the only stable baryon. *Mesons* are two quark systems containing a quark and antiquark, not necessarily of the same flavour. All mesons are unstable.

As Donoghue *et al* noted, *" No attempt is made in the Standard Model either to explain the variety and number of quarks and leptons or to compute any of their properties* [568]*."* Their acceptance as elementary particles is taken to alleviate any need for further explanation. While this may be acceptable in terms of elementary particle physics it is clearly not acceptable in terms of cosmology. It is the function of cosmology to explain the origin of all things, which must certainly include the material constituents of this universe. This is currently not done in the big bang model, which starts by simply postulating the existence of a quark-lepton plasma. This dissertation by contrast will consider the origin of the elementary particle, however since this has never been attempted before it should not be surprising that in this preliminary consideration it will only be possible to give a general description of this cosmology's suggestions as to how the various particle types originated. This task will be broken into two sections, with the origin of the fermions discussed as part of the reconsideration of the big bang and the origin of this bosons discussed later[72] when we consider the origin of the forces. It is worth noting that when the standard model was first introduced Weinberg called it a 'repulsive' model [451] and Thomas Kiddle concluded that, *" It was such an extraordinarily ad hoc and ugly theory that it was clearly nonsense* [570]*."* After many years of work by countless researchers it is now considered one of the cornerstones of physics.

50. The Flawed Nature Cosmology and the Missing Antimatter Problem

As we saw above[73], *the big bang singularity, in order to maintain the conservation of energy, needs to have contained an equal number of particles and anti-particles. However when astronomers look out into the current universe they see galaxies that are composed almost exclusively of matter and therefore cosmologists are forced to ask: What happened to the corresponding antimatter from the big bang singularity?* This is the first problem that we shall address in reconsidering the big bang model in light of the Flawed Nature Cosmology.

a. A Brief Review of Research into the Missing Antimatter Problem

Andrei Sakharov [571] attempts to explain the current imbalance of matter and antimatter by suggesting that during the big bang, as J. McLeish explains, *" For some reason, positively charged particles outnumbered the opposite kind (there was about one extra in each million). Consequently, antimatter totally vanished, along with more than 99 percent of ordinary matter* [572]*."* The search for a mechanism to explain this initial imbalance has prompted the establishment of a ten-year project involving some 600 physicists from three continents, headed by Jonathan Dorfan director of SLAC (Stanford Linear Accelerator Center) and using both its linear accelerator and the BaBar particle detector [573]. They are looking for evidence of a break in symmetry during the decay of the matter and antimatter counterparts of the

[72] Chapter Four: 56. *The Origin of the Forces of Nature*.
[73] Chapter Four: 46e. *The Missing Anti-Matter*.

B meson. In the B meson this phenomenon, called CP (charged-particle) violation [574], produces only a very slight difference in the decay to matter rather than antimatter components. As SLAC reported, *" Of 32 million decays, only 640 showed a difference. It took two years and $177 million to measure these differences with high enough precision* [575]*."* However Patricia Burchat, one of the main collaborators on the project, has questioned whether this rate of decay is sufficient of itself to explain the current imbalance of matter and antimatter in the universe. As SLAC reported, *" According to her, if the CP violation was the only phenomenon responsible for the lopsided universe, there would be 10 billion times less matter than there actually is. Hence, there must be other factors involved* [575]*."*

Since no definitive process has been found to explain how the antimatter may have been annihilated during the big bang, another theory holds that it is still present in the form of entire antimatter galaxies [576]. While much effort has been expended on the physical search for these antimatter galaxies [577-579], it has been shown by Dudarewicz and Wolfendale [580] that at very large scales the symmetry of matter and antimatter in the universe is not supported by the empirical evidence from gamma ray fluxes, a conclusion that is now generally accepted [581].

b. The Proposals of the Flawed Nature Cosmology regarding the Missing Antimatter Problem

Despite the enormous efforts of Dorfan's team, as Burchat has pointed out, the violation of CP-symmetry during the decay process of the B meson cannot of itself explain the current imbalance between matter and antimatter. However what the Flawed Nature Cosmology suggests is that a totally new approach to this problem may be available. When physicists examine the current universe they see only one example of the generation of new matter, vacuum pair production, which maintains an exact symmetry between matter and antimatter. However as we have seen above[74], in this cosmology such virtual pairs are the temporary realisation of previously unasserted potentia using the precedents established by the evolutionary process. But this only represents one of the three types of potentia expressed in this universe. There is also the potentia realised in epoch I and then expressed as orbitals in epoch II, as well as the intermediate potentia realised in epoch II and expressed as coexistent units. As we have seen, *the initial conditions for the big bang are a do over of the cross-coexistent unit interactions within a new temporal environment, the past, which must prevent them from resolving to a singular potentia, instead assuming a more mundane consequence*. The establishment of the matter of this universe is part of this *more mundane consequence*. But this is a process quite distinct from virtual pair production, one that only had a finite duration since there were only a finite number of coexistent units realised in epoch II and that were therefore available at the very beginning of the big bang. The big bang theory currently contains no model for the initial generation of matter. Instead it is simply assumed that at the end of the inflationary period a quark-lepton plasma existed. From this point the standard model states that, *" As the Universe continued growing in size, the temperature dropped. At a certain temperature, by an as-yet-unknown transition called baryogenesis, the quarks and gluons combined into baryons such as protons and neutrons, somehow producing the observed asymmetry between matter and antimatter* [582]*."* This cosmology's suggestions regarding baryogenesis are not

[74] Chapter Four: 47j. *Virtual Pairs*.

the replacement of an existing model but the first indication that a model of the origin of baryonic matter can be considered. This is possible because this cosmology justifies the big bang initial conditions based on earlier evolutionary epochs and because it can model the big bang from $t = 0$, where the energies are traditionally considered to be in the TeV-scale, and as we have seen[75], "*…most theorists expect new physics beyond the Standard Model to emerge at the TeV-scale, based on some unsatisfactory properties of the Standard Model* [546]." This cosmology can model the big bang from $t = 0$ because it does not presume that all of the matter of the universe was initially contained in the big bang singularity, instead the singularity is the single space-time axis of general relativity prior to gaining any extension, which provides the single place where the coexistent units are to interact. However the coexistent units are not initially interactive with this point space but must be brought into contact with it. This suggestion may seem reminiscent of Hoyle's [583] *steady state theory* whereby new matter is constantly being added as the universe expands, however the addition of new matter in the Flawed Nature Cosmology is limited since the number of coexistent units produced in epoch II is finite and therefore the addition of new matter will quickly be exhausted. However this process does allow us to consider what happens at $t = 0$ for the big bang. It is also that all the coexistent units do not simultaneously interact, and that the spatial environment of this universe changes with each interaction, that allows us to consider times infinitesimally beyond $t = 0$ in a totally new way. This cosmology therefore need not consider baryogenesis simply as the combination of pre-existing quarks and gluons, but in terms of cross-coexistent unit interactions in the initial point space of this universe.

There is no element of nature's design that requires there to be more matter than antimatter. The fundamental symmetry that must be considered here is that between the two aspects of the coexistent units. The breaking of this symmetry can be considered because these are fundamentally quantum states, superpositions that can eventually be resolved to a single value. However while the coexistent units can annihilate they are otherwise stable. They possess no capacity for choice, instead both aspects are guaranteed existence in their turn. Their evolution is stifled but for physical interactions. Nature has learned that the cross-coexistent unit interactions will produce a pseudo-choice that reduces one coexistent unit to a singular potentia, but that the other aspect of the coexistent unit is not eliminated but instead isolated within the second interacting coexistent unit. This is as close as nature actually gets to making Everett's [201, 202] many-worlds interpretation of quantum mechanics manifest. Each three state is the parallel universe in which the other aspect of the superposition is realised. But this is now a slightly different environment than was the case for the initial non-singular consequence of a cross-coexistent unit interaction. The singular space-time axis already provides a foreign axis for this state so that its three components can be expressed with reference to it. This establishes a totally new state that has three particle-like components. It is only this three state that is associated with the spatial singularity and that is therefore a component of this universe. The singular potentia is isolated beyond this universe in the same way as the first such state.

There is not time in this preliminary consideration to reconcile this new state, which has been considered only in terms of the minimum entities of this cosmology, with the standard quark model of particle physics, however we will pre-empt this work by stating that this three state can be equated with the neutron.

[75] Chapter Four: 47g. *Flawed Nature Cosmology and the Big Bang Singularity Problem.*

You might ask: *Why does this process not produce an equal number of neutrons and anti-neutrons?* but this is in fact not a valid question. Virtual particles are constrained to produce equal numbers of particles and antiparticles because no matter what precedent for structure they borrow from nature's evolutionary history, they must still reflect the flaw of two-directional time. By contrast the three state is the residue that results from the resolution of one coexistent unit to a singular potentia via a physical interaction and is therefore a consequence of the resolution of the flaw of two-directional time. The three state is not simply the combination of three objects, it is a totally new type of limited universe with a totally new temporality. It is not that the production of these three states violates the matter-antimatter symmetry, but that there is no constraint that imposes this requirement. It will only produce one state, which physicists now call matter. The precedent for these states can be used by previously unasserted potentia to establish virtual neutron-antineutron pairs, but this is an entirely different process.

c. The Expansion of Space and the Origin of Protons

Despite the speed with which coexistent units are associated with the space-time singularity, there are instances where only one coexistent unit makes contact with the singularity and there is therefore no cross-coexistent unit interaction. In this case the coexistent unit projects onto the space-time axis as an electromagnetic wave. It is the first such projection that establishes the normal *x*, *y*, *z* spatial dimensions and also expands the singularity by virtue of the propagation of the wave. This establishes a larger environment for the coexistent units to be brought into contact with. The first consequence of this is that there are fewer cross-coexistent unit interactions and therefore even more waves established to expand space even further. The second consequence is that it changes the nature of the cross-coexistent unit interactions that do continue to occur. In a three-dimensional space the isolated singular potentia remains within the environment of this universe and therefore also assumes a mundane representation as a free particle. This interaction, when fully developed, would be associated with the production of a proton and an electron.

Where there are two particles of the same type where one is charged and the other is not, for example the pions π^+ and π^0, the charged particle is heavier than the neutral particle with the difference equal to the energy required to create the electric field around the charged particle. But as Fritzsch pointed out, " *Oddly enough, the situation is reversed with nucleons: the neutral particle is heavier than the charged one. Why this is so we still do not know* [551]." Where the study of the current circumstances cannot provide an explanation for some property or phenomenon it is necessary to look to the evolutionary history for an explanation. The mass of the proton and neutron are determined by how they were established rather than by any factors within this universe. Such a consideration has simply been impossible in the absence of a cosmology willing to directly deal with the origin of matter. There is a distinct difference in the way the neutron and proton originate in this cosmology; the production of the proton retains the singular potentia as an element of this universe, an electron, while the production of the neutron does not. Because in this cosmology all energy is retained within the universe, the total energy of the consequences of the cross-coexistent unit interaction that were retained as particles with the universe must be the same. Therefore it would be expected that the neutron would be heavier than the proton by the energy of the electron, since in neutron production the singular potentia did not become part of the universe. This is approximately the case, with a slight correction that is accounted for by the production of an electron antineutrino in neutron decay[76].

But also within the environment of the early universe are both real and virtual particle pairs. Real particle pairs result from the off space-time axis projection of the coexistent unit, while with the expansion of space an enormous number of virtual particles are able to come into brief existence. Given the small expanse of space even the virtual particles are able to interact with both real particles and other virtual particles during their brief existence, or become real through energy exchange with annihilating real particle pairs. The establishment of an immense amount of matter first at a spatial singularity and then within a small but rapidly expanding space produces the traditional high matter density and temperatures that are the preconditions for the big bang. The early universe is truly a chaotic place. But while the environment becomes dominated by particle pairs as fewer and fewer cross-coexistent unit interactions occur, these interactions have already establish the small imbalance between matter and antimatter required to ensure that this universe becomes dominated by matter.

d. The Decay of the Neutron and the Stability of the Proton

Cross-coexistent unit interactions that produce only neutrons still threaten to stifle evolution by providing a singular potentia to define the initial state, while this is avoided, interactions that produce protons and electrons are preferable. This suggests that the decay of neutrons acts as a do over of the original cross-coexistent unit interaction that does not repeat the actual event but nonetheless changes the results to a proton and electron[77] as if this had been achieved by the initial event. The proton would not be expected to decay because no further precedent has been set for a further do over. No proton decay has ever been detected despite the expenditure of a great deal of money and effort, with experiments at the Super-Kamiokande detector [584], which is located in a deep mine in Japan, indicating that if protons decay at all their half-life must be at least 10^{35} years [585]. While it may seen strange to consider the decay processes in this context, it would indicate that do overs for the first time are occurring not only at the establishment of a new evolutionary epoch but within an epoch. This is not occurring in a way beyond our notice, as is the case for the backwards causality of Hawking's flexiverse cosmology which can only be seen from " *…an angel's-eye view from outside the universe* [320]*,*" instead it is occurring in a way that can clearly be evidenced by physics. By re-examining physical process in the context of this cosmology it may be possible to expand on the suggested resolution of the fine-tuning problem offered earlier[78] and actually be able to isolate the physical processes responsible. The two processes that can already be suggested by this cosmology are particle decay and the utilisation by the unasserted potentia of evolutionary precedents as soon as they are established to temporarily realise virtual particle-antiparticle pairs. The further development of these ideas may provide both a cosmological and phenomenological basis for observations that suggests that nature's 'constants' may have in fact changed over time [335].

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[76] We will deal with neutron decay later, see Chapter Four: 56f. *The Weak Force in this Cosmology*.

[77] The actual decay process is: neutron → proton + electron + electron antineutrino, however in this initial consideration for simplicity we are only considering a particle zoo consisting of protons, neutrons, electron, photons and their antiparticles.

[78] Chapter Three: 29. *The Anthropic principle and this Cosmology*.

But you might protest: *Physicists already know exactly why neutrons decay, there is a rule that says that massive particles will decay to particles of lower energy until the lowest possible energy state is reached*. But this is just a rule someone made up after observing decay phenomena. Another rule that says that decay is a do over that ensures that this universe is composed of the most desirable particles does not change at all what is being observed. There are no laws of physics only summations of observations. It is only reasonable to reconsider these summations from time to time.

e. Concluding Comments on The Flawed Nature Cosmology and the Missing Antimatter Problem

This vast universe contains no discernable stable antimatter in total violation of the expected matter-antimatter symmetry. This is a dramatic outcome that must have been established in only a fraction of a second at the very beginning of the big bang. Its explanation, we believe, can only be found in terms of a fundamental property of the big bang, not peripheral decay events such as that of the B meson. However what has been presented so far cannot be considered to be a theory of baryogenesis but merely an indication of how this cosmology would address this problem. But no matter the crude nature of this first consideration of the origin of baryonic matter, we feel that this is preferable to simply postulating the existence of a quark-lepton plasmas and then stating that they combine to form protons and neutrons *"…by an as-yet-unknown transition called baryogenesis …somehow producing the observed asymmetry between matter and antimatter* [582]*."* As for the missing antimatter problem, whereas the current approach taken by Dorfan's team is a ten year project involving six hundred scientists and using billions of dollars worth of equipment, which to date has cost $177 million to run, we would suggest that the further development of the ideas introduced by this cosmology would only require six months and one researcher using a pencil and paper.

51. The Particle-Antiparticle Pairs and the Further Evolution of Space

When considering the nature of time earlier[79] it was stated that there is *no recourse to excessive reductionism* and that therefore we must consider time with respect to different aspects of nature's evolution. The same is true for space. Principally what this means is that we must separately consider the affect of both types of projection of the coexistent unit onto the space-time axis, the waveform and the particle. A spatial point simply cannot express all of the complexity of the waveform and therefore the projection of the waveform onto the space-time axis has the affect of extending the dimensionality of space both in terms of being able to express the orthogonal maxima and the motion of the wave. However, because the waveform expresses the temporal evolution of the coexistent units while the particle represents its realised expression, the affect of the waveform on space must be considered as extending its potential domain rather than its physical domain. The boundaries set by the sum of the motion of individual waves, the *light cone* of the big bang, denotes the boundary of this universe in that wherever the waveform has reached a particle can be realised. This was sufficient to ensure that the singular potentia involved in the production of the initial protons and electrons was made part

[79] Chapter Four: 47p. *Time and the Big Bang Initial Conditions.*

of this universe, whereas the singular potentia involved in the initial production of neutrons was not because space-time was still a singularity. More generally the waveforms help establish the temporal environment of the past by quantifying the temporal gap between two points in four-dimensional spacetime, (x_1,y_1,z_1,t_1) and (x_2,y_2,z_2,t_2), in terms of the equation

$$I = (x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2 - (t_2 - t_1)^2 c^2 \qquad \textbf{E 15}$$

where I is the *interval*. This also establishes the relationship between the additional dimensions, x, y and z, and the principal space-time dimension in that when $I = 0$ motion in any direction is equivalent to projection onto the space-time axis.

What must be considered in more detail now are the affects on space introduced by the particle projections. Note that the three components of the neutrons and protons are centred on the space-time singularity and can be considered to be offset from it such that the three components appear as separate particles, but both the proton and neutron act like a limited universe so that this extension of space is specific to and contained by these baryons. The first utilisation of the potential space established by the waveform was the retention of the singular potentia as an element of this universe, an electron. This precedent is extended by the off space-time axis projection of the coexistent units as a particle-antiparticle pair. The introduction of such particle-antiparticle pairs does not involve any new process instead it simply projects the linearisation of the coexistent units that was occurring at the end of epoch II into the environment of this universe, but now with the space-time axis as a central boundary condition. This central boundary condition ensures that the linearisation does not re-establish an epoch I *ac*-environment that would lead to annihilation, since instead of two-directional time overlapping it is manifest by the particles travelling in two opposite directions away from a central origin. In this way not only waves but also particles can experience motion. Coexistent units are maintained as superpositions because both aspects are not expressed at the same time but instead there is x *then* $\neg x$. The particle-antiparticle projection equates this *then* to the minimum time of travel across their spatial separation, resulting in an equivalent expression of the maintained superposition as x_j *space* $\neg x_j$. But while we speak of a spatial separation it must be remembered that space is not a thing, Michelson and Morley [586, 587] were correct, there is no ether. Instead space has two aspects. Firstly it is the location where a particle could potentially be realised as mapped out by the motion of waves. Secondly it is the sum of all fields. What separates the particle and antiparticle is not space in the same sense as them being separated by a volume of water, instead they are separated by a field. Such fields can be manifest in different ways but they are all ultimately the retention of an association between discrete states or an attempt to establish an association.

a. Why are Elementary Particles Spatial Points?

The elementary particles are the building blocks of the physical universe, yet an elementary particle such as an electron occupies no space in the universe, but must be considered to be a point particle. This is such a perplexing situation that a new minimum entity with a definite spatial extent, the string[80], was postulated that avoids it. But let us re-examine this situation in light of this cosmology. The principal consequence of equivalently expressing the maintained superposition of the coexistent unit as x_j *space* $\neg x_j$ is that instead of having a single self-definition path its

[80] See Chapter Two: 13a. *A Brief Review of String Theory*.

two aspects have separate self-definition paths in the sense of the orbitals of epoch II. This is achieved in exactly the same way as for the first non-singular consequence of a cross-coexistent unit interaction, by the provision of a single central boundary condition, in this case the space-time axis. The particles remain isolated by their own closed self-definition paths rather than being defined by any geometric interface with the space of this universe. Physicists interpret this situation as the elementary particle being a spatial point.

b. Spatial Points and Mass

The mass of an elementary particle is its most fundamental property, yet physicists do not currently understand exactly what this property is or how it originates. The current approach simply involves another postulate, the Higgs field and its Higgs boson, a proposition introduced in 1964 by Peter Higgs [588, 589], building on the ideas of Philip Anderson [590], which attempts to explain the masses of other elementary particles by their association with the Higgs boson. In this theory all the elementary particles start with no mass and acquire mass through their interaction with the complex 'Mexican hat' potential of the Higgs field, which must be postulated to occupy all of space. However it must be noted that, *" As of 2006, the Higgs boson has not been observed experimentally, despite large efforts invested in accelerator experiments at CERN and Fermilab* [546]."

By contrast what this cosmology would suggest is that rather than being due to interactions with an external field, mass is an intrinsic internal property of a particle. While this is a perfectly reasonable idea it has not been pursued because the internal properties of a point particle simply cannot be studied. In fact Davies commented that, *" According to Bohr, it is meaningless to ask what an electron 'really' is. Or at least, if you ask the question, physics cannot supply the answer* [591]." This concept still dominates how we teach physics to new students. In his text on quantum chemistry, J. Lowe stated with regard to the wave-particle duality of the electron, *" The question ' What is the electron when we're not looking?,' cannot be answered experimentally, since an experiment is a ' look ' at the electron* [396]." This comes back to the concept that physics is only about what is experimentally observable. We would disagree; physics is about providing an accurate description of nature. It is not acceptable to postulate new aspects of nature simply to compensate for not being able to see nature's true form clearly. With the advent of this cosmology there is a way to see inside point particles and thereby see *what an electron 'really' is.* This cosmology demonstrates clearly that: *The properties of a point particle are determinable in terms of their evolutionary history*. What an electron really is, is the product of its evolutionary history. The internal structure of the electron can be understood independently of any specific experiment via the non-intrusive act of developing a cosmological model. In these terms, we can understand what the electron is even when we are not looking. Through fundamental cosmology we can develop a physics that does more than ask how the world works, but can give insight into what the discrete states that make up the world truly are. It is not necessary to look inside a point particle such as an electron in order to see how it expresses the property of rest mass, we can examine its evolutionary history in order to do this. This not only tells us how mass is represented as an internal property of the particle, but how mass originated as a property of matter and at what point along the evolutionary timeline this occurred.

Einstein's equation $E = mc^2$ states that mass and energy are the same thing and therefore it is here that we shall start to reconsider the nature of mass. In this cosmology we have given both the origin of energy[81] and how a coexistent unit represents this energy[82]. Energy evolved from the difference schema of epoch II, which was based on the number of maximum denoted by the property *n*. For the coexistent unit this number was related to the number of cycles of the significant instant around the self-definition path. If mass and energy are equivalent them mass is just a further refinement of this representation. A particle projection directly onto the space-time axis retains the characteristics of the coexistent unit in that it has only one self-definition path spanning both its aspects. Such a projection, a photon, appears as if it is one particle with no mass. In the simplest terms, this can be considered to be the case because the full self-definition path has two equal aspects one clockwise and the other anticlockwise. Such a discrete state has energy but this must be related to its waveform representation through Planck's equation $E = h\nu$. A particle projection that is off the space-time axis produces a new representation of the superposition of the coexistent unit that is not dependent on having a single self-definition path, but instead requires that the two aspects have sealed self-definition paths so that they can be represented as two individual particles separated by space. This suggests that the rest mass of a particle is determined by the representation of its internal energy in terms of a self-definition path with only a single direction.

In this cosmology it is not necessary to postulate a new constituent of nature, the Higgs field, in order to have particles acquire the property of mass. Instead all that is necessary is to better understand an attribute of nature that is already clearly evidenced – that an elementary particle is a point state with a sealed self-definition path. Whether a particle exhibits the property of mass or not is then determined by the configuration of this path, which in turn can be determined by its evolutionary history.

c. Mass and Gravity

Understanding the origin of mass does not automatically tell us anything about its relationship to the gravitational effect. However this cosmology traces the evolution of time so that ultimately all the basic phenomena of nature must be understood in this context. As Einstein pointed out gravity is simply a consequence of the curvature of spacetime. What we must seek to understand therefore is how this curvature originates. The usual answer is that the curvature originates because massive objects distort spacetime, like a metal ball rolling across a stretched plastic sheet. But this is a visualisation not an explanation. We stated above that a particle-antiparticle pair is separated by a field that expresses their retained relationship, however this is as yet too vague a concept. Let us therefore at this point examine the relationship between the original space-time axis and the three normal spatial dimensions.

Time has only two directions, forward and backwards, and therefore can be expressed using a one-dimensional line. The waveform overcomes two-directional time by providing a definite direction of motion. This also establishes the relationship between time and space. Since the waveform propagates at the speed of light, *c*, it maps out a spatial distance in the direction of motion equal to *ct*. In this one-dimensional universe the separation of events can be equivalently specified in

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[81] Chapter Three: 36. *The Origin of Energy*.
[82] Chapter Three: 38c. *The Coexistent Unit and Energy*.

terms of a temporal or spatial gap. However with the introduction of particles projected off axis the interchangeable relationship between time and space is compromised. While space has become three-dimensional time must continue to be expressed as if drawn out on a one-dimensional line. That this line must now be curved is necessary to compensate for the difference between the dimensionality of time and space. The more massive the object the more off axis it can be considered to be and therefore the more curved the temporal line will be in its proximity. In this way in the presence of a massive body time slows. The maintained relationship between temporal and spatial gaps ensures that the spatial separation is correspondingly longer, producing a non-straight geodesic path.

d. Concluding Comments on The Particle-Antiparticle Pairs and the Further Evolution of Space

The introduction of particle-antiparticle pairs involves no new processes but instead simply reflects the continuation of events that were already occurring at the end of epoch II, but now with the space-time axis acting as a central boundary condition. That these particles are point states that possess mass and are fundamentally involved in the gravitational effect is also explained without the need to introduce any new postulates. Since this dissertation only represents the initial consideration of a more fundamental cosmology these suggestions are as yet crude, but this is preferable to either making no attempt to understand the origin of the fundamental properties of this universe or accounting for them by using all encompassing postulates that ultimately provide no better comprehension of them.

52. The Flawed Nature Cosmology and Inflation

As we have already seen[83], Hawking and Turok stated that, *"…whether inflation actually occurs within a given inflationary model is known to depend very strongly on the pre-inflationary initial conditions. In the absence of a measure of the set of initial conditions inflationary theory inevitably rests on ill-defined foundations* [86]*."* This is so because, as Gefter reported, *" Standard inflation models require a very improbable initial state, one that must have 'finely tuned' values that cause inflation to start, then stop in a certain way after a certain time: a complicated prescription whose only justification is to produce a flat universe without any strange topology, and so on – a universe like ours. Such a prescriptive method makes hard and unsatisfying work of producing the universe we see today* [320]*."* The Flawed Nature Cosmology provides a new set of initial conditions that are not dependent on the postulation of a complex Higgs potential or the postulation of a de Sitter space with a positive cosmological constant to act like repulsive gravity. Let us therefore reconsider inflation in terms of this cosmology.

a. The Mechanism that Drives Inflation

If we were to explain inflation in broad terms to a non-scientist and then ask them what mechanism they considered might be driving it, we would suspect that the most common answer would be: *Particles and space coming into existence*. This is exactly the driving mechanism for inflation suggested by this cosmology. There is

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[83] Chapter One: 6. *A Brief Review of Quantum Cosmology and the Problems of Defining the Initial State and First Cause*.

not a singularity that already contains all the matter of the universe, but instead particles are established as the coexistent units interact at the same space-time point. Inflation is simply the consequence of this interaction being quickly repeated an enormous number of times, thereby establishing all the particles and space of this universe.

b. The Focal Point for Inflation

In quantum cosmology there is no unique focal point around which inflation occurs, instead random quantum fluctuations or tunnelling events can provide any number of inflation events, leading inevitably to the conclusion that these cosmological models must produce an infinite number of universes. By contrast in the Flawed Nature Cosmology the space-time singularity of the big bang is the only place where the coexistent units interact and therefore the single focal point for inflation.

c. Why Does the Inflationary Period End?

As Davies pointed out, " *No one has yet shown why the cosmic repulsive force is so near zero at the relatively low temperatures prevailing in the present universe. This is completely unexplained in either the inflationary model or the conventional big bang theory* [78]." This shortcoming of inflationary models that utilise repulsive gravity as a driving mechanism is called the graceful exit problem [592-596], which many authors [86, 597, 598] have tried to resolve, with no explanation yet finding broad acceptance. Because inflation must only act for a very short duration, repulsive gravity driven models are forced to suggest that at some point there is a phase transition in the nature of gravity which causes it to cease being repulsive and become attractive [78]. However, to accommodate this concept requires an enormous re-conceptualisation of our model of gravity and must bring into question the stability and consistency of the action of all the forces. By contrast the Flawed Nature Cosmology states that inflation stopped simply because it ran out of fuel. The initial association of the coexistent units with the space-time singularity drives inflation and there always were a finite number of coexistent units. When the last interaction occurs inflation ceases. The graceful exist does not represent a phase transition in the nature of gravity, but the end of the establishment of the universe and the start of the process of reconciling all the discrete states introduced into it.

d. Concluding comments on The Flawed Nature Cosmology and Inflation

We would suggest that if a mechanism for the establishment of the matter of the universe were known when the need for an inflationary epoch to address the horizon and flatness problems was first considered, no other driving mechanism for inflation would have been postulated.

53. The Flawed Nature Cosmology and Dark Matter

The above reconsideration of baryogenesis and the origin of particle-antiparticle pairs provide a basis in this cosmology for the establishment of the fermions. However such baryonic matter only accounts for approximately 4% of the energy density of this universe. Since the big bang must be able to account for the origin of the entire universe not just 4% of it, we must next consider the origin and nature of dark matter, which accounts for a further 22% of the matter in the universe.

The advantage that the Flawed Nature Cosmology provides when it comes to determining the nature of dark matter is that it models nature's evolution in terms of a single minimum entity – potentia. Therefore regardless of what strange properties dark matter has it must still be a variant of the same fundamental state from which baryonic matter was derived. The variation in how the potentia is realised in order to be evidenced as dark matter must be accounted for in the sequence of events involved in the big bang. There is a trick to understanding the big bang, you must come to terms with the fact that it is an imperfect process. Dark matter originates because of this imperfection. It was desirable that all the coexistent units be expressed at the same place, the space-time singularity, but they were not initially present here but had to be brought into contact with this state. Neutrons and protons originate from cross-coexistent unit interaction that occurred in contact with space-time. However there were also cross-coexistent unit interactions that occurred just before this contact was established and it is from these interactions that dark matter originates. Without space-time to act as a common axis the non-singular potentia resulting from this interaction, like the first such state, uses the foreign half coexistent unit as a central boundary condition to express the two aspects of the complete coexistent unit as particle-like states. It is then these states that are projected into this universe. Dark matter maintains the superposition of the complete coexistent unit in a manner similar to a particle-antiparticle pair except the spatial separation is not due to the three-dimensional space of this universe but an internal space derived by using the half-coexistent unit as a central boundary condition. Dark matter somewhat resembles a photon in that it reflects two aspects of a coexistent unit as a single particle in this universe, but it differs in that the central boundary condition allows its two aspects to have separate self-definition paths while not being spatially separated in terms of the space of this universe. Dark matter therefore has mass, but being a complete coexistent unit has no charge and therefore does not interact electromagnetically.

Dark matter can be considered to be the ultimate bound state of a particle-antiparticle pair, somewhat like positronium [599] the bound state of an electron and a positron, only with no spatial separation in terms of the space of this universe and therefore externally appearing as a single point particle.

54. The Flawed Nature Cosmology and the Accelerated Expansion of the Universe

As we have seen above[84] there is growing experimental evidence that the universe is undergoing accelerated expansion [135-139], a situation that is not predicted by the current big bang theory. Therefore we shall consider this problem in the context of the Flawed Nature Cosmology.

[84] Chapter Four: 46c. *The Accelerated Expansion of the Universe*.

a. A Brief Review of Current Theories to Explain the Accelerated Expansion of the Universe

While there have been many theories put forward to explain accelerated expansion including the evolution of extra dimensions [54, 600] some arising from M-Theory [601], other theories that have the acceleration driven by tachyonic matter [602, 603] or by *"…the repulsive force of vector boson exchange…*[604]," there are two general categories of theories that have come to prominence. The first associates dark energy with Einstein's cosmological constant [605]. The cosmological constant describes a physical situation whereby a volume of space has some intrinsic, fundamental energy, called *dark energy*. Because of its nature this energy is constant and homogeneously distributed through all of space. The second class of theories called *quintessence* models, involve, *"…a classical scalar field having a small mass and a self-interaction involving several parameters* [525]," which can vary in both space and time [606, 607]. The quintessence field is postulated to have negative pressure, which over a large scale would have an effect opposite to gravity and so could be considered to act as repulsive gravity. This negative pressure scenario is similar to Guth's [39] suggested mechanism for driving inflation.

An outstanding difficulty with the cosmological constant and quintessence models of accelerated expansion is the *coincidence problem* [608, 609] which involves showing why the expansion of the universe did not start accelerating until approximately 5 billion years ago, before which time the expansion was decelerating. If accelerated expansion had happened earlier galaxies would not have had an opportunity to form. Current models build in this coincidence by fitting them to agree with available data. But when extrapolated backwards in time these models produce unacceptable predictions, rather than a clear explanation of why the universe switched from deceleration to acceleration.

b. The Accelerated Expansion of the Universe in this Cosmology

Padmanabhan and Choudhury [610] have already suggested that cold dark matter and the quintessence mass can be modelled to arise from a common source. This cosmology would expand on this suggestion by providing a definition of the origin of dark matter that shows that it is derived from the same fundamental entities as baryonic matter. The standard model states that for every particle there exists an antiparticle. What this cosmology suggests is that this statement must be extended to include: *and a bound state of the particle anti-particle pair called dark matter*. In this way dark matter is exactly as diverse in its mass spectrum as baryonic matter. But given that baryonic matter accounts for only 4% of the energy density of the universe, the number of dark matter particle pairs of any given mass scale will far outnumber their baryonic matter equivalents. Therefore the low mass components of the quintessence field are just the dark matter counterparts of the neutrinos of normal matter. In this way dark energy and dark matter are not two different constituents of the universe but are essentially the same thing. However it must be noted that baryonic neutrinos could not account for the missing mass of the universe [531] and nor can their more prevalent dark matter equivalents. But if for every baryonic particle there is a far more prevalent dark matter counterpart, this suggests that there is a lot of dark matter that has not yet been observationally detected since it would be more uniformly distributed throughout space than the dark matter in galactic halos.

We do not suggest that the simple presence of a quintessence field automatically explains accelerated expansion. Rather we would follow the reasoning of Zimdahl *et al* [611] who presented a model of accelerated expansion *"…based on the assumption that the observational evidence for an effective cosmological constant is an indication for the existence of additional interactions within the cosmic medium, which macroscopically manifest themselves as negative pressure* [611]*."* What must be considered here is what these *additional interactions* might be within the context of this consideration.

The next critical phase in the evolution of the universe after the inflation and the hot big bang occurred some 300,000 years after the big bang when the first atoms started to form, allowing photons to decouple from the plasma of baryonic particles. It is the photons released at this time, having cooled over billions of years to a temperature of 2.725 K, which forms the cosmic background radiation that permeates all of space. This period is also important in terms of this cosmology since it marks a significant transition in the nature of the evolution of space. The universe has two spatial horizons one determined by the free motion of light and the other by the motion of matter. As the universe expands and the impetus from the big bang weakens the expansion of matter slows. However this does not affect the expansion of the light cone. Eventually a point would be reached where matter would slow its expansion to such a degree that it would never be able to fill the potential space established by the light cone. Potential would once more overwhelm realisation, reducing it to insignificance. This is *why* the universe starts accelerating. As for *how* acceleration is achieved this involves another do over instigated within this evolutionary epoch. Experience of our own biosphere should be enough for us to understand that we live in a universe that has not yet achieved its ultimate form but continues to evolve. Creation is not a single event lost to the distant past, but a continuous process of refinement. Particles of dark matter were established before they contacted the space-time axis and therefore underwent an interaction quite different from the establishment of baryons or particle-antiparticle pairs. But as we pointed out above this was a flaw in the big bang brought about because nothing occurs without process. The do over involves re-expressing the dark matter particles as if they had been established as a particle-antiparticle pair. Again this can also be expressed as particle decay by stating that dark matter can spontaneously decay into a particle-antiparticle pair determined by its mass. But this is a lesser comprehension. The phase transition of dark matter particles does not only result in particle pairs but must assimilate the third component that provides dark matter with a central boundary condition, or space, into this universe. It is this process that this cosmology suggests provides the negative pressure to drive the accelerated expansion of the universe.

Phase transitions in dark matter particles are the *additional interactions within the cosmic medium* that provide the process driving accelerated expansion. But note that these dark matter phase transitions are distinctly different from the momentary appearance of virtual pairs. Virtual pairs can only become a permanent part of this universe by energy exchange, whereas dark matter particles were derived from coexistent units that were already participants in the difference schema expressed in this universe as energy. Also the appearance of virtual pairs does not involve the assimilation into this universe of a central boundary condition, or space, which is a property unique to dark matter. Therefore in this cosmology virtual pair production plays no role in explaining the accelerated expansion of the universe. Quantum field theories that do apply the contribution of virtual pairs produce a value for it that is

120 orders of magnitude too large to agree with observational data. This however does provide some indication of the relative frequency of virtual pair events to phase transitions of dark matter. This is to be expected since there are an infinite number of previously unasserted potentia, while there were only a finite number of coexistent units produced in epoch II. While the phase transition process would see a transition from dark matter to baryonic matter, if observed these could easily be mistaken for virtual pairs that have acquired the energy to become permanently existent. In order to distinguish between these two types of apparent pair production a careful study would need to be made of a vacuum region that should evidence both virtual pairs that do no maintain existence and less frequently, what appear to be virtual pairs that persist with no apparent mechanism for an energy exchange.

c. Will the Accelerated Expansion Continue Forever?

There are several doomsday scenarios in the literature based on the accelerated expansion of the universe continuing forever [612-615]. As Barrow *et al* explained, *" A universe doomed to accelerate forever will produce a state of growing uniformity and cosmic loneliness. Structures participating in the cosmological expansion will ultimately leave each others horizons, and information processing must eventually die out* [616].*"* Since in this cosmology the universe came into existence to extend knowledge, were information processing to cease the universe would continue to exist without the capacity to fulfil any purpose. Then we would truly have a situation where Geller would be correct, *" …It's just a physical system, what point is there?* [90]*"* But Barrow *et al* [331, 616] go on to suggests that the accelerated expansion of the universe may in fact only be a temporary phenomena. In terms of this cosmology this is correct. The accelerated expansion of the universe must stop for the same reason inflation did, the fuel driving it is finite. There are only so many dark matter particles available to undergo phase transitions.

d. Observational Verification of this Cosmology's Model of Accelerated Expansion

Current attempts to distinguish between cosmological constant and quintessence models of accelerated expansion revolve around the prediction that accelerated expansion due to a cosmological constant should be constant whereas that due to quintessence may vary in both space and time. This cosmology expands on this by stating where in space this variation should be most evident – where there is a greater concentration of dark matter. The neutrino like dark matter of the quintessence field, which will have a more or less homogeneous distribution, may well have the greatest bearing on acceleration due to being more susceptible to phase transitions. This would tend to produce a constant acceleration. However, since the dark matter of the galactic haloes is not a different form of matter but merely has a different mass, the same phase transitions should occur in it, perhaps at some lesser frequency. But even if detectable dark matter only contributes slightly to the acceleration of a region, this should still be significant where such dark matter is concentrated. Therefore if we have a map showing both the distribution of regions with greater acceleration and the distribution of detectable dark matter, there should be a correlation between them.

55. Summary of the Reconsideration of the Big Bang Theory

The Flawed Nature Cosmology does not simply provide refinements to the big bang model but an entirely new conceptualisation of it. There can be no doubt that such a radical reconsideration is required since the current big bang model contains absolutely no mechanism that can explain the origin of matter or the complexity of the initial conditions required for the big bang to occur. The justification of these complex initial conditions necessitates the investigation of nature's evolution leading up to the big bang. Without this the big bang model is so dependent on all encompassing postulates that its status as a valid scientific theory must come into question. This shortcoming cannot be disguised by saying that the model works when starting from the end of the inflationary epoch at $t = 10^{-34}$ seconds, if the preceding moments are filled with postulates on which all further modelling depends. But even given these postulates the current approach to the big bang fails to explain the missing antimatter problem and fails to predict the accelerated expansion of the universe. Researchers such as Dorfan are trying to fine tune the existing theory to overcome the missing antimatter problem, but to date this has not been successful and we doubt that it ever will be. The approaches so far taken to the accelerated expansion of the universe involve the introduction of more postulates, which dilute even further the credibility of the theory. By contrast the Flawed Nature Cosmology provides a consistent conceptualisation of the big bang that follows on from nature's earlier evolution without needing to introduce new elements. It is simply about the further evolution of the potentia.

Our current understanding of biological evolution, based on Darwin's theory [314], suggests that the diverse living species can be traced back to a few, or even a single, progenitor. Our understanding of the synthesis of the elements also follows such a pattern [617, 618]. It is not surprising then that this cosmological consideration reveals a similar pattern. In the Flawed Nature Cosmology the previously unasserted potentia provide the basis for virtual pairs, while the potentia that evolved into the coexistent units provides a common cosmological basis for baryons, particle-antiparticle pairs, photons and dark matter. Dark matter originates from cross-coexistent unit interactions that occur before contact is made with the space-time singularity. The neutrons originate from cross-coexistent units interactions in contact with the space-time singularity but where there is as yet no extensible space. The protons originate from cross-coexistent unit interactions where there is extensible space. Photons are the projection of the coexistent units on the space-time axis as a single particle. Particle-antiparticle pairs are the projection of the coexistent units off the space-time axis as particle-antiparticle pairs. Virtual pairs are the utilisation by previously unasserted potentia of precedents for structure established by the evolutionary process, while the two types of projection of the coexistent unit accounts for wave-particle duality. These are connections that have not been made by any other cosmology, or conceptualisation of nature. Yet all our experience of other evolutionary trends indicates that such connections should exist. This reconsideration of the big bang suggests that the formal development of the minimum entities of this cosmology may provide a more direct path to an understanding of the elementary particles than string theory.

Inflation in this cosmology is driven by the introduction of particles and space through a new conceptualisation of baryogenesis that also accounts for the missing antimatter. The hot big bang is then driven by interactions between these particles.

The accelerated expansion of the universe is accounted for by a phase transition in dark matter from being a single state with its own central boundary, or internal space, to a particle-antiparticle pair that must also assimilate this internal space into the environment of this universe.

It is time to reconsider the big bang model from scratch rather than repeat the mistakes of those who insisted on continually refining Ptolemy's cosmology.

56. The Origin of the Forces of Nature

Charles Misner commented that, *" The organic chemist, in answer to the question, 'Why are there ninety-two elements, and when were they produced?' may say 'The man in the next office knows that.' But the physicist, being asked, 'Why is the universe built to follow certain physical laws and not others?' may well reply, 'God knows.'* [619]*"* Cosmologists have tended to accept the existence of the forces of nature as an *a priori* fact, and that cosmology was therefore about modelling their affects on different environments, usually determined by energy levels in the moments after the big bang. But cosmology at its most fundamental must be about the origin of all things and the forces of nature are no exceptions. However the closest that physics has come so far to considering the origin of the forces is to consider their unification. Such a model, a *Grand Unified Theory* (or GUT, an acronym introduced by Dimitri Nanopoulos [620]), has been the holy grail of elementary particle physics for many years [621]. There has even been some remarkable success in terms of electro-weak theory [622], which combines the electromagnetic and weak forces. But whether the big bang starts with one force or four does not directly address the origin of this unified force.

The present approach to finding a GUT Gell-Mann summarised as, *" Well, you try a lot of possibilities. They usually fail to be self-consistent, or they fail to agree with known facts, and so you throw them away. Finally you find something that agrees with known facts and is self-consistent. This is so difficult that by the time you have done it you are likely to be right* [14]*."* But no universally accepted GUT has yet been found, which Gell-Mann suggested may be because the, *"…possibility is that we are just not asking our questions in exactly the right way…*[14]*."* What we are suggesting is that by taking a cosmological model into consideration when dealing with the problems of formulating a GUT, a new way to ask the questions can be introduced that may provide different and unanticipated answers. The additional advantages of referring to a cosmological model in the search for a GUT is that it provides a broad initial justification for the possibilities to be considered and should produce a model that must have agreement with known facts outside the range of those that would normally be used in particle physics, thereby providing more general support for the overall schema.

While to date cosmologists have not been able to conceive of a viable approach to defining the origin of the forces, the one we shall take here is actually quite simple. Unlike other cosmologies where the initial conditions may be locked away in inaccessible dimensions or lost to the distant past, every aspect of the cosmology of this consideration remains evidenced, since the present universe is the cumulative consequence of the entirety of the evolutionary process and therefore current aspects of it can be explained by their maintenance of previous evolutionary precedents. It is this aspect of the cosmology that makes it more open to empirical scrutiny than any other. This discussion of the origin of the forces is done to emphasise this.

Physicists have tended to simply look at the current state of the universe, record how it functions and then try to find associations between different aspects of it. This simple approach applied by brilliant minds over centuries has produced a tremendous pool of knowledge. But it is nonetheless a temporally one-dimensional view, which either ignores or actually denies the capacity for fundamental change. What this dissertation attempts to emphasise is that a true understanding of how this universe currently functions can only be gained by considering each aspect of it in the context of nature's entire evolutionary history. In this context we cannot simply consider the forces as they currently operate, but in terms of their evolutionary history. There are two aspects of this. Firstly there is the repetition of fundamental cosmological precedents within the environment of this universe. In this context the origin of the forces takes the form of a simple mapping of the forces to precedents set in this cosmology's description of events along the evolutionary timeline. This emphasises that this universe is the product of a specific evolutionary history, rather than being simply one of an infinite number of alternative parallel universes with different, and fundamentally unjustified, physical laws. Secondly, we must consider the evolution and reapplication of the processes responsible for the forces as the environment of this universe changes. This involves looking both at why a process originates and how it is perpetuated, or is reapplied, even if changes to the environment mean that the original goal cannot be achieved. Nature is flawed but it is not wasteful, everything learned is retained in some manner.

a. Spooky Action-at-a-Distance

Newton was so distressed that his theory of gravity implied action at a distance that he wrote, *" It is inconceivable that inanimate brute matter should, without the mediation of something else, which is not material, operate on and affect other matter without mutual contact… That gravity should be innate, inherent, and essential to matter, so that one body can act upon another at a distance, through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it* [623]*."* Indeed much of Einstein's criticism of quantum mechanics was due to it implying what he called, "*…spooky action-at-a-distance* [389]*,"* which in his view had no place in a scientific theory, a position he felt to be justifiable since, *" As a result of more careful study of electromagnetic phenomena, we have come to regard action at a distance as a process impossible without the intervention of some intermediary medium* (e.g. the electromagnetic field) [30]*."* In recent times the electromagnetic field has come to be modelled in terms of discrete intermediate states, as Roos points out, *" In quantum electro-dynamics (QED) the electromagnetic field is mediated by* (virtual) *photons which are emitted by one charged particle and absorbed very shortly afterwards by another* [550]*."* However the use of *virtual photons* as force carriers for electromagnetic phenomena, while it addressed concerns about explaining action at a distance, seemed quite strange and somehow unnatural. Why should nature utilise such ghost particles? But given this cosmology we can recognise that this is how nature's first interactions occurred and there is no reason to believe that this precedent is not carried forward into our current universe. Therefore we shall first consider a mapping of the electroweak force to the *ac*-events of epoch I. We saw in Chapter Two that the realisation of a second random potentia establishes a situation where the next event must be the attempt to realise a potentia intermediate to them in order to establish their causal association and thereby re-establish a consistent, if changing, definition of the initial state. In this universe we essentially have the realisation of billions of potentia, in the form of the elementary particles, whose causal association is also unestablished. Each pair of particles forms the boundary conditions for one *ac*-environment and the attempted realisation of an intermediate potentia. Note that there is no pre-condition whereby this situation only applies to charged particles, instead the difference in how charged and uncharged particles react to each other depends on how these *ac*-events are resolved.

b. A Brief Review of the Electromagnetic and Weak Forces

As Veltman explained it, *" …a given particle is always spinning at the same rate. You can not change that. It is a definite property of the particle and it is called spin* [64]*,"* so that spin can be treated as a type of angular momentum. Two aligned spins equals spin 1. Two opposing spins equals spin 0. A free electron has spin ½. A free electron can be considered to have spin up or down because this depends only on how it is observed. The Higgs boson is theoretically supposed to have spin zero, but as Veltman pointed out, *"…experimentally we have never encountered an elementary particle that has spin zero* [64]*."* Force carrying particles, called *gauge bosons*, have integer spin. However the only theoretically proposed spin 2 gauge boson is the *graviton*, the force carrier for the gravitational effect, which like the Higgs boson has never been experimentally detected. All other gauge bosons have spin 1.

This cosmology has already considered the origin of spin[85]. In this cosmology a photon is the on space-time axis projection of a coexistent unit and can be considered to have spin 1 because there is one self-definition path spanning both aspects of the coexistent unit, which ensures that the spins are aligned. It is worth noting that in terms of this cosmology the only particles with spin zero are dark matter particles, where the aspects of the coexistent unit have separate self-definition paths that would be opposed. Care must be taken therefore in claiming that a spin 0 particle detected is the Higgs boson. The Higgs boson and dark matter particles can be distinguished because the dark matter particles will have a specific range of masses based on the earlier[86] statement that as well as every particle having an antiparticle, this cosmology suggests that they also have *a bound state of the particle anti-particle pair called dark matter*.

Two electrons with the spin pointing in the same direction attract each other, while if their spins are pointing in opposite directions they repel each other. This is the basis of the magnetic force, but this effect is small in comparison with the attraction and repulsion due to charge. Therefore the magnetic force appears as a slight correction to the total attractive and repulsive force, producing slightly different energy spectra, called *hyperfine splitting*, depending on different spin configurations. When the electromagnetic force is referred to below it shall be assumed that we are dealing with the electric component of it.

As for the attraction and repulsion due to charge, the explanation for this by quantum electrodynamics (QED), as Gell-Mann noted, is that *" The exchange of a 'virtual' photon between them* (two charged particles) *gives rise to the electromagnetic force, which causes them to repel each other, if the charges having the same sign* [14]*."* These photons are virtual, as Feynman explains, because they,

[85] Chapter Three: 38d. *The Coexistent Unit and Spin*.
[86] Chapter Four: 54b. *The Accelerated Expansion of the Universe in this Cosmology*.

"…never really appear in the initial or final conditions for the experiments…[2]*."* A virtual photon can also return to the emitting electron to be reabsorbed, something a real photon would not do.

While we can consider the electromagnetic force as being either attractive or repulsive, as Jonathan Allday pointed out, *"…the categories 'attractive' and 'repulsive' do not really fit the weak force. This is because it changes particles from one type to another* [569]*."* The weak force works to a range of about 10^{-15} m and *" If two leptons come within range of the weak force, then it is possible for them to change into other leptons… However, it is only possible to change leptons within the same generation* (family) *into each other* [569]*."* The weak interaction is not mediated by virtual photons but by the heavy virtual vector bosons $W^{\pm}$ and Z^0 [550]. Interactions involving Z^0 do not cause a flavour change, just scattering, and are called *neutral current interactions*. Interactions involving $W^{\pm}$ do cause a particle to change into another particle within its family group and are called *charged current interactions*.

For right-handed fermions the spin is aligned in the same direction as the momentum of the particle, or spin clockwise with respect to its direction of motion. For left-handed fermions the spin is aligned in the opposite direction to the momentum of the particle, or spin counter-clockwise with respect to its direction of motion. However, spin alignment with momentum can be seen by observers moving at different velocities differently, e.g. one observer might say a system is right-handed while another moving at a different velocity may record that the same system is left-handed. But if the system is travelling at the speed of light its handedness becomes fixed for all observers. For particles of fixed handedness, this reverses for its antiparticle. Photons react the same way with right and left-handed electrons. However the $W^{\pm}$ boson only couples with left-handed leptons and quarks and so only these participate in charged-current interactions. However as Fritzsch pointed out, *" We have no idea why this is so and simply have to accept the left-handed nature of the weak force as an experimental fact* [551]*."* While neutral-current interactions are predominantly left-handed they also have right-handed components.

c. A Brief Review of the Strong Force and Quark Theory

As Fritzsch explained, *" The electromagnetic repulsion between these protons is so great that the nucleus should explode. According to the laws of electrodynamics, therefore, atomic nuclei should not be stable. There is only one solution to this problem: there must exist in nature another basis force that keeps the atomic nucleus together* [551]*."* This is the strong force. Before we can discuss the strong force we must first extend our review of particle physics to consider the sub-structure of protons and neutrons – quarks. This is necessary because the strong force only acts between quarks.

Quark theory was introduced by Gell-Mann, Feynman and George Zweig [624] in 1964. This work was prompted by the fact that there were at the time hundreds of hadrons known but only 6 leptons. This suggested that a common way to describe all hadrons was required.

Since protons and neutrons have baryon number 1 it is assumed that quarks have baryon number 1/3. Similarly, in order for three quarks to make up the observed charges of the neutron and the proton quarks have to have fractional charges +2/3 and -1/3. There are also antiquarks with charge -2/3 or +1/3, with antiprotons made out of antiquarks. This concept was initially not well received. Zweig recalled that,

“ When the physics department of a leading university was considering an appointment for me, their senior theorist, one of the most respected spokesmen for all of theoretical physics, blocked the appointment at a faculty meeting by passionately arguing that the model was the work of a ‘crackpot.’ The idea that hadrons, citizens of a nuclear democracy, were made of elementary particles with fractional quantum numbers did seem a bit rich. This idea, however, is apparently correct [551].*”*

Quarks are also presumed to have another property called *colour* with three varieties *red*, *green* and *blue*, that in interpreted to act like a different form of charge. Colour was first proposed so that hadrons could conform to the Pauli exclusion principle, which was not the case unless another quantum number was introduced. Fritzsch said of the introduction of colour, *“ In physics it is quite customary to make such assumptions and study their consequences without knowing whether the assumptions are correct* [551].*”* There is now some experimental evidence for the existence of colour in that without taking colour into account the decay time of the neutral pion, π^0, could not be calculated correctly. It turns out that the more colours are present the faster the pion’s decay rate.

Hadrons are composed of quarks and react to the strong force. There are two subgroups, as Roos pointed out, *“ In the quark model the mesons are $q\overline{q}$ bound states, and the baryons are qqq bound states* [550].*”* Mesons have integer spin and are the exchange particles in interactions between two nucleons. However all particles composed of quarks are *colour neutral* or *white*. Such a state is called a *colour singlet*, which is a system where there is no colour preference. This means that for a three-colour system all three colours must be present, and for a two-colour system there must be a colour accompanied by its negating anti-colour. In short we must always be able to consider the sum of the colours to be white. As Veltman pointed out, *“ It turns out that combinations of quarks that are color neutral always have an integer amount of electric charge, never anything like -7/3 or +5/3* [64].*”* For example the proton has charge +1 and the antiproton has charge –1.

As we have seen the strong force is what overcomes the electromagnetic repulsion between protons in an atomic nucleus, but is effective onto to a range of about 10^{-19} m. Only quarks feel the strong force. As Jonathan Allday stated, *“ This incredibly strong force acting between the quarks holds them together to form objects (particles) such as the proton and the neutron. If the leptons could feel the strong force, then they would also bind together into particles* [569].*”* The strong force does not just mean that quarks can bind together to form particles, it *“…means that they can* only *bind together to form particles* [569].*” “ We can never get these colored particles out singly to examine them; they can never be directly detected* [14],*”* as Gell-Mann noted.

Colour acts in the opposite way to electromagnetic charge in that like colours attract. This means if there were such a thing as a free quark its vacuum polarization effect would not reduce its effective charge, as is the case for an electron, but would increase it charge. This would create a snowball effect whereby the stronger the effective charge, the greater the polarization effect, leading to an even stronger charge, etc., resulting in the distortion of the entire universe. It is therefore good that there are no free quarks and that hadrons only occur as colour singlets that have no polarising effect.

The force acting between quarks is considered to be due to the exchange of *gluons*, in the same way that the force between electrons is considered to be due to the exchange of virtual photons. But while both photons and gluons are electrically neutral, the gluons are not colour neutral so that there are different gluons for different colour combinations of quarks. Gluons carry one colour and one anticolour charge, for example there is a red-antiblue gluon. Gluons only couple to colour charged particles, that is, only to quarks. In interactions involving gluons the colour of the quarks can change. In fact within a proton or neutron it is impossible to say which quark has a specific colour as they are continually interchanging colours. The theory that describes these quark-gluon interactions is called *quantum chromodynamics* (QCD) [625, 626]. As Oerter explains, *" In QED, the photon that mediates the interaction between electrically charged particles is not itself electrically charged. In contrast, the gluon of QCD* (quantum chromodynamics), *which mediates the interactions between the colorful quarks itself carries color. As a result, gluons can interact with each other, something photons can't do* [451]*."*

In QCD a gluons may be emitted [64]

$$u_r \rightarrow u_g + g_{r\bar{g}} \qquad \textbf{E 16}$$

where a red up quark has become a green up quark with the emission of a red-antigreen gluon. Gluon interactions change the colour of a quark but nothing else. Quark flavours changes via the weak interactions [64]

$$d \rightarrow u + W^- \qquad \textbf{E 17}$$

In Hideki Yukawa's [627] theory the nuclear force is mediated by pion exchange. In quark theory the pion, like all mesons, is seen as a quark-antiquark pair. The mesons act as the intermediate states for quark flavour change. In this way a neutron with a quark configuration *udd* can decay into a proton with a quark configuration *uud*.

Table 1: Generations of Quarks and Leptons [64]

	First Generation			Second Generation			Third Generation		
	Quarks								
Charge +2/3	u_r	u_g	u_b	c_r	c_g	c_b	t_r	t_g	t_b
Mass	5 MeV			1.3 GeV			175 GeV		
Charge -1/3	d_r	d_g	d_b	s_r	s_g	s_b	b_r	b_g	b_b
Mass	10 MeV			200 MeV			4.5 GeV		
	Leprons								
Charge 0	ν_e			ν_μ			ν_τ		
Mass	< 0.0000051 MeV			< 0.27 MeV			<31 MeV		
Charge -1	e			μ			τ		
Mass	0.511 MeV			105.66 MeV			1,777.1 MeV		

The mass of the quarks increases with their generation as does their rarity. But what must be remembered, as Fritzsch pointed out, is that, *" Everything that we can observe in our macroscopic world – its galaxies, stars, the earth, a tree, ourselves – consists of the first generation of fermions, namely, the u and d quarks (nucleons) and the electrons* [551]*."* The masses quoted for the neutrinos are the upper limits set by experiment and the masses for the quarks are effective masses, since as Veltman noted, *" It is obviously not easy to determine the quark mass in these circumstances*

(where no isolated quark can be detected). *A certain amount of not too clear theory goes into that, and consequently there are quite large uncertainties here, in particular for the up and down quarks* [64]*."* However, this table indicates that if a proton is composed of *uud* quarks, they only provide 20 MeV of the proton's 938.27 MeV mass. The balance must be made up of the binding energy of the gluons. This is very different from the situation with an atom, or even a nucleus, where the binding energy provides only a small correction to the mass of the constituent particles. For this reason, as Veltman pointed out, " *Today a proton is understood as a glob of gluons with three quarks spinning in it* [64]."

Gluons are never found except in associated with quarks. If an attempt is made to separate the quarks in a two quark state, the surrounding glob of gluons stretches but does not break and no matter how stretched maintains the same binding force. Veltman stated that, " *People have idealized and abstracted these strings of glue to string like objects that have no quarks and are not glue either, and that has given rise to string theory, studied widely. However there is no evidence of any kind that Nature uses strings other than in the approximate sense of gluon matter between quarks relatively far apart* [64]."

As for the binding of the nucleons themselves, Gell-Mann states that, "…*we can explain the nuclear force that binds the neutrons and protons together in the atomic nucleus as a secondary effect of the basic quark interaction that comes through the exchange of gluons. In the same way, the binding of atoms in a molecule is known to be a secondary effect of the electromagnetic force acting among the electrons and nuclei* [14]." The van der Waals force describes the repulsion between outer orbital electron distances the atoms see each other as neutral. Only when the outer shells of the atoms are close together can there be a significant effect due to the repulsion of electrons. The force binding nucleons against electromagnetic repulsion is seen as acting like the van der Waals force. Nucleons are as a whole colour neutral. But if they are close enough to each other, less than 10^{-13} cm, one coloured quark from each nucleon will be seen rather than the neutral whole. It is the interaction between these two closest quarks that is taken to be responsible for the strong force between nucleons.

But if no isolated quarks can ever be detected, how can quarks be proven to exist at all? Scattering experiments conducted SLAC firing electrons at protons demonstrated that protons had substructure [628, 629], earning Jerome Friedman, Henry Kendall and Richard Taylor the 1990 Nobel Prize in Physics [630]. However these experiments also presented a problem for quark theory, since they implied that the quarks must be weakly bound and nearly uninteracting. But if this were the case why could they not easily be knocked out of protons to be detected as free particles? The resolution of this problem provided by David Gross, David Politzer and Frank Wilczek [631-634] earned them the 2004 Nobel Prise in Physics [635]. Called *asymptotic freedom* it simply states that as the distance between quarks increases the colour force binding them together strengthens. Therefore inside the proton or neutron the quarks can be weakly bound but if a quarks is struck in an interaction experiment, as it is pushed away from the other quarks the strength of the colour force will increase as the separation increases quickly becoming so strong that it prevents the quark from being knocked free.

d. Distinguishing between Motion and Force

As we have seen above[87] the motion of a discrete state continues to be affected by the fact that for an initial state devoid of a first cause anything that can happen will, which means that the causal gap established by a second measurement that could potentially fix the location of the particle must be closed as if all possible paths

[87] Chapter Four: 48a. *The Establishment of the Past and Quantum Mechanics.*

had been taken between the two spatial locations. While a physicist can measure any random region of space to determine if any elementary particles are there, to determine the motion of a specific particle at least two measurements are required. This situation differs from the resolution of a causal gap in epoch I because it uses the waveform representation of the discrete state itself mapped out over multiple potential paths rather than an attempt to realise a new intermediate potentia. It is this process that governs the motion of free elementary particles within this universe. But note that this process does not speak directly to the consequences of the realisation of the particle in the second spatial location. For example, if an electron is realised in the second spatial location interactions with other elements of the physical environment may produce other consequences, but its realisation as such elicits no automatic temporal response in that no new potentia must be realised due to this process. The only necessitated affect is that the spatial region where the electron was last realised through measurement and the spatial region where it is now realised, are associated through the evolutionary history of this electron.

However, what we were dealing with in epoch I was the possible realisation of the intermediate potentia itself. If an intermediate potentia is realised it is as an existent state and so does not prompt the establishment of any new potentia, so that there is no automatic temporal response in this sense. However, it does affect the two bounding potentia which have already been realised. This, as we saw in Chapter Two, provides the basis for the flow of time from past, through the present, to the future. Therefore this process does describe how a consequence is achieved. When two discrete particles form the boundary conditions, what we see as the affect of a force upon them is simply the physical evidence of the flow of time. A force therefore must involve the realisation of a new intermediate potentia, which affects the boundary particles and thereby provides physical evidence of the progression of time. Because these intermediate potentia are new realisations that did not participate in the energy difference schema of epoch II, they can only participate in the difference schema of this universe beyond the constraints of the time-energy uncertainty by the exchange of energy. It is this process which is described by particle physics as the action of a force through the exchange of virtual bosons.

e. What is Charge?

It is generally accepted that in physics, *" One does not define charge but takes it as a basic experimental quantity and defines other quantities in terms of it* [636].*"* However in terms of this cosmology we can think of charge as the inherent temporal direction that distinguishes the two aspects of a coexistent unit, but that is only part of the story. What must be understood is that truly elementary particles are not the final realisation of the coexistent unit but a further representation of this superposition in terms of *x space ¬x*. In these circumstances its two spatially separated aspects must possess equal but opposite properties, so that there is no net consequence resulting from an as yet unresolved state.

The confusion with interpreting the charge of the quarks comes from assuming that they occupy the same spatial and temporal environment as other particles. In this cosmology this is not the case, instead the proton and neutron must be considered as distinct limited universes. Two-directional time arose as a consequence of the two boundary conditions of epoch I *ac*-events. The proton and neutron must be considered as states defined by three boundary conditions, the three components of the interacting coexistent units. For a state with three boundary conditions there are six directions in time and therefore six charges, red, green, blue and their anticolours. The three-state of this cosmology is not a superposition, but rather the residue resulting from a cross-coexistent unit interaction that resolved one coexistent unit to a singular potentia. The singular potentia provides a single definition for the initial state and therefore a single temporal direction. The residue must be temporally neutral in order not to affect the resolution provided by the singular potentia. This is the constraint within this cosmology that requires quark states to be colour singlets, that is, to have no net colour.

Mesons are not the product of interactions that have occurred in the evolutionary history, but are new realisations of intermediate potentia that must be defined in conformity with their boundary states, which are quark systems. Being new realisations they follow the precedent of coexistent structure and are therefore evidenced as a particle-antiparticle pair. They are quark systems because the properties of the bounding states must be reflected in the intermediate states. But like all particle-antiparticle pairs these are superposition states that must also be neutral both in terms of colour and normal change.

Proton and neutron also have two temporal neutralities that must be maintained, however for these states the determination of the normal charge is based on earlier evolutionary events. The baryons arose from cross-coexistent unit interactions that resulted in a three-state and a singular potentia. For the neutron its singular potentia did not become part of this universe, therefore to maintain a zero net temporal direction its charge must be neutral. For the proton its singular potentia did become part of this universe as an electron. In order for the singular potentia to assume this more mundane representation that prevents it from providing a single definition of the initial state, the net temporal direction provided by the singular potentia and the three-state must be zero. Therefore the proton must have a positive charge.

Quarks must therefore have two types of charge, colour, which is how charge is defined within their own limited universe, and normal charge, which can be equated with the charge of external particles such as the electron. These are the constraints that dictate that quarks have fractional normal charge and six colour charges.

This universe was established with temporal neutrality, with no direction of time preferred over another. This simply reflects its status as an unresolved state, a state that at its inception must maintain equivalence with oblivion.

Fritzsch pointed out that, " *The electroweak theory, however, contains a serious and as yet unresolved problem. It fails to explain why the electric charges of leptons and quarks are quantized in different units (The electric charge of electrons and mesons is -1, and the electric charge of quarks is either +2/3 or -1/3). It appears that physics contains a secret law that compels the various particles to contain only well-defined charges. But what is that law* [551]*?"* This cosmology states clearly what this law is: *Neither superpositions nor the residue resulting from their resolution can possess a net temporal direction*. That there are two types of charge simply reflects that there are two distinct temporal environments, the six-dimensional time within the baryons and the two-dimensional time of the external universe.

f. Particle Decay in this Cosmology

A common attribute of the strong, electromagnetic and weak interactions is that they are all involved in particle decay, although the weak interaction is the only one that involves a particle changing flavour. What is remarkable about particle decay is that the resultant particles are not constituents of the original particles, but totally new objects. As Oerter pointed out, *" It is as if a Great Dane could be walking down the street and then spontaneously transform into a Weimaraner and a Siamese cat* [451]*."* We should not lose our sense of wonder that nature should not only allow but require such seemingly bizarre behaviour. The principal rule applying to particle decay is that: *Any decay that can happen, will happen*. Given this cosmology this is in itself not surprising, since it is simply a continuation of the consequence of there being no first cause: *Anything that can happen will*. However that this still applies to this universe further emphasises that it is not the final product of evolution, but remains fundamentally an unresolved state still seeking a clear cause.

Strong and electromagnetic decay events involve the annihilation of either a quark-antiquark pair or a particle-antiparticle pair, resulting in the production of the relevant bosons, either gluons or photons, which then decay into other particles. What must be done now is consider these events in terms of this cosmology, which makes no distinction between physical events and the nature of time. Currently physicists treat time either as part of the coordinate system of general relativity, (x, y, z, t), to label where in spacetime an event occurs, or simply as a parameter in quantum mechanics. What the Flawed Nature Cosmology says about time and its association with physical events goes far beyond this – it says that physical events are the mechanisms by which time progresses. In this cosmology there are not physical events and time, but rather physical events that are an aspect of time. Specifically it was stated earlier[88] that *nature includes virtual pairs in its description not because of any uncertainty, but because of the necessity to maintain the capacity to express all of its potential* and that since nature's evolution is fundamentally about the evolution of time, *it should not be surprising then that the establishment of this material universe makes the passage of time manifest. We can literally see the transition from future to present and from present to past. The future is manifest, even before it becomes truly real, as virtual pairs. As particles and antiparticles collide and annihilate they fade from existence leaving only the energy that cannot be taken from the present instant. This energy can be taken up by virtual pairs to make them legitimate participants in the present's difference schema and therefore real particles. In this way as part of nature's potential fades from existence, having exhausted its turn at expression, fresh elements of nature's unbounded potential are given their turn at existent expression. The passage of time in terms of the realisation of nature's potential is no abstraction but clearly visible*. Strong and electromagnetic decay provide the most structured events involved in this temporal progression. There is nothing strange about these decay events even though they may be compared with *"…a Great Dane …spontaneously transform into a Weimaraner and a Siamese cat* [451]*,"* this is merely the realisation of the concept that *a definition need not persist forever to be valid*[89], and therefore that existence itself need not be permanent to be valid. These decay events are the equivalent of death and rebirth as played out amongst inanimate matter.

For an evolutionary epoch to be perpetuated it must have the capacity to realise all of nature's potential. But for it to represent a consistent composite definition of the initial state this definition must in some sense be fixed, which in the case of this universe is achieved through the conservation of energy. The solution is to mix with the static definition a changing definition that respects the conservation of energy, and in fact also other constraints, so that there is always a consistent present instant, but one from which some potentia fade to be replaced by others. Strong and

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[88] See Chapter Four: 47j. *Virtual Pairs* and 47o. *Time and the Big Bang Initial Conditions.*

[89] See Chapter Three: 37d. *The Realised Intermediate Potentia and the Origin of Mortality*.

electroweak decay events do not represent an unfathomable chaotic behaviour, just the physical events involved in both maintaining a consistent definition of the present instant of time, while allowing the past to fade and be replaced by a new future, new potential.

But as significant to the nature of time as particle decay is the fact that some particles, such as the proton, do not decay. It has been noted that, " *Conservation of energy and electric charge would allow a proton to decay into a positron and a photon* [637]," however this is a decay that cannot occur because it would violate the constraints of conservation of baryon and lepton number. But why, in terms of this cosmology, do these constraints apply? These conservation laws represent an instance where nature's evolutionary history is maintained. During the interaction that fuelled inflation[90] some coexistent units interacted and formed baryons, while others did not and provided the basis for leptons. If the number of baryons and leptons were not conserved this would represent a do over of the evolutionary history of the big bang. This cosmology suggests that such a do over can and does occur in terms of the decay of the neutron[91], however there is no reason in terms of overcoming nature's flaws to prefer the production of baryons over leptons, or vice versa. It is that this aspect of the evolutionary history is not altered by interactions within this universe that is reflected by the conservation of baryon and lepton number. These constraints in turn, along with those imposed by the energy difference schema and the conservation of charge, allows a universe that is essentially an unresolved state to assume a stability of structure it would otherwise not possess. The universe is not inherently a stable place, not only because anything that can happen will, but because there is the capacity to do over past events. Not even the advent of quantum mechanics has overcome the general assumption that past events dictate the current nature of the universe, however in terms of this cosmology this is neither certain nor absolute. All the constraints on particle decay, based partly on what do overs are or are not justified in terms of resolving nature's flaws, are necessary to establish a universe that maintains to some significant degree the consequences of past events. This is a part of the fundamental nature of this universe, why it is characterised in this cosmology as the past.

What does it mean then when a particle decays via the weak interaction without the catalyst of particle-antiparticle annihilation? In the case of the decay of the neutron, essentially into a proton and an electron, it means that there is a reason for the do over of the original cross-coexistent unit interaction. This is more than to say that there is no constraint to prevent this decay. Instead there is a reason why it should happen. However for this decay to occur and still maintain the conservation of baryon and lepton number it must also include the production of an electron antineutrino. The existence of the neutrino (a name coined by Fermi [638]) was postulated by Pauli in 1930 in order to maintain the conservation laws involved in neutron decay. It was not until 1953 that Frederick Reines and Clyde Cowan [639, 640] experimentally detected it. It is interesting to consider that Pauli's prescription for the neutrino may have in fact been followed by nature itself. The overriding consideration was the need to do over the establishment of the neutron. In the interaction that produced the proton the singular potentia was realised as an electron. Therefore the W^- must decay into an electron, with the conservation constraints of this universe satisfied by the accompanying realisation as an electron antineutrino.

[90] Chapter Four: 52a. *The Mechanism that Drives Inflation.*
[91] Chapter Four: 50d. *The Decay of the Neutron and the Stability of the Proton.*

This precedent is carried over to the other electron-like fermions and their modes of decay.

Decay events, whether due to the strong, electromagnetic or weak forces, are significant not just in terms of their physical consequences, but in terms of what they can tell us about the interaction between the physical environment and the ongoing evolution of time.

g. The Weak Force in this Cosmology

The weak interaction has a range of only 10^{-18} m, some 1000 times smaller than the diameter of an atomic nucleus. The boson's involved are the $W^{\pm}$ with a mass of 80.4 GeV/c^2 and Z^0 with a mass of 91.2 GeV/c^2 (both approximately 100 times as massive as a proton) and a mean life of about 3 x 10^{-25} s. In interactions involving $W^{\pm}$, charged current interactions, particles can change flavour. While interactions involving Z^0, neutral current interactions, only produce scattering.

It was stated at the beginning of this section that the discussion of the origin of the forces will *take the form of a mapping of the virtual particle representation of the electroweak and strong forces to precedents set in this cosmology's description of events along the evolutionary timeline*. The evolutionary precedent responsible for the weak force is the *ac*-events of epoch I, where it is particles that serve as the boundary conditions.

Let us consider this mapping first in terms of charged current interactions, such as the decay of the neutron. It might not at first be clear that the decay of the neutron can be equated with an epoch I *ac*-event, but this is simply because we cannot see the two boundary conditions at the same time, however it must be remembered that the original purpose of the *ac*-event was to establish a causal timeline and thereby a consistent non-static definition of the initial state. Therefore the boundary conditions are two discrete states separated along the timeline so that one morphs into the other through the catalyst of the realisation of an intermediate potentia. In this case all that would be seen from the present instant is that one particle becomes the other via the temporary realisation of a third virtual particle.

The *ac*-events as realised in the environment of epoch II involved orbital collapse with the emission of a coexistent unit. This can be compared with the decay of the neutron into a proton with the emission of a W^- boson, by equating particles of different rest mass and therefore energy with epoch II orbitals. The difference is that epoch II started with a complete set of orbitals, whereas for this universe different processes established the particles at different times. The neutrons started to decay when the first proton established the precedent for a compatible lower energy state. The present state of the particles, that it is a neutron, acts like an epoch II upper orbital since it has the higher rest mass and therefore energy. The future state of the particle, its capacity to become a proton, acts as the lower orbital since it has a lower rest mass and therefore energy. That the energy difference schema dictates that only a downward transition is possible allows the realisation of an intermediate state. However decay events differ from the orbital transitions of epoch II in that the bounding states themselves have an inherent temporality indicated by their charge or neutrality. This allows the intermediate potentia to also possess a distinct temporality indicated by the charge of the $W^{\pm}$ boson, for example for a 'downward' transition where a neutron decays to a proton the intermediate potentia is realized as a W^- boson. However in the same way that an incoming photon can negate orbital collapse, an incoming W^+ boson can negate the decay process. For example, if a proton were to absorb a W^+ boson, then the opposite temporal transition would occur and a neutron will replace the proton. The W^- and W^+ bosons not only represent the capacity to realise an intermediate potentia because of the constraints on actual events introduced by the environment, they represent the capacity to realise one temporal aspect of the intermediate potentia independently of the other. The W^- and W^+ bosons are a particle-antiparticle pair, that is, they represent as separate particles the two temporal directions inherent in the intermediate potentia.

There are two factors involved with the weak force, the emission of a boson, which results in decay, and the exchange of this boson between two particles, which results in interactions between particles. With charged current interactions decay is the predominant factor, with interactions due to the exchange of $W^\pm$ bosons being incidental. The intermediate $W^\pm$ boson results from boundary conditions set in time, which is evidenced by it being charged. But the decay process is limited, eventually resulting in particles that cannot decay further. This represents the exhaustion of one method of defining the discrete states, a changing definition whereby they are defined by what they presently are and what they can become. But each discrete state must also be defined in terms of its place in the composite definition of this universe. It is this requirement that is responsible for the neutral current interactions. These are also a repetition of the precedents of epoch I *ac*-events, but now the boundary conditions are set in space rather than time, with the bounding states being two spatially separated particles. Where the boundary conditions are only spatial so are the consequences of the realisation of an intermediate potentia, so that neutral current interactions only result in scattering. Therefore for the neutral current interactions it is the exchange of a boson that is fundamental, since this results in interactions that demonstrate a relationship between the boundary particles. Decay events confirm the relationship between particles within the temporal environment, while interactions confirm the relationship between particles within the spatial environment. The way in which discrete particles are included in the overall definition of this universe therefore utilises both the precedent of a temporal changing definition and a static composite definition.

Neutral current interactions involving the Z^0 boson occur between all elementary particles except the gluon. Quarks are include because the quarks although defined within a distinct three-space have a footprint in the normal spacetime environment of this universe. Gluons are excluded because in being the bosons of the three-space they are exclusively a temporary manifestation within this environment, as indicated by gluon exchange only occurring between quarks.

But if there is no temporal transition that can be equated with epoch II orbital transitions, why can an intermediate potentia be realised? Space itself allows for the realisation of an intermediate potentia that inherently encapsulates both temporal aspects, because the action on one bounding state and its negation in terms of the affect on the other bounding state is separated in time by the time of flight of the boson. There is an affect on the emitting boundary particle at $t = 0$, which in terms of the conservation of momentum is negated by the affect on the absorbing boundary particle 3×10^{-25} seconds later. The intermediate potential can be realised because the opposite temporal affects of this realisation do not overlap but are actuated at different times. However while in terms of all relevant conservation laws nothing has happened, there is still a retained affect upon this universe in terms of the change in location of the bounding particles. This is sufficient to establish their relationship in terms of the composite definition of this universe.

One of the aspects of the weak interaction not explained by the standard model is why the boson involved in charged current interactions, $W^{\pm}$, carries a charge while the boson involved in neutral current interactions, Z^0, does not. In this cosmology this can be explained both in general and specific terms. In general terms the charge of the $W^{\pm}$ boson indicates that it is the intermediate potentia for boundary conditions separated along the timeline, with the sign of the charge indicating in which temporal direction the transition is occurring, that is, $n \rightarrow p$ involves W^-, while $p \rightarrow n$ involves W^+. Equally it is because the boundary conditions for neutral current interactions are spatial rather than temporal that the intermediate boson, Z^0, has no charge. In specific terms the W^- and W^+ bosons represent the realisation of one temporal aspect of the intermediate potentia independently of the other, while the Z^0 boson encapsulates both temporal aspects in one intermediate particle.

In order to understand the limited range of the neutral current interactions in broader terms than the relationship between the Z^0 boson mass and the time-energy uncertainty, it is necessary to understand that the forces of nature were not established within an environment containing billions of diverse particles within an immense spatial environment, but rather they initially only involved one coexistent unit and its expression as *x space* $\neg x$, that is, as a spatially separated particle-antiparticle pair. This suggests that the range of the neutral current interactions is related to the extent of the discrete space initially established by one spatially expressed coexistent state. But the big bang involved the introduction of billions of such states, resulting in the separation of particle-antiparticle pairs beyond this spatial extent. Therefore in the current environment of this universe the relationship between particles is established by a variety of means. Where particles are within 10^{-18} m of each other neutral current interactions continue to play this role. But at greater separations the relationship between charged particles can be established through electromagnetic interactions and for massive particles through gravitational interactions. While for all states their relationship can be established by the resolution of causal gaps in terms of the past spatial trajectory of an intermediate particle.

h. The Electromagnetic Force in this Cosmology

When QED was first introduced there was a problem, as Feynman pointed out, *" When calculating terms with couplings, we must consider (as always) all the possible points where coupling can occur, right down to cases where the two coupling points are on top of each other – with zero distance between them. The problem is, when we try to calculate all the ways down to zero distance, the equation blows up in our face and gives meaningless answers – things like infinity* [2]." Such zero distance calculations were considered necessary according to Feynman because *" One should be able to go down to zero distance in order to be mathematically consistent…*[2]." The work around encapsulated in renormalisation is to stop the calculation at some arbitrary, but small, separation distance. This gives different answers depending on the choice of separation distance, but as Hans Bethe [641] and Victor Weisskoft [2] pointed out, these different values could be used to calculate the answer to some other problem and these answers would be nearly the same. But as we have seen above[92], Feynam himself was never fully satisfied with renormalisation, referring to it as a " *dippy process* [2]." The problem is that while

[92] Chapter Three: 34b. *A More Fundamental Basis for Renormalisation.*

going down to zero distance may seem necessary in order to maintain mathematical consistency, what is actually required is the maintenance of cosmological consistency. The electromagnetic force, like the weak force, repeats the precedents of epoch I *ac*-events and such events cannot be mapped down to zero separation. The zero separation calculations that seemed mathematically necessitated are in fact invalid on cosmological grounds.

But while both weak force neutral current interactions and electromagnetic interactions involve verifying a relationship between spatially separated particles, charge particles can both interact through the weak force by the exchange of a Z^0 boson or through the electromagnetic force by the exchange of a photon. Both interactions involve spatially separated boundary conditions and therefore have consequences on the boundary states restricted to spatial motion. The boson for the electromagnetic force, the photon, carries no charge for the same reason Z^0 is neutral, the boundary conditions are set in space rather than time and the boson encapsulates both temporal aspects of the intermediate potentia. But why does Z^0 have mass while the photon is massless? This suggests that the Z^0 is more intimately related to the initial space established by particle-antiparticle pairs or quark triplets. It establishes the relationship between the distinct aspects of the coexistent states as if they were newly realised potentia such as *a* and *c* in epoch I. This occurs when they are first realised as independent particles and to the maximum spatial extent these particle representations establish as an aspect of their discrete nature. But this is not the only aspect of the establishment of space. Space originated as a new way to express the coexistent unit superposition, x *space* $\neg x$, that is, as a particle and antiparticle separated by space. However there are constraints that apply to this new representation. Firstly, the fundamental distinction between the aspects of the coexistent unit, that they are resolutions in two distinct temporal directions, must be maintained even when no temporal transition is occurring. This constraint is satisfied by the property of charge. Secondly, in recognition that the two particles remain components of an unresolved superposition their properties must be equal but opposite, so that there is no net consequence. This constraint is evidenced by the capacity of a particle and antiparticle to annihilate upon contact. Thirdly, it is essential that these pseudo-singular potentia be prevented from acting as isolated definitions of the initial state. To do this the relationship between the two aspects of the superposition within the spatial environment must be maintained, no matter the extent of their spatial separation. This allows us to understand the difference between neutral current interactions and electromagnetic interactions. Weak force interactions involving Z^0 seek to establish a relationship between two separated particles within the environment of the initial separation space that they establish, as if they were newly realised potentia. In this case there is no predetermination of the nature of the relationship and it is simply necessary for them to interact with each other in some way. This precedent can be extended to interactions between all particles participating in the increasingly entangled general spacetime environment. The electromagnetic interaction has a different basis, instead of establishing a new relationship between the boundary states it must verify whether or not the bounding states possess the pre-existent relationship of being components of a coexistent unit superposition. This allows us to understand why the electromagnetic force only affects charged particles. The two aspects of a coexistent unit have opposite temporal orientations, which are expressed in this universe as opposite charges. Particles that have no charge do not provide boundary conditions that can determine whether they could have been components of a coexistent unit or not.

All causal associations must be evidenced by an affect on the bounding states, which in the case of spatially separated boundary states is manifest as motion. The only environmental constraint affecting this motion is the same as that which acted on weak force neutral current interactions, the maintenance of conservation of momentum, which only requires that the two particles experience equal but opposite alterations in momentum so that there is no net change. This constraint is satisfied if the two bounding particles either both move towards each other or both away from each other by the same degree. Note however that nature has no rulebook that states: *Like charges should repel and opposite charges attract.* This is the outcome because what is occurring is the reaffirmation of an existing relationship between the bounding states so that if they have opposite charges they could have been part of a coexistent unit, which is manifest as their attraction to each other, but if they have the same charge this could not be the case, which is manifest as their repulsion from each other.

Time is not just driven forward, there is always a tendency for regression, to set things back the way they were. It is only the evolution of the environment that ensures that this does not occur. If two aspects of a coexistent unit, for example an electron and positron, were brought together they would not reform a coexistent unit, but would instead annihilate. This is necessitated by the difference schema of this universe and allows potentia to surrender existent expression and thereby provide new potentia with their turn at participation in this universe. Also the environment of this universe allows states other than elementary particles, such as composite quark states and ionised atoms, to have a net electric charge. A process that had originated as the maintenance of the coexistent unit relationship is reapplied to all states with a net charged. But this is possible since the only affect of this process is spatial motion. The current matter-antimatter imbalance means that the electromagnetic force cannot in most cases achieve its original goal, matching up particles and antiparticles as components of a coexistent state. But the process continues nonetheless, so that all that remains of the tendency for temporal regression is its spatial expression as the attraction of states of opposite net charge and the repulsion of states with the same net charge.

i. The Amalgamation of the Electromagnetic and Weak Forces

The amalgamation of the electromagnetic and weak interaction into one the electroweak theory by Sheldon Glashow [642], Abdus Salam [643] and Steven Weinberg [644], for which they were awarded the 1979 Nobel Prize in Physics [645], involved suggesting that *"…at very high energies, the universe has four identical massless gauge bosons similar to photons and a scalar Higgs field. However, at low energies the symmetry breaking produces three massless Gladstone bosons which are 'eaten' by three of the photon like fields, giving them mass. These three fields become the W and Z bosons of the weak interaction, while the fourth field remains massless and is the photon of electromagnetism* [646]*."* While this theory established its credibility by successfully predicting the mass of the Z^0 boson before its discovery, its dependence on the Higgs field when the Higgs boson is yet to be discovered, does leave this subject still open. Physicists must either retain this theory for the unification of the electromagnetic and weak forces and continue searching for the Higgs boson forever, or propose new theories.

This cosmology states that the weak and electromagnetic forces are indeed linked, but not via a process requiring the postulation of the Higgs field, but by their association with the same evolutionary precedent. This would seem a simpler and more consistent way to understand the association between these forces.

j. The Strong Force and Quarks in this Cosmology

Quarks are only found in very specific configurations, baryons which contain three quarks that must form a colour singlet and mesons containing a quark and an antiquark. There is never a combination of more than three quarks, never a configuration with a net colour and never an isolated quark. However as Veltman pointed out, *" There is, however, no strict theoretical proof showing that there can be no colored bound state or free particles* [64]*."* The reason why quark systems cannot contain more than three quarks, why they must be colour neutral and why there can be no free quarks cannot be found by examining their current structure, but must be demonstrated in terms of their evolutionary history.

Why was it suggested that baryons were composed of three quarks? As Fritzsch explains, *" Obviously, baryons cannot be two-quark systems because the spin of a two quark system cannot be a half integer (as the spin of the nucleons is). Therefore the simplest possibility for baryons is a three-quark system* [551]*."* But this reasoning could not explain why there cannot be quark systems involving even more quarks, such as a five-quark system. The explanation that this cosmology would provide for there being no quark systems containing more than three quarks is that there is no precedent in the evolutionary history for a single state of greater complexity than three components. The cross-coexistent unit interactions were the most complex physical interactions to occur before the establishment of this universe. Their most complex consequence was a state with three components, which provides the basis for the baryons. There can be no free quarks simply because of what quarks are. This cosmology does not start by postulating a range of elementary particles, as the big bang model does, but instead deals with the evolution of a single minimum entity, the potentia. Fundamentally then a quark cannot be any different from any other elementary particle except in terms of the environment in which it is defined. The difference between how this cosmology would conceptualise the baryons and how they are currently perceived is that current theory sees baryons as composed of independent quarks that are only inseparable because of the strength of the strong force, while this cosmology would see them as limited universes with unique environmental properties that determine how quarks are defined. The most fundamental of these properties is that this is an environment defined in six-dimensional time, which as we have seen above[93], leads both to the three colour charges and their anticharges, with colour neutrality arising because these states are fundamentally the residue resulting from a cross-coexistent unit interaction that resolved one coexistent unit to a singular potentia and must be temporally neutral in order not to affect the resolution provided by the singular potentia. A quark is different from an electron because it is defined in this environment. It is not and cannot be made an independent constituent of a universal environment defined in terms of two-directional time.

An electron or neutrino can penetrate a proton or neutron as if moving through normal space because baryons have a footprint in normal space. But this is the footprint of a differently configured temporal environment. The normal charge of the quarks is the evidence of the interface of these two temporal environments. The

[93] Chapter Four: 56e. *What is Charge?*

gluon is the realised intermediate potentia between two quarks within the six-dimensional time of the baryon environment. The meson is the intermediate potentia as realised within the two-dimensional time that results from the baryon's presence in the larger universe.

Why do gluons carry the colour charge where photons do not carry the electric charge? For the electromagnetic force the charge is defined in terms of two-directional time as is the intermediate state, the photon. The six colour charges arise from the six-dimensional time of the entire three-state, however gluons remain the intermediate states between individual pairs of quarks and is therefore still defined in two-dimensional time. In these circumstances the gluon can only carry two out of the three colour charges. Given this configuration there are nine possible ways of coupling gluons to quarks thereby changing the quark colour: red → green, red → blue, green → red, green → blue, blue → red, blue → green, red → red, green → green, blue → blue. However as Fritzsch points out, " *Note that the last three couplings differ from the others in that the colours do not change. In particular, there is a situation that is completely symmetric with regard to colour: namely, the superposition red → red + green → green + blue → blue. We disregard this type of coupling since it can produce no change of colour. Thus, only two independent superpositions of the last three couplings count. Together with the first six, we are dealing with a total of eight different couplings. We now proceed to assume that there is a gluon for each of them, that is, we suppose eight different gluons* [551]."

As we have seen above[94], one of the features of the gluon force, as evidenced by the deep scattering experiments conducted at SLAC [628, 629], is that it becomes weak at small distances, but increases as quark separation increases until it becomes constant independent of distance at about 10^{-34} cm. As Fritzsch put it, " *That the force between quarks becomes weak at very short distances is called asymptotic freedom. At such distances, quarks behave like independent particles and no strong force exists between them* [551]." In this cosmology this would be interpreted as the quarks behaving as independent particles within their natural environment or limited universe, while resisting any attempt to separate them from that environment. We stated earlier[95] that space is not a thing in the sense of the old concept of the ether, but instead *it is the location where a particle could potentially be realised as mapped out by the motion of waves* and that *it is the sum of all fields*. The gluon field provides a substantial part of the definition of the space of the baryon's limited universe. The natural, or equilibrium, state of the baryon's space is to be found at the small distances where quarks act like independent particles. This represents the natural footprint of the quark system on the external space. Interactions such as the deep collisions of the SLAC experiments can seek to change this footprint by accelerating a quark away from other quarks. The attraction between quarks as the separation distance is increased is not so much a binding force, since in this case it would be more natural to be strongest when the quarks were closest together, rather it acts as an elastic response to trying to extend this footprint. It can be considered therefore as not arising from the quarks themselves, but as a consequence of placing the quark states in an external spatial environment. It becomes constant independent of distance when the external space becomes dominant.

In the context of this cosmology, the attractive aspect of the strong force has more in common with gravity than electromagnetism. It is about the interaction between particles and the spatial environment they inhabit. You cannot simply say

[94] Chapter Four: 56c. *A Brief Review of the Strong Force and Quark Theory*.
[95] Chapter Four: 51. *The Particle-Antiparticle Pair and the Further Evolution of Space*.

that the force carried by the gluon increases as the separation distance increases, since this implies that the gluon's mass must increase in contradiction to the time-energy uncertainty, which would require that as the distance and therefore time of flight between two quarks increases the mass of the intermediate boson should decrease. Instead what this cosmology suggests is that as the geometry of the baryon's natural space is altered there is a response to this similar to the gravitational response that occurs as the curvature of normal spacetime is altered. The forces of nature do not pre-exist, they arise in response to specific environments. The quarks, which are defined in terms of the baryon's limited universe, also have a footprint in normal space, which is a totally different environment. What we see as the attractive nature of the strong force as quark separation increases is not a pre-determined law of nature that has existed eternally, but rather it is a reaction to a new situation involving the interaction between two spatial environments.

The strong force in this cosmology therefore is similar to the weak and electromagnetic forces in its reapplication of the precedent of *ac*-events, but differs from them in that it adds to this a new attribute that only arises with the advent of this universe, the reaction of particles to the configuration of the spacetime environment they inhabit. There is nothing unusual about this since the leptons interact in much the same way. The electroweak force is a reapplication of the precedent of *ac*-events, while the gravitational force is their reaction to the configuration of the spacetime environment they inhabit. The way the quarks and leptons experience this reaction to the configuration of the spacetime environment differs simply because their natural spacetime environments differ. With the strong force this distinction between the gluon interactions that affect the colour of the quarks and the attraction that increases with the separation distance between two quarks has not yet been made. However this cosmology suggests that a unified understanding of all the forces cannot be complete until this common basis for the attractive forces between quarks and leptons is fully understood.

k. The Gravitational Force in this Cosmology

In the Flawed Nature Cosmology the gravitational force repeats no previous evolutionary precedent but instead establishes a new relationship between massive discrete states and space[96]. Gravity is therefore not an *ac*-type event that acts through the realisation of an intermediate boson. This cosmology therefore suggests that the graviton will never be found. Instead the intermediate state is space itself. A massive body distorts spacetime and this distortion affects other discrete states, just as Einstein originally proposed.

l. The Forces of Nature and Time

The motion of a particle through space has long been considered as evidencing the passage of time, since if a particle moved from spatial point *A* to spatial point *B*, time itself must move so that point *A* was the past location of the particle while point *B* is its present location. However the relationship between physical events and time is more complicated than this. The attraction and repulsion of charged particles due to the electromagnetic force is the spatial expression of the achievement or otherwise of temporal regression. Particle decay involves the temporal evolution of a single

[96] See Chapter Four: 51c. *Mass and Gravity*.

state, while the stability of particles ensures the retention of aspects of nature's evolutionary history. Time is more than a component of the coordinate system of general relativity or a parameter in quantum mechanics. Time has not been extensively studied by physics because it has been considered to be less tangible than the particles or forces examined in mechanics. It is not. Every aspect of the physical universe tells us something about the nature of time. All that is needed is an instrument through which this study can be performed. Although admittedly in its infancy, the Flawed Nature Cosmology is such an instrument.

m. The Flawed Nature Cosmology and Future Research regarding the Standard Model

Two fundamental questions are not answered by the standard model: *Why are there three generations of quarks and leptons?* and: *How are the masses of the various particles determined?* While there is not time during this preliminary consideration to fully address these issues, what the Flawed Nature Cosmology suggests is new ways to approach these as yet intractable problems. Why there are three generations of quarks and leptons may be related to the number of do overs involved in the establishment of this universe. While the mass of the various particles may ultimately be determined by allowed orbital transitions in epoch II, a question that may become addressable as this environment is more formally modelled.

n. Concluding Comments on The Origin of the Forces of Nature

This dissertation seeks to demonstrate that physics can be about more than observation and prediction, but can contain a fundamental understanding of why nature has chosen to utilise a particular mechanism and where along the evolutionary timeline the precedent for this mechanism first occurred. In this context we have done something beyond precedent in this section by considering the origin of the forces, however clear conclusions can be drawn. In the Standard Model the forces are propagated by the temporary existence of virtual bosons, with no explanation offered as to why nature should choose this particular schema. However in this cosmology the electroweak and most aspects of the strong force trace their origin to a repetition of the *ac*-events of epoch I as applied to new environments, which include bounding states with a greater range of properties than were present in epoch I. The gauge bosons are the realisation of intermediate potentia, which must be virtual because they are a new realisation that never gained participation in the energy difference schema through the events of epoch II. As the bounding states come to possess more complex properties, so do the realised intermediate potentia, which explains the diversity of the bosons. These intermediate potentia are interpreted as force carriers because their realisation has an affect on the bounding states. However there are two distinct types of boundary conditions, one set in time that results in decay events and one set in space that results in scattering events.

The force of gravity, and the attraction between quarks with increasing distance of separation, is not based on any earlier evolutionary precedent but is a new attribute of nature that arises as a consequence of the spatial environment of this universe. Therefore this cosmology would not predict the existence of the graviton as a force carrier for the gravitational effect, but would retain Einstein's model of gravity purely in terms of spacetime curvature.

There is a fundamental distinction between the two types of forces that cannot be overcome simply by increasing the energy level of the environment within which they act. It is therefore not possible to establish a GUT by simply proposing that there was a time when there was only one force that diverged as the environment became less energetic. The forces of nature are distinct in ways more fundamental than energy level. The search for a GUT is another example of the expectation of nature's perfection driving physicists to conceive of models that are more simple and consistent than a flawed nature can actually provide. This however in no way limits our capacity to have a unified understanding of all the forces, it is simply that this understanding must be framed in terms of a cosmology that provides a common framework within which the origin and operation of all the forces makes sense. In this dissertation we have attempted to demonstrate that the full development of the Flawed Nature Cosmology may be able to do this, no other cosmology even attempts it.

57. The Flawed Nature Cosmology and the Definition of Space and Motion

This dissertation has repeatedly emphasised the belief that the task of physics is to provide humanity's best direct description of nature. In order to achieve this goal we must describe the universe as it is and not according to our idealised conception of it. This consideration has already repealed our most cherished idealisation of nature – nature is not perfect. But accepting this harsh fact has allowed a better understanding of the motivation and progress of nature's evolution. Next we shall reconsider how space and motion are defined within physics in light of the Flawed Nature Cosmology.

When examining nature's latest evolutionary epoch, this universe, it must be keep clearly in mind that it does not represent the resolution of the flaw that nature has no initial cause, but instead is part of the process of seeking causal determinacy. This tells us that the establishment of a definite causal system is this universe's goal rather than being an attribute inbuilt at its inception. Therefore if we look along the evolutionary timeline of this universe we should see a greater degree of causal determinacy amongst the most recently evolved states compared to more primitive ones. The evolution of this universe is essentially a simple process involving the aggregation of elementary particles to form composite macroscopic states. Therefore unlike biological evolution this universe's dinosaurs never becomes extinct, they remain the constituent parts of the composite states. It was pointed out earlier[97] that *when we look at smaller and smaller objects we are looking back along the evolutionary timeline, in much the same way as an astronomer looking at a distant star is looking back into the past state of the universe*. When physicists started examining the atom and then elementary particles at the turn of the last centaury they were shocked and dismayed that causality itself seemed to be stripped away. But given this cosmology this is exactly what we would expect to see. However the universe is not the product simply of the latest evolutionary development, but is the cumulative consequence of all of nature's evolution. Cosmologies that have evolution begin at the big bang lose too much detail of nature's earlier evolution and therefore cannot explain why this universe functions as it does. However in this cosmology it is expected that this universe will exhibit two causal schemas, one based on the desired causal schema of this universe, past spatial trajectory, but only

[97] Chapter two: 18g. *Predicting the Introduction of Macroscopic Objects.*

applying to the relatively recently evolved macroscopic objects, and the other based on previous epoch's use of composite wavefunctions, which will apply to the more primitive microscopic states. To describe nature accurately the way physics conceptualises space and motion must be inherently intertwined with the nature of causal resolution.

a. A Brief Review of Minkowski Spacetime

The space of general relativity and therefore of macroscopic physics is based on the geometry of Minkowski [647], who defined a spatial point in this way, *" Let us imagine some idealized* events *in the world, for example, the collision of two perfectly unextended point masses or the intersection of two nonparallel perfectly breadthless light rays. We will take an idealized event as 'marking' a definite location in spacetime. It will be convenient, however, to have such locations where events do not ever occur; so we will use a trick, at least as old as Leibniz, and speak not only about actual idealized events but possible ones as well. The points of spacetime, then, will be all the locations of possible idealized events. Since the events are extensionless, so are their locations* [648]*."* The fully specify an interaction that defines a point in Minkowski space we must know both where and when this event occurred, therefore the coordinates of this space are (*x*, *y*, *z*, *t*), this is how the concept of four dimensional spacetime entered into physics.

But in order to use the coordinate *t* we must first understand what we mean by time. Einstein stated that, *" The object of all science, whether natural science or psychology, is to coordinate our experiences and to bring them into a logical system* [649]*."* It is not surprising therefore that this is how our conception of time is framed in physics, as Einstein went on to explain, *" The experiences of an individual appear to us arranged in a series of events; in this series the single events which we remember appear to be ordered according to the criterion of 'earlier' and 'later,' which can not be analysed further. There exists, therefore, for the individual, an I-time, or subjective time. This in itself is not measurable. I can, indeed, associate numbers with the events, in such a way that a greater number is associated with the later event than with an earlier one; but the nature of this association may be quite arbitrary. This association I can define by means of a clock by comparing the order of events furnished by the clock with the order of the given series of events* [649]*."* The only universal time in this arrangement is achieved by agreement between individuals to associate their personal series of events with a commonly viewed clock. But such consensus is necessary since, *" We are accustomed to regard as real those sense perceptions which are common to different individuals, and which therefore are, in a measure, impersonal. The natural sciences, and in particular, the most fundamental of them, physics, deal with such perceptions* [649]*."* This is the basis for time in general relativity.

As for quantum mechanic's treatment of time it is even easier to review – time is simply treated as a parameter. Quantum mechanics contains no deeper understanding of time than the ticking of a clock. No wonder Baggott stated, with regard to the debate as to whether quantum mechanics represents a complete picture of nature, that, *" …my recommendation is to watch **time** closely: we do not yet seem to have a good explanation of it* [95]*."*

b. The Definition of Space and Motion in this Cosmology

Of the fundamental aspects of this universe, time is the least understood in terms of physics. This is why considerations such as this one are necessary, to lend new perspective to such fundamental problems. Time in this cosmology is neither treated as an eternal universal clock nor as a consensus reached about the ordering of human experiences. This cosmology states not only that time has an origin, but that it has an evolving nature, a concept not dreamt of by Saint Augustine [60] in his contemplations.

As for space itself this cosmology challenges the most fundamental assumption contained in Minkowski's schema, that the points defined are automatically included as elements of a unified space. On the contrary what this cosmology asserts is that any pair of spatial points must prove their association. This is done in one of two ways. Firstly the association between two spatial regions can be established by them both being part of the timeline of a single particle, that is, a particle that was in spatial region *A* is later found in spatial region *B*. This is a proof based on them being part of a non-static definition of the initial state. Secondly, the association between spatial regions can be established through forces that reapply the precedent of *ac*-events to produce scattering. This is a proof based on the two spatial regions being part of a composite definition of the initial state. In both cases space and time are not universal attributes but defined between two boundary conditions as a causal gap, which must be closed by some causal schema. If a causal gap is closed this is evidenced by the temporal evolution of the bounding states. Time and space are inherently intertwined not because of a coordinate system of human design, but because spatial motion is how temporal evolution is expressed when the boundary condition are part of the same present instant.

Classical physics dealt with the spatial evolution of particles without a clear emphasis on specific bounded regions, but instead concentrating on the past spatial trajectory of the particles and the affect this would have on their further evolution. This is exactly the causal schema this universe was to establish. However the presumption made by classical physics was that this schema had always existed. The examination of microscopic states, which provides a view backwards along the evolutionary timeline, showed that this was not the case. The evolution of macroscopic states was necessary for this schema to apply. Microscopic states behaved in a far less causally deterministic manner, which was eventually described by quantum mechanics. This shattered any clear understanding that physics was providing a direct description of nature. However in light of this cosmology this is not necessary. Both classical physics and quantum mechanics are providing a direct description of nature, it is just that it is a description of two distinct points along the evolutionary timeline. Where a causal gap can be closed in terms of the past spatial trajectory of the particles involved this is preferred, since it is the causal schema applicable to the current evolutionary epoch. However where the particle systems involved are not sufficiently evolved to allow a clear determination of spatial trajectory, nature simply falls back on the precedents established in earlier evolutionary epochs.

The second assumption made by classical physics is that the systems being examined are permanently existent. This is true for macroscopic states only because there are always sufficient microscopic components realised at any instant of time to satisfy the definition of the group state. However when dealing with individual elementary particles existence is only maintained for a brief instant of time after measurement. In these circumstances there can be no continuous spatial trajectory. Instead between measurements the elementary particle evolves according to its own internal clock, which physicists model as the unitary evolution of a waveform.

When there can be no clear determination of past spatial trajectory, nature must deal with several difficulties when resolving causal gaps. The first is the over-specification that results from there being no first cause. If we consider a causal gap to define a limited universe, this environment can be defined by any potentia whose waveform representation satisfies the boundary conditions. This leads to a superposition of possible definitions of this limited universe, all of which must be taken into account when determining its evolution. The second problem is the lack of constraint inherent in a system devoid of a first cause, which ensures that anything that can happen will. This has an affect when the evolution of a discrete state is being considered and is manifest in the spatial environment by the need to consider all possible paths between two spatial points. This again results in a superposition of possible paths that must all be taken into account when considering the evolution of the discrete state. Quantum mechanics describes how nature uses past evolutionary precedents to overcome these problems. The results of quantum mechanics are always given in terms of particles, because the waveforms represent the evolution of the states while the particles represent their realised expression.

While for a macroscopic state what is important in the resolution of a causal gap between two regions of space is its past spatial trajectory, it is never necessary to ask what the trajectory of an elementary particle was between two points, since this knowledge is unimportant in terms of the causal schema being applied to closing a causal gap involving it. For elementary particles all that is necessary is the final amplitude that determines the probability that the particle will be realised in the second spatial region. The macroscopic object causally justifies its presence at the second location because of its motion through space. The microscopic object causally justifies only the final amplitude for its realisation in the second location, which is done in terms of its evolution in time. Physicists must look at each situation only in terms of the causal schema being applied, without involving concepts applicable only to other causal schemas.

The space of this cosmology cannot be considered to be comprised of points that have an inherent association, but must be modelled in terms of individual causal gap that must be closed by some causal schema in order to establish their association. Classical physics models this process in terms of a causal schema based on the past spatial trajectory of particle systems. Here temporal evolution is expressed as motion through space. Quantum mechanics models the closure of causal gaps in terms of the internal temporal evolution of elementary particles, taking into account both over-specification and the lack of constrain in terms of spatial trajectory. Here the states evolution is expressed as motion through time, with its spatial motion expressed as a series of discontinuous realisations. Classical physics and quantum mechanics are not two incompatible schemas, but two necessary elements of any fundamental description of space and motion.

c. The Double-Slit Experiment

Thomas Young [398] conducted his famous double-slit experiment [650, 651] in 1801 and yet its interpretation is still the subject of hot debate [652] more than two hundred years later. Young passed a beam of light through two small, parallel slits in an opaque screen, revealing a pattern of alternating light and dark bands on a white screen set up behind the slits. Young's conclusion from this experiment was that light was composed of wave. In 1909 Geoffrey Taylor [653] showed that even the feeblest light source would produce interference fringes, suggesting that even a single photon passing through a double-slit would produce an interference effect. However the introduction of the concept of wave-particle duality and subsequent experiments using streams of electrons [654-656], neutrons [657] and even helium atoms [658] rather than light, reopened debate regarding the experiment's interpretation.

Let us consider the double slit experiment illustrated in Figure 5 below. Electrons emitted at S strike the detector at screen C, after passing screen B that has two small slits in it.

Figure 5

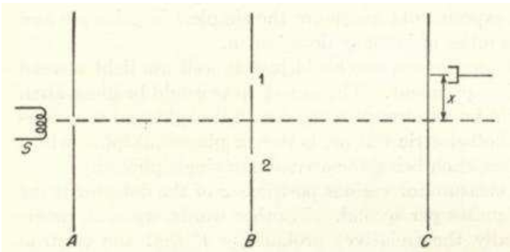

Figure 6

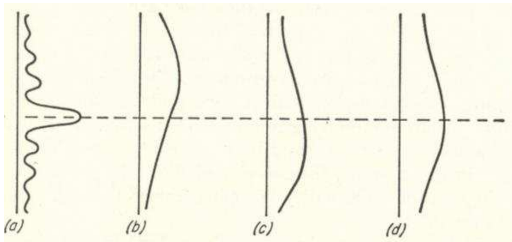

Fig. 5 [659] The double slit experiment with electrons emitted at S striking the detector at screen C, after passing screen B that has two slits. **Fig. 6** [660] The results of the experiment showing the probability of arrival at x plotted against the position x of the detector. (a) gives the results with both holes open while (b) and (c) give the results with just one hole open. If the electron simply passes through one hole or the other we would expect the curve for both holes being open to be (d) = (b) + (c). This is considerable different from the experimental result (a).

Figure 6 illustrates four sets of results showing the probability of arrival at *x* plotted against the position *x* of the detector. (a) is the experimental result with both slits open, while (b) and (c) are the experimental results with just one slit open. If P_1 is the probability of arriving at *x* with only hole 1 open and P_2 is the probability of arriving at *x* with only hole 2 open, then standard probability theory [231] would suggest that, if the electrons passed through one hole or the other [563]

$$P = P_1 + P_2 \qquad \textbf{E 18}$$

where P is the probability of arriving at *x* with both holes open as illustrated by Figure 6 (d). It is clear that the theoretical result 6(d) is substantially different from the experimental result 6(a) and therefore that the expression for P is incorrect. A comparison of 6(a) with the pattern that would be produced if waves passed from S through 1 and 2 to C does however give agreement. This occurs because waves allow for constructive and destructive interference since the amplitude of waves can take negative as well as positive values. The probability of each single event is however a nonnegative number [661]**.** Therefore the term *probability amplitude* is used in quantum mechanics for the complex numbers, ϕ_1 and ϕ_2, which are the most convenient way to represent the wave amplitudes. It is therefore an postulate of quantum mechanics that [563]

There are complex numbers ϕ_1 and ϕ_2 such that

$$P = |\phi|^2 \qquad \textbf{E 19}$$

$$\phi = \phi_1 + \phi_2 \qquad \textbf{E 20}$$

This expression allows for the interference of the waves, but does little to establish an intuitive picture of what is occurring when a slow stream of individual electrons is used in a double-slit experiment. While it is clear how a wave can pass through both slits and therefore provide an interference pattern on the final screen, it is less obvious how a single electron can be considered to pass through both slits at the same time and interfere with itself.

The situation is even stranger when with regard to the experiments conducted by Wootters and Zurek's [662] examined earlier[98], where a detector can be used to establish which hole the electron passes through. Without the detector in place there is an interference pattern. With the detector in place and switched on the interference pattern disappears. But with the detector in place and not switch on there is still a partial interference pattern, as if it is not only the actual detection of the path that removes the interference patter but the very potential for such a measurement to be performed, whether this actually occurs or not. According to the current interpretation of Bohr's concept of complementarity we would expect the interference pattern to disappear when path information is available, however as stated earlier, *clearly, mutual exclusion by degree is not what Bohr had in mind*. Such results lead Greenstein and Zajonc to conclude that, " *While valuing the principle* (Bohr's complementarity) *for the light it throws on the perversity of the quantum world, we do not agree with him that it resolves the unrest caused by modern experiments in quantum mechanics. Rather, we believe that the complementarity principle forcefully illustrates the scope of the dilemma they pose. If, as Einstein expressed it, Bohr hoped complementarity would prove a soft pillow to lull scientific thinking to sleep, Bohr failed. The challenges to thinking have only intensified and broadened* [13]*.*"

Let us now consider how the Flawed Nature Cosmology would interpret a double slit experiment using a slow beam of individual electrons, initially with no detectors to determine which slit an electron passes through. It must first be noted that the classical picture of a point particle in continuous motion through space simply does not apply, since the electron is only temporarily realised at each spatial location where a measurement is conducted. Therefore there is no consideration of the electron's trajectory before the two boundary conditions for the causal gap are established. Let us start by removing the screen with the double slit in it altogether. A causal gap is established between the last place the electron was realised, which we will take to be the source, and the next place where the electron can be detected, the final screen. While the electron is free to take any path between the source and the screen, the least action principle dictates that the preferred path will be the one that takes the least amount of time, that is, the straight-line or gravitational geodesic path. This establishes for the elementary particle a pseudo-spatial path. However, the electron has no true spatial path. It is realised at the source and it is realised at the screen, with the probability of being realised at a particular point on the screen, x, being determined by the amplitude of the waveform representation at this point. However in retrospect the final position of the electron is the same as it would have been if it had travelled along the pseudo-spatial path. This allows a result that is determined as if there had been an actual spatial path, in conformity with the preferred causal schema of epoch III. We have examined earlier[99] the concepts of retrocausality. In this cosmology retro-causality describes two situations. Firstly, that the evolution of the particle is only determined once the boundary conditions have

[98] Chapter One: 2. *Physics or Metaphysics?*

[99] Chapter Two: 10b. *Retrocausality in Physics.*

been established. Secondly, it applies to the final selection of the causal schema to be applied to the causal gap. An interference pattern indicates that the wavefunction causal schema has been used to establish the final distribution of the electrons. However, if the position of the electrons could be established as if there had been a determinable spatial trajectory between the two points, the past spatial trajectory causal schema is preferred, since it is the causality of the current evolutionary epoch and a ballistic type pattern is evidenced instead.

Now let us replace the slit screen with only one slit open. This affects the electrons reaching the screen but does not eliminate the pseudo-path, therefore a ballistic pattern will still be evidenced.

Now let us open both slits. This makes the path indeterminable and so the wavefunction causal schema must be used to close the causal gap. There is now no question as to which path the electron takes between the spatial locations where it is realised, since the past spatial trajectory causal schema is simply not being used.

Lastly, let us place a detector is the slits so that path information through the slits can be detected. The normal explanation given to explain why this removes the interference pattern is that the introduction of a second measurement device totally changes the experiment by ensuring that there are in fact two separate sets of boundary conditions. The first set of boundary conditions is the source and the detectors in the slits, and the second set of boundary conditions is the slits and the screen. Therefore the wavefunction describing the event is said to collapse at the slit detectors terminating one event, so that the progress from the slits to the screen is a second independent event. This cosmology is in agreement with this interpretation, since all events are defined by a single set of boundary conditions. The affect of this is that there is a determinable pseudo-path between the source and the slits, and a second determinable pseudo-path between the slits and the screen, so that a ballistic patter is evidenced at the screen.

However it is not so clear what is happening when the detectors at the slits are left in place but turned off. Now there is a partial interference patter, that is, some electron act as if the slit detectors were still functioning, while others act as if it were not present at all. But it must be remembered that in neither situation is an actual measurement taken that would cause the collapse of the wavefunction. What is happening? This cosmology would interpret the situation this way. The physical presence of the detectors allows a minute probability that detection might occur, for example a power surge coupled with a fault in the detector might cause it to be turned on without human intervention. But this in itself does not resolve the problem, since if we calculated this minute probability it would in no way be sufficient to explain the frequency of ballistic points on the screen. However nature places a sufficiently high weighting on the resolution of causal gaps that use the causal schema of the current evolutionary epoch, that this minute probability is magnified to the point where it provides the evidenced proportion of ballistic detections. What this cosmology is suggesting is that there is a weighting on the probability of specific outcomes occurring other than that provided by the least action principle, and that this weighting may be more significant than that provided by the least action principle.

d. Cramer's Enhanced Delayed-Choice Experiment

Earlier[100], when describing the delayed-choice experiment conducted by Wang *et al* [11], we summarised the experiment by quoting the analogy of Greenstein and Zajonc, " *In this case, first the final photon is emitted, and only later is the initial photon absorbed. No ball game we know of has the player throw the ball before catching it. If interpreted literally, the process represented by the second* (Feynman) *diagram says precisely this, and so does violence to our ideas of a well-running, causally ordered universe.*

" We might ask if we really need the perverse second quantum amplitude? The answer turns out to be a clear 'yes.' One can calculate the cross section for Compton scattering in two ways: first by using only the straightforward first Feynman diagram…, and second by using both. The result is that the two calculations differ from each other. Furthermore, experiment has clearly shown that the second calculation agrees with the data and the first does not. We conclude that the Feynman diagram…, in which the normal flow of time is scrambled, must be included in the analysis [13]*."* Wang, *et al* concluded that, *"…the state not only reflects what is known about the photon* (from an actual measurement) *but to some extent also what is knowable, in principle, under the given circumstances, whether it is actually known or not* [11]*."* The point that must be emphasised here is that the possibility of a photon being emitted before stimulation must be included in the quantum calculation, the sum of Feynman diagrams, rather than being an isolated observation. That this is necessary is not surprising given this cosmology, since as we have seen above two-directional time is introduced by the same boundary condition that makes a pre-asserted representation of the potentia possible. However the point of the composite wavefunction is to take account of all intermediate potentia in determining the uncertainty of realisation of any specific potential within the boundary conditions. The reversed time event must be taken into account, but it need not physically occur.

Does this mean that reversed temporal order events cannot be directly observed? Cramer [108] believes that they can be and has suggested a variant of the delayed-choice experiment to achieve this. His experiment combines double-slit effects with the use of entangled states, building on the work of Anton Zeilinger [663-665] and Birgit Dopfer [666]. In the experiment a beam of *entangled* photons would pass through a beam splitter and then each would pass through a double-slit. This, according to Cramer, would help isolate entangled pairs of photons. One beam of now entangled photons would then pass through a second double-slit. The double-slits will produce an interference pattern unless the photons path through one slit or another can be detected. Behind the second double-slit is a terminating detector that could also determine which slit the photon passes through, but this is moveable so that whether it is close enough to detect the path of the photons or not can be controlled by the experimenter. Using an entangled beam of photons is crucial since, *" Dopfer showed that measuring a photon as a wave or a particle forces its twin in the other beam to be measured in the same way* [108]*."* Cramer next suggests passing the photons that emerge from the second double-slit through several kilometres of coiled-up fibre-optic cable in order to delay by microseconds their arrival at the detector that can, if the experimenter moves it close enough, determine

[100] Chapter One: 2. *Physics or Metaphysics?*

which slit the photons passed through. The other beam, which passes through only one double-slit, terminates in a detector at a fixed location that can never determine the slit-path of the photons.

Because of the delay provided by the fibre-optic cable before the photons from the second double-slit arrive at the detector that can determined their path through the slits, the other entangled beam can arrive at the terminating detector before the experimenter chooses whether this detector is at a distance to remove the interference effect or not. As Barry explains, "*…since the rules of quantum mechanics are indifferent to the timing of measurements, the state of the other beam should correspond to how you choose to measure the delayed beam. The effect of your choice can be seen, in principle, before you have ever made it* [108]," and that, " *Cramer says that they could control the moveable detector so that it alternates between measuring wave-like and particle-like behaviour over time. They could compare that to the pattern that wasn't delayed and was recorded on a sensor from a digital camera. If this consistently shifts between an interference pattern and a smooth single-particle pattern a few microseconds before the respective choice is made on the delayed photons, that would support the concept of retrocausality. If not, it would be back to the drawing board* [108]."

Before we can analyse this experiment in the context of this cosmology we must first consider the nature of entangled quantum states [667]. Alain Aspect *et al* [668-670] demonstrated the phenomenon of entanglement, as Wilson explains, " *They created pairs of entangled photons in their Geneva laboratory. Each pair was then split so that one photon travelled north to the village of Bellevue while its companion travelled south to Bernex, a total distance of about 7 miles. The EMS team placed a signal analyzer at each end of the line. As a photon passed through an analyzer, it had a random chance of being counted. When the data from the two analyzers was later evaluated, there was compelling statistical evidence that a photon "knew" whether its entangled companion had been counted* [401]." The Aspect experiment shows, as Bell put it, that, " *The correlations of quantum mechanics are not explicable in terms of local cause* [177]," since a measurement performed on one entangle quantum state can affect the other over any distance. However Cramer's experiment would go further than this, since to achieve a delayed-choice a measurement performed on one entangle quantum state must affect the other retrospectively.

Nature is concerned with closing specific causal gaps defined by two boundary conditions, where a state was last realised and where its realisation will next be attempted. A new causal schema that is meant to establish this association is introduced with each new evolutionary epoch. However because the causal schema of this universe, past spatial trajectory, requires the evolution of macroscopic objects, the wavefunction schema of earlier epochs still applies to microscopic states. This intermingling of causal schemas is simply another aspect of general relativity's concept of a *block universe*, where the past, present and future all exist seamlessly, since in this cosmology each aspect of time is associated with its own causal schema. The causal schema for the epoch of this universe involves causes that are determined by a particle's past spatial trajectory. But, as we saw when considering epoch I[101], *nature is not only flawed in having imperfect initial conditions it can fail to achieve a desired outcome!* But because the second boundary condition must satisfy the definition of a measurement, that is, any physical circumstance that necessitates the

[101] Chapter Two: 19d. *Failure!*

realisation of a potentia at a specific spatial location and time, some result must nonetheless be realised whether the causal schema of epoch III can provide it or not. To achieve this nature simply reverts to the causal schema of the previous evolutionary epoch, that is, epoch II's use of the sum of the pre-asserted representations of all intermediate potentia to determine the flow of uncertainty of realisation of any specific potentia, what physicists model as quantum mechanics. Quantum physicists accept that the interference pattern will be lost if path information is available, without really being able to explain why. The answer given by this cosmology is that nature will give preference when resolving causal gaps to the causal schema of the current evolutionary epoch.

Let us consider Cramer's experiment as being built up in stages. In the first stage there is no fibre-optic cable. When the slit-path detector is at a distance so that it can give no slit-path information the boundary conditions for the events involving both beams are indistinguishable, the point at which the photons originally became entangled and a terminating detector. The physical environment for one beam is different because of the second double-slit but this does not induce any measurement. Independent of entanglement both beams would register interference patterns due to the presence of either one or two double-slits in their path. The final outcome is that both detectors will register an interference pattern.

When the movable terminating detector is positioned so that it can determine the path of the photons through the slits this capacity for measurement changes the boundary conditions for this event. Now for this beam the second boundary condition is the spatial region where the photon is detectable as being present in one slit's fibre-optic cable or the other, rather than the spatial location where the photon physically strikes the detector. There is a second event between the photon's realised location exiting the fibre-optic cable and the surface of the detector, but this introduces no new circumstances that can reintroduce interference effects. The first instance of wavefunction collapse will occur when the photons are detected exiting one fibre optic cable or the other. This will induce collapse in the other entangled beam so that its photons also assume realised locations at this time, although there is no detector to verify this. They too undergo a second event that cannot reintroduce interference so that no interference pattern is registered by the terminating detector. The final outcome is that both detectors will register a ballistic pattern rather than an interference pattern.

Next we add the fibre-optic cable. Now the two sets of outcomes from the terminating detectors are recorded at different times, t_i for the beam with no slit-path detector and for the beam with the slit-path detector $t_i + \varepsilon$, where ε is the time taken to travel through the fibre-optic cable. First the movable detector is placed at a distance where it can provide slit-path information after the time t_i when the other beam has reach its terminating detector. What Cramer is hoping for is that the terminating detector for the non-delayed beam will show a particle pattern even though the slit-path information from the second beams has not yet been detected. However the entanglement works both ways, with the entangled states being resolved by the first measurement that affects either beam. When the non-delayed beam strikes the terminating detector at time t_t, wavefunction collapse will be induced for the photons of the other beam that are still travelling inside the fibre-optic cable. When we considered Hellmuth, *et al*'s [10] delayed-choice experiment earlier[102], we concluded that: *The only choice nature ever experiences is whether or*

[102] Chapter Three: 28b. *Do overs and the Delayed-Choice Experiments.*

not a potentia is realised. Since the first event was abandoned before a measurement was attempted there can be no delayed-choice, no change of mind at all. The new event is a complete do over that need take no account of imagined locations of the photon that were not tested by its attempted realisation. But while with Hellmuth, *et al*'s [10] delayed-choice experiment the photons never had a realised location within the interferometer, with Cramer's they are realised effectively within the double-slit apparatus. In this cosmology there can be no do over of an event once realisation has been attempted. What has been determined by the entanglement with the non-delayed beam is when realisation must be attempted and what causal schema must be used. There is now an event bounded by the spatial location where the two beams became entangled and the spatial location along the fibre-optic cable that the photons would have reached at t_i, that is to be resolved using the wavefunction causal schema, including the constraints imposed by the fibre-optic cable itself. This last constraint would tend to limit the locations where the photons could be realised to within one cable or the other and therefore render the original interference pattern undetectable. However, it should be possible by locating the two fibre-optic cables so that one coincides with a probability maximum for the calculated wavefunction and the other coincides with a minimum, so that the higher incidence of photons realised in the cable coinciding with a maximum will demonstrate that this event was in fact resolved in terms of an interference pattern. At this point the entanglement between the two beams has been resolved. The photons will be detected as leaving one fibre-optic cable or another and the terminating detector will register a ballistic pattern. The final outcome is that the beam travelling through the fibre-optic cable will register a ballistic pattern, while the other beam will register an interference pattern.

However, even if we withdraw the movable slit-path detector to a position where it can provide no information, wavefunction collapse will still be induced within the fibre-optic cable, and even though this is in terms of an interference pattern, because the photons will assume a definite location, the terminating detector will still register a ballistic pattern. The final outcome will still be that the beam travelling through the fibre-optic cable will register a ballistic pattern, while the other beam will register an interference pattern.

This last outcome, if it were detected, would be very significant in terms of the debate as to when wavefunction collapse actually occurs. For the interference pattern to be removed it must have occurred before the terminating detector is triggered and therefore before the experimenter could observe it. In this cosmology measurements are finalised when nature must note them, not when human beings do. Nature's memory is affected each time a potentia is realised. In the evolutionary epoch of our current universe this occurs whenever the spatial location of an elementary particle is fixed. If a tree falls in the forest and there is no one there to listen, it will most definitely still make a sound because nature itself will hear it.

It may seem strange that by reference to a cosmology that states that *retrocausality, that is, the establishment of a cause only after the initial and final boundary conditions have been set, is inherently the way nature resolves events* and that allows for the possibility of do overs, does not predict that Cramer's experiment will produce a result that would indicate that a delayed-choice has occurred. In this cosmology the resolution of current events does affect the past, but not in as direct a way as this experiment seeks to demonstrate. The affect of present events on the past is not mediated, as Cramer suggests in his transactional interpretation of quantum mechanics, by particles *sending and receiving physical waves that travel forwards and backwards through time,* but by the need to assimilate the consequences of present events into nature's generalised memory, which always resides at $t = 0$. In this way the past is not dramatically affected by a single event but by the accumulated refinement of nature's constraints algorithm. There are determinable instances in this cosmology where we can see retrospective influences, but these are the rare instances when there is a transition to a new evolutionary epoch. This is not about changing the outcome of a single event, but changing the causal schema by which events are subsequently to be resolved. This cosmology's solution to the fine-tuning problem[103] does suggest that do overs within the same evolutionary epoch are introduced as an aspect of this universe, but these are evidenced by processes such as the decay of the neutron[104] rather than single instances of retro-causality.

e. The Schrödinger's Cat Paradox

Our understanding of the nature of space and motion is inseparable from our understanding of quantum mechanics, particularly with regard to the establishment of measurement events and the subsequent resolution of superpositions. The most widely known example of a superposition is that involving Schrödinger's imaginary cat, which was introduced by Schrödinger in 1935 through one short paragraph in a sixteen-page paper [671], that after translation reads, " *One can even set up quite ridiculous cases. A cat is penned up in a steel chamber, along with the following diabolical device (which must be secured against direct interference by the cat): in a Geiger counter there is a tiny bit of radioactive substance, so small that* ***perhaps*** *in the course of one hour one of the atoms decays, but also, with equal probability, perhaps none; if it happens the (Geiger) counter tube discharges and through a relay releases a hammer which shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives* ***if*** *meanwhile no atom has decayed. The first atomic decay would have poisoned it. The ψ-function of the entire system would express this by having in it the living and the dead cat (pardon the expression) mixed or smeared out in equal parts* [672]*."* Instead of becoming lost as one obscure paragraph in a old scientific journal, the plight of Schrödinger's cat and its implications for our perception of reality is so well recognized by the general public that new debate and developments concerning it are not only published in scientific journals [673, 674] but reviewed in popular science magazines [675, 676], popular science books [212] and newspaper articles [677, 678].

Most physicists today would accept that Schrödinger's cat will remain in a superposition of *cat alive OR cat dead* until someone opens the box and observes it, since this best fits the model of quantum mechanics whereby reality is determined only upon measurement. In this situation then it is the box that keeps the cat isolated from observation thereby maintaining the superposition. This cosmology, since it deals more than anything else with the nature of time, would interpret this situation in temporal terms. There is no universal time, each potentia can define the entire initial state and therefore possesses its own unique timeline. Superpositions involving a single state such as Schrödinger's cat are just a specific configuration of this discrete timeline, or self-definition path. The illusion that there is a universal time is maintained by interactions, instances where two or more states are apparently involved in the same event at the same time. But such events do not involve a universal time but simple the intersection of the timelines of two or more discrete

[103] Chapter Three: 29. *The Anthropic principle and this Cosmology*.
[104] Chapter Four: 50d. *The Decay of the Neutron and the Stability of the Proton*.

states. Therefore when the box is opened the timelines of the observer and Schrödinger's cat intersect.

We have already dealt with measurement as it applied in epoch I, stating that *if an observer is required for the measurement process to occur and if real objects only come into existence through measurement, then the observer must exist before there is existence. Applied to cosmology, the interpretation of measurement whereby an observer is required means that physics necessitates the existence of God, both to define an initial state wavefunction and to conduct a measurement using it*. But this was not the case. Potentia are defined by the property that they must be realised at some point along the evolutionary timeline. This point need not be determined by a measurement conducted by a conscious observer, but merely requires the intersection of the timelines of two states. The superposition is maintained either by isolating its aspects in time, *x then* ¬*x*, or is space, *x space* ¬*x*. However an observer, whether conscious or not, can potentially perceive both aspects of these superpositions. However two realisations of the same potentia are not possible, so that in the timeline of the observer the superposition must be reduced to a single value. However the value to be taken into the observer's timeline is further influenced by how the observer is itself defined. Quantum mechanics is already modelled this way, using different measurement operators to represent the different perspectives established by various measurement equipment, so that for example a momentum operator will only resolve a superposition in terms of momentum, the parameter by which its timeline is defined, while a position operator applied to the same superposition will only resolve it in terms of position.

Let us re-conceptualise the Schrödinger's cat paradox in terms of this cosmology so that we can examine the process of observation in more detail. The superposition arises because there is no constraint to prevent the assertion of a potentia but insufficient cause to determine the final value of all of its properties. The superposition awaits the provision of additional causal resolution by some future events. In Schrödinger's paradox the superposition is *cat alive OR cat dead* and we shall associate the *radioactive substance*, *hammer* and *small flask of hydrocyanic acid* with an original cause that was not sufficient to resolve this superposition, while the box itself is the cat's independent timeline. Note that this situation must be slightly different to the one Schrödinger posed since we are not considering whether in one hour the radioactive substance decayed, where there is a definite probability for decaying or not decaying, but a situation where the event defined by the radioactive substance, hammer and flask of hydrocyanic acid is insufficient over any amount of time to provide a causal resolution of the *cat alive OR cat dead* superposition. Now with this more cosmologically significant scenario we can examine not just one but two types of observation.

The first type of observation is one in which the observer contributes additional factors to the causal resolution of the superposition. Such an observer need not be a human being but may be some additional radioactive substance that ensures that decay will happen and thereby causally resolves the superposition to *cat dead*. This is what nature has sought, a causal event that is more complex than was initially possible for an isolated system, which is introduced by interactions between states. In this cause the value of the superposition assumed by the cat's timeline and the observer's have been resolved to be the same by an enhanced and shared causal event.

The second type of observation is one in which the observer does not contribute additional factors to the causal resolution of the superposition. This is the case when a human being simply lifts the lid and looks inside, since this does not directly affect whether the radioactive substance will decay or not. However the human observer must nonetheless assimilate only a single value of the *cat alive OR cat dead* superposition into their personal timeline, without the guidance of a clear cause for selecting one alternative over the other. In terms of the evolutionary history this is a quite remarkable situation. People generally consider consciousness to be the pinnacle of evolution, its most recent achievement made possible by the complex biology of this planet. However its cosmological basis belongs to a far more sparse environment where there was no complex physical system to provide an enhanced cause, only the intersection of independent timelines that demanded the resolution of superpositions independent of the provision of addition or sufficient causal justification. The intervention of a conscious observer, if they do not make a deliberate choice of preferred outcome, is not the most advanced method for resolving superpositions it is the most primitive. The physical interactions of this universe that provide an enhanced causal basis for resolution are more advanced. The foundations for consciousness are laid down where there is not sufficient physical complexity to provide a causal resolution, instead the observer does not resolve the superposition itself but simple assumes one value of it as its experience of the interaction. Experience is not to remember what did happen as determined independently by causal circumstances, instead it is a false memory not supported by the actual resolution of the superposition but only by the constraint that only one value of it be assimilated into the observer's timeline. In this case the *cat alive OR cat dead* superposition is not resolved for the cat only for the observer. It is not that the conscious observer creates reality, but that the alternative to the establishment of reality in terms of the actual resolution of the superposition is for the superposition not to be resolved but rather to simply be experienced. The resolution of whether Schrödinger's cat is alive or dead ultimately is an observation that need only be true for that observer. It can be the case that in one observer's timeline the cat is dead but in another's it is alive. There is indeed a subjective element to reality imposed by the nature of measurement.

A physicist can construct an experiment that provides an enhancement to the causal resolution of the situation to be observed. In this case there is a real collapse of the wavefunction and the reality for the observed superposition and the observer is the same. However a physicist might observe a situation without adding to its causal resolution, in which case the 'truth' they assimilated into their personal timeline does not need to be reflected in the superposition itself, so that another observer might honestly testify to a totally different 'truth.'

Whether Schrödinger's cat is alive or dead does not only depend of whether the box is opened, but also on how the observation is made. If two different observes add nothing to the causal resolution within the box, one might state that the cat was dead, while the other states that the cat alive, with the cat itself remaining in the *cat alive OR cat dead* superposition. This is the ultimate non-interference measurement. Where the physical circumstances of an observation do not provide additional causal resolution for a superposition, a conscious observer can still experience a single value of it in terms of a false memory, that is, the superposition resolves for the observer but not for the observed state. Therefore there are instances, just as von Neumann [270], London and Bauer [194] suggested, where measurements are only complete when they are resolved by a conscious observer. But now we can understand this in broad cosmological terms, rather than wondering why the products of random biological evolution, which have only existed for a heartbeat in terms of the age of the universe, should hold such a privileged position in nature. Physical structures still evolve towards the establishment of causal determinacy, since nature retains its original intent to overcome the flaw that there was no first cause, however physical systems must be given time to evolve before this can be achieved. However to simply experience events as a means of self-development is part of the duality of intent that arose just before the establishment of this universe. It is this role that the conscious observer fulfils, independent of the actual resolution of the superposition observed. However, it is interesting to note that the conscious observer is more important to the primitive environment described by quantum mechanics than the more evolved and causally deterministic macroscopic environment described by classical physics. This indicates that it is more important for consciousness to exist near the beginning of this universe's evolution than it is for it to exist now.

f. Concluding Comments on The Flawed Nature Cosmology and the Definition of Space and Motion

Minkowski space defines points by ideal interactions and presumes that these points form the elements of a coordinate system for a unified spatial environment. By contrast this cosmology asserts that spatial points are not automatically associated, but that this must be achieved through them being part of the timeline of a single particle or through forces that use the precedent of *ac*-events. This is a spacetime that must be dealt with in terms of individual causal gaps between two points in space. Such causal gaps are closed by one of two causal schemas, the past spatial trajectory of macroscopic states or the wavefunction evolution of microscopic states. In this context classical physics and quantum mechanics both have a role to play in defining at a fundamental level the model of space and motion that physicists must use, since both apply to the same environment of causal gaps.

58. Concluding Comments on Chapter Four

At the beginning of this chapter[105] it was stated that what shall be emphasise in our description of the origin of the universe are the ways in which the pre-big bang evolution we have been considering affects the final structure of the universe and therefore allows us to understand it. What is sought is for the reader to be able to look out their window and say: *Yes, it's all starting to make sense*. In this chapter we have seen that this pre-big bang evolution allows us to address issues that previously could not be dealt with at all, such as the origin of the particle that make up this universe and the origin of the forces of nature. Not everything proposed in these sections will prove in the long run to be correct, however what is important at this stage is that this dissertation provides a consistent cosmological basis and a starting point for future research, which simply did not exist before the consideration of this cosmology. This includes providing a basis for understanding how all the particles of this universe could be derived from a common minimum entity and why much of the action of the forces is based on the temporary existence of virtual bosons. The fundamental nature of this universe does not as Feynman [2] suggested lie beyond our comprehension, but can be made to make sense through a more detailed consideration of fundamental questions in cosmology.

[105] Chapter Four: 45. *How to Describe the Origin of the Universe?*

Chapter Five:

Conclusions -

A New Conceptualisation of Nature

“ *In physics, you don’t have to go around making trouble for yourself – nature does it for you* [679]*.”*

59. Introduction

In this chapter we shall finalise and summarise the conclusions that can be drawn from the above consideration.

60. A Final Statement on the Many Universe Theories in Physics

We stated earlier[106] that *the various quantum cosmologies because of their reliance on spontaneous events as a pseudo-first cause share a common feature, the prediction that our universe is just one of an infinite number of other inaccessible, parallel universes.* But apart from the quantum cosmologies there are three other reasons many universes models have entered our current conceptualisation of physics. Firstly, there is Everett's [201, 202] many-worlds interpretation of quantum mechanics in which all the elements of a superposition are realised upon measurement, either in our universe or by the spontaneous creation of another. *In this scenario even the simple tossing of a coin, since all outcomes must actually occur, would result in the establishment of a new parallel universe*. Secondly, because it is necessary to express string theory in greater than the normal four spacetime dimensions of general relativity, it was possible for string theory's cosmological extension, brane theory, to postulate that these extra dimensions are occupied by additional parallel universes. Thirdly, there is the fine-tuning problem, whereby the fundamental constants of nature must be very finely tuned in order to make possible the development of life. The existence of many parallel universes is suggested as a solution to this problem so that no matter how low the probability is of the fundamental constants all taking appropriate values so that life can develop, there are sufficient universes available so that one with these values must exist. But no matter how the concept of parallel universes enters our model of physics *there is a high price to be paid for this result – if our universe is merely one of an infinite ensemble then physics is reduced to the examination of an infinitesimally small fraction of the totality of nature that despite our self-interest, since it is the universe we inhabit, may be totally insignificant. The laws of physics that we have spent centuries unravelling may be repeated nowhere else and have no deeper basis than – 'Why not?'*

The Flawed Nature Cosmology of this dissertation demonstrates that there are alternatives to utilising spontaneous events as a pseudo-first cause for cosmological models and therefore that the prediction that there needs to be many universes is not necessitated by all fundamental cosmologies.

As for Everett's many universes interpretation of quantum mechanics, *while human imagination can conceive a scenario where quantum measurement instantaneously creates as many parallel universes as there are unrealised outcomes of the event, nature does not have the capacity to achieve this* and is therefore *forced to take a far simpler approach to satisfying the guarantee that all potentia will at some point be realised, the very approach that has been evidenced in every experiment ever conducted – one outcome is realised when a measurement is done and another when an indistinguishable system is measured at some future time*.

With regard to the parallel universe postulated by brane cosmology to exist in the extra dimensions of string theory, it is necessary to make a judgement whether string theory itself is required in light of this cosmology. If we consider string theory to be fundamentally an avoidance theory that postulates a spatially extended

[106] Chapter One: 6. *A Brief Review of Quantum Cosmologies and the Problem of Defining the Initial State and First Cause*.

minimum entity to avoid dealing with elementary particles as spatial points, then we can simply note that all such avoidance theories are eventually overtaken by the resolution of the original problem. In this case the resolution provided by this cosmology is: *We can see inside point states and have a comprehension of their internal structure in terms of our understanding of their evolutionary history, quite independent of them being extensible objects in space*. In these terms it is not the point particles that we cannot see inside but the strings, since these were postulated fully developed into a pre-existing spacetime without any cosmological basis or evolutionary history. If string theory is thought of as a way to more fundamentally model the elementary particles, then we would note that the minimum entity of this cosmology also provides a common basis for all elementary particles and that this goes beyond simply postulating a smaller constituent of matter but instead establishes the origin of matter in a fundamental way. This cosmology also allows a comprehension of the quantum nature of the elementary particles, something not possible for string theory since despite their strange properties strings are fundamentally classical objects that possess intrinsic properties. It is not a matter of determining whether string theory is correct or incorrect, it has been refined and developed for more than thirty-five years by innumerable researchers and yet can still make no testable prediction that could provide any empirical evidence that strings actually exist. There is in evolutionary terms no cause to justify the existence of strings, their cause is some physicists' dislike of describing the universe in terms of point particles. This stringy universe is not the one nature created, but the one some would prefer to create. Nature's universe originated with no physicist to play god, with no cause at all, and remains as a consequence of this unresolved to this day. This is what our physics teaches us; this is what quantum mechanics describes, the universe of this cosmology, both over specified and causally unresolved. To say that nature has this overall character, but that its minimum entities are resolved states is, in our opinion, incorrect. Therefore in terms of this cosmology we simply find string theory unnecessary. It is long past time to seek another approach to the problems it was postulated to address.

As for the fine-tuning problem this cosmology proposes a solution based on the concept of do overs. *No chimpanzee randomly striking typewriter keys has had enough time to come up with a Shakespeare play, but perhaps a poor playwright given even a finite number of revisions could. Evolution is not about a headlong progression into the future, it is about learning and refinement. Note that this is not an argument for design, since while it is true that refinement is directed by the need to overcome flaws, as we have seen, this involves a process of trial and error rather than the pre-existence of a flawless plan*.

Not only are there alternatives to each of the problems that introduced the concept of many inaccessible parallel universes into the current model of physics, they all arise naturally from the same conceptualisation of nature's evolution.

a. The Orbital Environment and Many Universes

None of the usual reasons for proposing that nature must include many parallel universes is included in this cosmology, however there is little in human imagination that does not possess some measure of truth. The realisation of all potential in separate parallel universes is the solution to over-specification that nature is proposing with the establishment of epoch II. Each orbital is the pre-asserted representation of a potentia capable of defining the entire initial state, or in this composite environment its own parallel universe, albeit a rather structurally sparse one. No first cause is required if there is no need for choice, but instead the realisation of all alternatives each within its own parallel universe.

The difference between physicists' perception of the many universes scenario and the reality of it is that these orbital universes proved not to be completely isolated. Nature wanted isolation to be maintained, and because of the failure to realise intermediate states in epoch I had every reason to believe that this would be the case, however the more complex environment of epoch II did allow intermediate states to be realised. This instigated a causal sequence whereby upper orbitals were proven to be equivalent to lower ones and the many universes collapsed into one. However, if no intermediate potentia had been realised this many universes scenario would have been nature's final definition. There was no pre-determination that this scenario was inherently unacceptable, it is just that this approach to resolving nature's flaws failed since this environment could not be maintained.

b. Concluding Comments on A Final Statement on the Many Universe Theories in Physics

Epoch II is nature's attempt at a many universes solution to the flaw of over-specification. However it did not succeed with the independent timelines of the orbitals collapsing to one ground state orbital. Nature had to move on to other possible solutions to its flaws, the very ones we evidence within this universe. Ultimately nature seeks, through the interaction of multiple states, to establish a more complex physical environment that can enhance the capacity to provide a causal resolution of superpositions. But even before this ideal is realised, over-specification can be satisfied by this universe's capacity to repeat indistinguishable events so that one possible outcome is evidenced when an event occurs and another the next time an indistinguishable event happens, in this way giving all elements of the superposition physical realisation. This can happen even in the absence of sufficient causal determinacy to resolve the superposition itself, because an observer can take from the interaction a false memory as their experience of it. What we experience in the current evolutionary epoch of this universe are these approaches to resolving over-specification, not the many universes solution that was tried and failed in epoch II.

61. A Summary of the Dissertation's Conclusions

Let us briefly summarise what has been achieved by this dissertation. It was undertaken as a preliminary reconsideration of fundamental problems in cosmology with the intent of introducing some new ideas that could reinvigorate debate. That a specific model has been offered in the form of the Flawed Nature Cosmology goes somewhat further by providing a starting point for research, where in most cases none was previously available. The specific solutions offered in this dissertation need not in the long run prove to be the correct answers; they need only allow the reestablishment of research into issues long placed in the *'Too hard'* basket.

a. The First Cause

The most significant achievement of this dissertation is to demonstrate that there can be a solution to the Tower of Turtles problem that does not trivialise the definition of the first cause by making it a spontaneous event, which must result in an infinite number of parallel universes. This is the most fundamental question in cosmology and one of the oldest in human experience. If the remainder of the thesis only served to demonstrate that this solution to the first cause problem was potentially relevant to physics, we would be satisfied that this dissertation had made a significant contribution to cosmology.

b. The Initial Conditions

The problem with defining the initial conditions for any cosmology can best be summarised by Saint Augustine, " *How did it occur to God to create something, when he had never created anything before?* [60]" The presumption in this statement, as with all cosmologies that start with a homogenous initial state that must then be perturbed, is that there is first an acceptable initial state, to which some motivation must be applied for it to become something totally different. Instead this cosmology presents a flawed set of initial conditions and the concept that evolution is motivated by the need to overcome these flaws. In this way the first cause is neither a wilful act nor a spontaneous event, but simply a response to the fact that the initial conditions are flawed. This reveals an evolution that is purposeful without being predetermined. This expands the very domain of physics to be able to ask *why* a particular aspect of nature evolved as it did, since such flaws are a determinable part of the physical makeup of the system, as open to empirical examination as any other aspect of it.

c. Time

Cosmologies to date have had to introduce time as an additional initial postulate, but this places the origin and fundamental nature of time forever beyond the reach of empirical physics. By contrast this cosmology deals directly with the origin of time, as well as introducing the new concept that this nature is not fixed at its inception but evolves. The origin of the three levels of time, future, present and past, are dealt with as causal schemas on which successive evolutionary epochs are based. This leads to a cosmological justification of general relativity's concept of a *block universe,* where the past, present and future all exist seamlessly.

d. Mathematics

The cosmology of this dissertation is only presented as an initial consideration with no formal mathematical model presented, instead we have dealt with Wigner's dilemma regarding "*…the unreasonable effectiveness of mathematics* [49]," by providing a cosmological basis for the association between abstract mathematical concepts and a direct description of nature. This consideration also demonstrates the limitations of this association for a flawed nature and concludes that this will necessitate the development of a mathematics of physics that is distinct from pure mathematics.

e. Quantum Mechanics

There are a number of cosmologies that take as their first cause quantum phenomena such as tunnelling [75-77], vacuum pair productions [79] or fluctuations in an initial state wavefunction [78]. However such cosmologies must simply accept all of the postulates of quantum mechanics as part of their initial conditions. This introduces three problems. Firstly, that if we are simply to presume that the structures and interactions that we experience in the current universe also exist at the very beginning of the evolutionary timeline, physicists can only construct cosmologies that include no true evolution at all. Secondly, such spontaneous pseudo-first causes must result in cosmologies that predict the existence of an infinite number of inaccessible parallel universes as well as our own. Thirdly, a cosmology that simply incorporates all of the postulates of quantum mechanics into its initial conditions can provide no greater understanding of the basis for these postulates, or their relationship with a direct description of nature. By contrast the cosmology of this dissertation assumes none of the quantum postulates, but instead is able to demonstrate that the fundamental attribute of quantum mechanics, such as the wavefunction and its relationship to probabilities, as well as the basis for the wave-particle duality, can be derived from a description of nature's evolution. This provides a clear resolution of the quantum reality problem, by demonstrating that quantum mechanics can be considered to be a direct description of nature as revealed by this cosmology.

f. The Big Bang

The initial conditions for the big bang are inherently complex, a situation that leaves any model of it prone to the inclusion of too great a number of founding postulates. By contrast this cosmology traces nature's evolution through two pre-big bang epochs and is therefore able to derive the big bang initial conditions from a model of nature's evolution rather than simply postulating them. In this way this cosmology is able to suggest new approaches to several outstanding problems including how to model through the big bang singularity; providing a new basis for inflation as well as an explanation for why inflation terminates; providing a new solution to the missing anti-matter problem and providing a basis in this cosmology for the accelerated expansion of the universe. Other researchers have addressed all of these problems separately, but no other cosmology reviewed offers a solution to all of them within a single consistent context.

g. The Origin of Matter

The current big bang model makes no attempt to address what should be one of the most fundamental questions in cosmology: *Where does the matter that is the substance of this universe come from?* Instead the big bang model simply postulates the existence of the fundamental constituents of matter and simply models variations in their location and configuration. This leaves particle physics in a state where Weinberg, commenting on the complexity of the current elementary particle zoo, stated that, " *I think just looking at this picture superficially one would have to conclude that we have not come very far towards a simple view of nature, and therefore that we are not very close to a fundamental understanding of nature* [680]." Veltman pointed out of elementary particle physics, " *One can compute many things in great detail, but it is often extremely difficult to 'understand' these same things in any detail* [64]." This dissertation's concern with regard to particle physics is not with calculation but understanding. While ever physics continues to simply categorise the elementary particles rather than attempt to understand their common origan this must be the case. By contrast this cosmology introduced in its consideration of nature's pre-big bang evolution a new minimum entity, the potentia, and models its evolution from the initial state to the beginning of the big bang. It is suggested that all the various types of fermions can be modelled as variant representations of this minimum entity given different physical circumstances. Included in this consideration is a derivation of the origin and nature of dark matter and its relationship to dark energy. In this way instead of the big bang model only being able to describe the evolution of 4% of the universe's energy density, it is extended to address the entire composition of this universe. What is presented in this dissertation is only a broad sketch of how to approach defining the origin of the various elementary particles and baryons, however

h. The Origin of the Forces

The origin of the forces of nature is another question that should be fundamental to cosmology, but is instead not addressed at all. However what this cosmology proposes is quite simple - since the present universe is the cumulative consequence of the entirety of the evolutionary process, current aspects of it can be explained by their maintenance of previous evolutionary precedents. Therefore this dissertation demonstrates that the electroweak and aspects of the strong force can be mapped to the same evolutionary precedent as applied to different environments. This provides a more fundamental basis for their association than is the case for other Grand Unification Theories. However this dissertation also demonstrates that there is a limit to unification in that the gravitational force, and in all likelihood some aspects of the strong force, do not map to the same precedent. This consideration also gives a basis in this cosmology for the origin of the bosons, also in terms of the potentia, thereby completing this dissertation's consideration of the origin of the matter of the universe. The consideration of the origin of the forces is again a situation where there is more work to be done, but where there is current no approach to addressing this issue.

i. Virtual Pairs

While what is presented in this dissertation is only a preliminary consideration of the origin of the particles, no other cosmology reviewed offers any such explanation, instead either postulating their existence outright or accepting as an adequate explanation for their origin Roos' statement that, " *It is a property of the* vacuum *that particle-antiparticle pairs such as* e^+ *and* e^- *are continuously created out of nothing, to disappear in the next moment by* annihilation *which is the inverse process.* [550]." This cosmology instead includes a definition of the origin of virtual particles that is associated with, but not the basis for, the origin of real particles.

In this dissertation all the particles are derived from the same minimum entity and therefore both their common properties and differences can be understood in a fundamental way, which exceeds simply categorise them as members of a particle zoo.

j. Consciousness

This dissertation takes heed of Penrose's advice that, " *A scientific world-view which does not profoundly come to terms with the problem of conscious mind can* *have no serious pretensions of completeness. Consciousness is part of our universe, so a physical theory which makes no proper place for it falls fundamentally short of providing a genuine description of the world* [269]*."* While such research is still in its infancy, this dissertation has sought to show that the same cosmological model that addresses fundamental issues regarding the physical make up of this universe, can also provide a basis for further research into the fundamental nature of consciousness.

k. The Capacity for Experimental Verification

We pointed out earlier[107] that cosmology currently faces a crisis that is *not caused by the diversity, or even the absurdity, of the ideas introduced, but by the inability to conceive any means for experimental scrutiny*. This situation arises because it has been assumed that in order to verify a cosmological model physicists must look into the past either by examining distant galaxies or the cosmic background radiation. But at best this data tells us the state of the universe 300,000 years after the big bang when photons decoupled from matter. The other approach is to try and recreate in miniature within accelerators some of the conditions of the big bang. However this assumes that the condition for the big bang in terms of the nature of space and matter were the same as they are now, something that this cosmology would bring into question. At any rate, both approaches to verifying cosmological models are both time-consuming and extremely expensive. Even worse, cosmologies such as brane theory [36-38] that have their most crucial elements hidden in inaccessible extra-dimensions, and those that have as their first event tunnelling from an inaccessible superspace [75-77], can never be empirically verified in any real sense. While humanity's most basic assumption about nature, that it is perfect, is overturned by the Flawed Nature Cosmology's redefinition of the initial conditions and first cause, what is provided in its place is a cosmology where nothing of the initial conditions is lost to the distant past or inaccessible extra dimensions. Instead every aspect of this cosmology remains evidenced, since the present universe is the cumulative consequence of the entirety of the evolutionary process and therefore current aspects of it can be explained by their maintenance of previous evolutionary precedents. It is this aspect of the cosmology that makes it more open to empirical scrutiny than any other. This dissertation has provided sufficient such connection so that as the cosmology is developed methods for seeking experimental verification from a wide variety of phenomena might be sought. The experimental evidence needed to give credence to or falsify this cosmological model exists not only within the physical universe and the current time, but within a wide variety of terrestrially accessible phenomena. This will tremendously reduce the cost and time involved in verifying the cosmology, as well as give a greater variety of predictions that can be tested. The formalisation of the cosmology may take a little time, but we should note that with regard to string theory Peat commented that, *" …there is little possibility of superstring theory making direct contact with experiment within our lifetime* [7]*,"* even after more than thirty-five years of development. Instead, with respect to the Flawed Nature Cosmology, this dissertation seeks to satisfy Popper's criterion for its acceptance as a theory in physics, in this way making a contribution to progressing cosmology beyond the infancy of wild speculation, to the maturity of a fully empirical science.

[107] Chapter One: 2. *Physics or Metaphysics?*

l. A Re-conceptualisation of Nature and its Evolution

It was stated earlier[108] that *apart from new concepts we hope will reinvigorate the debate on cosmology and lead it to address more fundamental issues, the most significant immediate benefit this dissertation offers is a totally new conceptualisation of nature and its evolution consistent with all that has been learned since the introduction of quantum mechanics. It has been more than one hundred years since Planck, on 19th October, 1900, presented his results implying the quantisation of energy [3], an event which is taken as the birth of quantum mechanics. It is long past time for physics to once again be able to claim that it provides humanity's best direct description of nature and thereby encapsulates a general comprehension of " …what the hell is going on* [65]*!"* This dissertation demonstrates that there can be a conceptualisation of nature and its evolution that leads only to the universe of our experience and that therefore its seemingly bizarre behaviour can be put into a cosmological context within which it makes sense. This includes the probabilistic nature of quantum mechanics, which can be seen ultimately as the natural consequence of an initial state devoid of a first cause. What this dissertation offers therefore is a way for physics, after a one hundred year gap, to say once more that it is providing humanity's best direct description of nature.

m. Concluding Comments on A Summary of the Dissertation's Conclusions

In this dissertation we have emphasised understanding rather than formalisation. Now, after examining a wide range of topics the advantage of this should be clear, it allows a broader assessment of the subjects that can be addressed within the discipline of physics. Subjects such as the fundamental nature of time or the origin of consciousness have previously been considered unassailable by physics, however this consideration clearly indicates that this need not be the case.

The broad understanding introduced by this consideration can also act as a constraint on human aspirations, such as that to unify all forces into one *Grand Unified Theory*. It also provides insight that can allow us to understand that attempting to apply successful models, like that for the electro-weak force, to other problems, such as the strong force, may not be entirely appropriate. The broad understanding offered by this preliminary consideration of the Flawed Nature Cosmology provides potential benefits to a greater variety of disciplines within physics than any other cosmology reviewed. Its further development can only serve to enhance these potential benefits, since as the model gains credibility it can be relied on more and more to provide broad guidance to the direction of research in many areas of physics. Without this too much time can be wasted, as we believe has been the case with string theory, with overall schemas that do not reflect nature's true character.

What is obvious from this summation is that this dissertation has introduced a great many new concepts that require further development. But what must be understood is that without first presenting the overall framework for the Flawed Nature Cosmology the development of specific recommendations cannot proceed. This is the function of this dissertation, to demonstrate that there is a consistent conceptualisation of nature and its evolution that can suggest resolutions to a great

[108] Chapter Two: 9. *Introduction – Time and Cosmology.*

many outstanding problems in physics. This preliminary consideration and presentation of the overall concepts involved in the Flawed Nature Cosmology already represents the maximum volume of material allowable in a dissertation. The further development of specific recommendations was always meant to be the subject of post-doctoral research.

62. Is the Flawed Nature Cosmology Correct?

In attempting to demonstrate how this cosmology could be applied to a wide variety of outstanding problems, given the limited time available, we could not aspire to be correct, instead what we have attempted to achieve is to be worth correcting. It was said of the brilliant mathematician and physicist Julian Schwinger, " *Other people publish to show you how to do it, but Julian Schwinger publishes to show you that only he can do it* [681]." We are not so arrogant instead *we do not seek to solve all problems, only to see all problems solved*. *What is sought, either by your agreement with the proposals outlined in this dissertation or by your disagreement with them, is to remove these issues from the 'Too hard' basket and place them in the 'Work in progress' basket, where they can again be addressed by the entire scientific community*. In short, dear reader, you!

Science is in the end like a horse race, a theory need not be perfect to be worthy of further consideration it need simply be better than other theories involved in the same race. We submit that there can be little doubt that the Flawed Nature Cosmology outlined here shows more promise than any of the quantum cosmologies reviewed or string theory's brane cosmology. The prize for victory in this race is not the title 'correct' but recognition that the further development of the theory is worthwhile. In the context of this initial consideration this is enough. Further work needs to be done, but at least it is clear what might be achieved by this effort. It should be remembered that for nearly a decade after the initial ideas for quantum electrodynamics were introduced physicists such as Victor Weisskopf [570] considered it to be too crazy and ugly to be worth working on. However QED is currently the most successful theory in all of physics. Nothing of value is ever achieved without the investment of time and effort, but this cannot commence before the initial *crazy and ugly* ideas are put forward.

The alternative to the extensive consideration of problems undertaken in this dissertation is the far too often used process of resolving difficulties by using all encompassing postulates. This avoids the problem of actually having to understand what is happening and can allow you to proceed straight to doing calculations based on these postulates, but in our opinion this process bypasses the whole reason for doing physics in the first place, which was not to create new technologies but to come to a fundamental understanding of nature and our place within it. Better nonsense that can be corrected than all encompassing postulates that can never be questioned.

The narrative style of this dissertation has allowed us to cover an enormous range of subjects in a relatively short time. This was essential since none of the specific research recommendations made in this dissertation can be implemented without a comprehension of the overall schema. But there is a cost for this style of presentation, a narrative cannot have a gap between one section that is well understood and another, but must be continuous even where comprehension is not.

However we stated at the very beginning of this dissertation[109] that *an elaborate consideration is often necessary for the development of new ideas, even if in consequence of this only key concepts are retained*. Einstein reflected that, *" One thing I have learned in a long life: that all science, measured against reality, is primitive and childlike – and yet it is the most precious thing we have* [215]*."* This presentation is indeed *primitive and childlike,* but we make no apology for this, since we are at the commencement of the journey towards a greater understanding of nature, not at its end.

On the first page of the working notebooks for this dissertation is always written the phrase: *Trying to cram abstract concepts into a defined language, how absurd* and on the last page: *Knowledge - an instrument for the forming of more involved questions*. Everything presented here falls somewhere between the absurd and the incomplete. All that can be hoped for is an audience that recognises that even within these narrow constraints can be found a greater fundamental understanding of *"…what the hell is going on…* [65]*"* than humanity has ever previously possessed.

63. The Ultimate Significance of Cosmology

Humans are perverse creatures unwilling to keep to their own place in the evolutionary timeline. We are macroscopic but insist on peering into the microscopic world and in so doing into a different instant along the evolutionary timeline. But more than this, we do not just want to see but add mathematical formalism that makes these more primitive epochs make sense in terms of their relationship with the current macroscopic world. Even if Alfred the Wise were present at the Creation and sought to *"…given some useful hints for the better ordering of the universe* [69]*,"* he would run into a language problem since nature's natural language is mathematics. But the physicists of today, whether they realise it or not, strive to resolve this problem since their equations can enhance nature's understanding of the evolutionary process in a language that it can assimilate, adding a perspective directed back to the origin of all things from its consequence. The evolution of the universe was not a perfect process, many attempts introduced new flaws that then needed to be overcome. The universe we now inhabit is derived from many failed attempts whose consequences were built upon nonetheless. But humanity wants to imagine nature as perfect and will tend to smooth out the story of evolution to give it more consistency. This is the advice that nature seeks from human hindsight. Cosmology is how we provide it. George Wald stated that, *" A physicist is an atom's way of knowing about atoms* [682]*."* Equally a cosmologist is nature's way of knowing about its own evolution. To seek such knowledge is not an act of human arrogance but part of the reason why humanity exists within nature at all.

64. Extending the Domain of Physics

The history of science has always been about an expansion of the domain of study, whether this was achieved by Galileo's telescope that brought the stars and planets into better view [492], or the accelerators at CERN [683] and Fermilab [684] that smash atoms to allow physicists to look inside, or the theoretical insights of general relativity [685] and quantum mechanics [686]. Those who would restrict the domain of physics, placing a boundary on it beyond which it has no place, ignore this

[109] Chapter One: 1. *Prologue*.

history. The domain of physics extends to wherever human comprehension can penetrate in such a way that empirical verification can be sought.

The requirement for experimental verification has lead physicists such as Davies [78] to insist that the domain of physics must start at the big bang. But this cosmology demonstrates that this need no longer be the case if we reconsider the type of experimental verification we are looking for. The precedents established by earlier evolutionary epochs are evidenced by their re-application as the laws determining how this current universe works. Physics must cease simply observing the laws of nature and finding associations between them and come to consider how they evolved. The concept of a perfect nature has stifled such a consideration, since under this presumption the physical laws are considered to be eternal and unchanging. But this makes the laws of physics as *a priori* an assumption as the existence of God. But an imperfect nature that must strive to overcome its flaws develops its laws for this purpose and therefore they bear witness to its evolution. Without surrendering the requirement for experimental verification, the domain of physics need no longer be restricted to the current evolutionary epoch.

In this consideration it has been found that we must surrender the concept of a perfect nature, accepting instead its flaws and failures to achieve required outcomes. But in return for this we can expand the very nature of physics so that it can address the question: *Why?* since *purpose is determinable in terms of flaws that can be addressed. Such flaws are a determinable part of the physical makeup of the system, as open to empirical examination as any other aspect of it.*

This cosmology deals extensively with the nature of time, both its origin and evolution. Time is no longer something that physics must simply postulate, it can be seen as a natural consequence of an initial state devoid of a first cause. We have given a physical basis for Saint Augustine's assertion that, " *The world was made, not in time, but simultaneously with time* [60]," that does not, as Davies would have [78], limit cosmology to examining no process prior to the big bang. Instead we have pushed back the threshold for the origin of time and physics, thereby extending the domain of science to before the big bang.

Weinberg pondered, " *I wonder if we lack the conception of the kind of science - perhaps it won't even be called science - that will be done in the future. Perhaps in the future, they will look back at us as being intelligent but limited, in that we hadn't yet realized the right way to do things. I'm not sure we've reached the end of this story in the development of ways of learning* [161]." This dissertation suggests that we are far indeed from the end, but that we need not wait for future generations to show us the way, but may start the process of change now. But to do this we must redefine our epistemology. The lesson of this cosmology is that to retell nature's story as it occurred can produce no new consequences, but to exceed the truth of it can. If we define knowledge as merely a record of the truth then we become nothing more than living books [687]. But in a universe that remains an unresolved state, humanity's role is not merely to record what is true, but to choose what we would have be true. This cannot be done by simply acting on knowledge, since such actions change our world but little else. What is required is knowledge that nature can assimilate as part of its self-definition. But nature will not accept a lie, but instead demands the same level of experimental proof as science. But where experimentation is currently seen as verifying an existing truth, to verify knowledge that exceeds truth we must look to technologies that can achieve what was not previously possible. This can be done because it merely involves resolving some aspect of nature's flaws that the normal physicality of the universe cannot – resolution by design. This will have a universal affect because our requirements for scientific proof and nature's requirements for the provision of cause are the same and so can be simultaneously met. We need not travel to the stars to command their attention, but simply choose to become involved in the evolution of the universe, rather than just passive observers of it. This is the ultimate expansion of the domain of physics.

65. Concluding Comments on Chapter Five

" The Pole at last! The prize of three centuries… I cannot bring myself to realise it. It seems all so simple and commonplace [688],*"* as Robert Peary recorded in his diary about reaching the north pole. To understand the origin of the universe is the prize of countless millennia, but in order to construct a cosmology that makes sense it is necessary for the resolution of long outstanding problems to be made *simple and commonplace*. In doing so we realise that the ideas expressed here have not been encapsulated in a perfect terminology. But as for rhetoric we defer to Aristotle, *" The modes of persuasion are the only true constituents of the art: everything else is merely accessory* [59].*"* We submit that the best way to win the debate is to speak simply and be understood. An imperfect humanity should not seek an unattainable perfection of expression, but rather strive for the communication of ideas.

For thousands of years the most intelligent researchers have struggled to find the first cause that resulted in the universe around them. The answer we have given to this question is the most obvious - if after all this time and effort no first cause has been found, it is because none was there to find. This concept was no doubt ignored because it was thought that it would make the definition of further progression impossible. Within the Newtonian conceptualisation of nature prevalent in the nineteenth century this no doubt was true. But with the advent of quantum mechanics it has become undeniable that the universe is composed of unresolved states, which evolve as such before their resolution through measurements events. Nature is no doubt *as content with a cause provided by the future as by the past*.

Through the simple proposition that the lack of an initial cause represents a flaw manifest as over-specification, which nature must strive to overcome, we have constructed a re-conceptualisation of nature's evolution. This involves a more fundamental starting point and less postulates than any other cosmology reviewed. This cosmology also incorporates an understanding of the origin of more aspects of the evidenced physical system than any other. By reference to this conceptualisation of nature we can understand why the universe has the characteristics that physics has previously quantified but not explained. A universe of elementary particles immersed in a sea of virtual pairs makes sense. The bizarre nature of causality revealed by quantum mechanics can be seen as the necessitated description of nature, rather than denying the existence of an objective reality. We realise that this dissertation represents only the initial introduction of these ideas, rather than a cosmological model as such, but this is a roadmap that cosmology can follow to the fulfilment of all of its dreams.

Physicists have become extraordinarily skilled at observing nature in greater and greater detail. From these observations they have established connections between different observed phenomena, which make predictions possible. This ultimately has lead to the development of technology. But at the same time, as the history of physics over the last hundred years amply demonstrates, physics has lost the capacity to see and understand nature's overall design. Physicists can make absolutely correct predictions without understanding why nature works in the strange ways modelled by their equations. But while prediction without understanding can satisfy the desire for technological innovation, it cannot satisfy the fundamental yearning for understanding that was the motivation that set science on its path. Of all the disciplines of physics, cosmology offers the greatest opportunity to recapture an overall understanding of nature's design. But to do this cosmologists must not restrict themselves to the narrow considerations of other specialisations, but have the courage to approach the problems in the broadest terms.

By the end of the 1800's physicists were convinced that they had achieved a full understanding of nature. The 1900's have increased our knowledge, but paradoxically reduced our understanding, to a point where our science has become disjoint from any coherent picture of nature. At the beginning of the twenty-first century what better gift than to re-establish the nineteenth century's sense of understanding, by incorporating into a simple conceptualisation of nature all the fantastic discoveries of the twentieth century. The separation of the mathematical formalism of physics from any easily communicated conceptualisation of nature, has reduced the interest of the average taxpayer to the technology science can produce and thereby focused public funding in that direction, to the detriment of theoretical research. But with the capacity to assert that physics once more provides an easily understood description of nature, its relevance to non-scientists can be broadened and their support for non-technology based research sought. To neglect this inclusive approach to science, risks research becoming so narrowly focused on immediate technological benefits, that its past predominance in extending our knowledge of the natural world may be forever lost.

Ultimately there is neither science nor religion but merely the quest for truth. Over the centuries this quest has become fractured into a multitude of categories and separate specialisations, each with its own conceptualisation of nature that need have no agreement with another. This is clearly wrong. What is required is to have one conceptualisation of nature that is wholly open to scientific scrutiny, but broad enough to encapsulate all aspects of humanity's quest for understanding.

There are no doubt still many aspects of this consideration with which you disagree, that is understandable, there are things that have been stated here with great conviction that are no doubt wrong. But equally there are concepts introduced here that are absolutely indispensable if cosmology is to progress as a science. If we restrict the concepts that the cosmological community can address, we lose the opportunity to extend the very domain of physics by expanding the questions to which it can be applied. If we have the courage to consider the possibility that nature can be flawed, we gain the capacity to define purpose, and by experimental scrutiny verify that this purpose is valid. Scientists shall ask not merely how the universe functions, but fundamentally what it is and why it is - what purpose it serves. We shall do science not for the sake of technology, but to satisfy the most fundamental yearnings of our humanity. The impact of a physics that can address such issues is beyond precedent or imagining, but not beyond our capacity to create.

As Veltman noted, *" When an idea is launched for the first time you will often see it followed up by many articles, one grander than the other, and most of them, seemingly, much clearer and brilliant than the one containing the original idea.* (But)*…It is this odd idea, the thing orthogonal to everything else that is so hard to produce. Usually after it is introduced everyone will say: 'of course'* [64]*."* The goal of this consideration is not credit but progress. Physicists have become too timid, too afraid of being wrong and have therefore withheld insights that, even if their author could not carry them through to fruition, could have provided inspiration to others, resulting in the resolution of many currently outstanding problems. It may seem that this dissertation attempts in one fell swoop to resolve every outstanding problem in physics, but this has never been the purpose of this consideration. What we have sought is simply to take questions long considered impossible to address and re-establish them as valid tasks for physics.

Cosmology is not for the faint hearted, not for those who want a safe path through their academic careers. It deals with the most fundamental and far-reaching concepts humanity has ever dared to address. But as John F. Kennedy eloquently stated, *" The problems of the world cannot be solved by sceptics or cynics whose horizons are limited by the obvious realities. We need men who can dream of things that never were* [689]*."* Cosmologists are the new lords of La Mancha [690], tilting their lances against impossible tasks, fighting monsters that others simply cannot see, but if our task as scientists is a quest for knowledge, there is no better arena than cosmology in which to fight.

Afterword:

…and God?

“ For the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and godhead; so that they are without excuse [691].*”*

A1. Introduction – The Aspirations of Physicists

We have come to the end of the physics content of this dissertation, but not to the end of its capacity to comment on the aspirations of physicists. Sir Arthur Eddington asserted that, " *Life would be stunted and narrow if we could feel no significance in the world around us beyond that which can be weighed and measured with the tools of the physicist or described by the metrical symbols of the mathematician* [692]." Indeed Einstein stated that, " *I want to know how God created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element. I want to know His thoughts; the rest is detail* [4]." These are not just the aspirations of past generations, but repeated today by scientists such as Hawking, " *Which came first the chicken or the egg? Did the universe have a beginning and if so what happened before then? Where did the universe come from and where is it going?* [94]" There can be no more significant, and perhaps no more dangerous, questions a human being can ask. Despite the theological implications Saint Augustine refused to stifle such debate, " *My answer to those who ask 'What was God doing before he made heaven and earth?' is not 'He was preparing Hell for people who pry into mysteries'. This frivolous retort has been made before now, so we are told, in order to evade the point of the question. But it is one thing to make fun of the questioner and another to find the answer. So I shall refrain from giving this reply. For in matters of which I am ignorant I would rather admit the fact than gain credit by giving the wrong answer and making a laughing-stock of a man who asks a serious question* [60]." If as Sir Francis Bacon stated, " *God has placed no limits on the exercise of the intellect he has given us…*[693]," then neither should science or theology. In fact, as Davies points out, " *…theology was the midwife of science* [694]," and therefore to him it is not surprising, " *…now that science has matured over three or four hundred years, that it has begun to rediscover its theological roots. Armed with their knowledge, scientists have begun to return, in a very serious way, to those ancient questions of existence, questions like the ultimate origin of things. And they are getting some answers!* [694]" This dissertation has a role to play in this by demonstrating that there is more to the evolution of the universe than the bashing together of rocks, more than gravity's dance, that there is within the physics itself the capacity to understand the purpose of evolution and to consider the emergence of consciousness and being. However a religious perspective that personifies all action cannot accurately reflect the evolution of the universe, but neither can a purely materialistic physics. Neither separately can tell the whole story. There is nothing new in this assertion, not simply in reference to Einstein's statement that, " *Science without religion is lame; religion without science is blind* [695]," but because so many prominent physicists feel it naturally in their hearts.

A2. Does God Have a Role to Play?

Does God have a role to play in the creation of the universe or has scientific knowledge eliminated any need for this concept? It is necessary to rekindle this debate not for the sake of either point of view but in order to understand the origin of the universe in its entirety, not just that part acceptable to a particular discipline or prejudice. " *A man should look for what is, not for what he thinks should be* [5]," this is Einstein's advice and should be heeded.

Simone Weil wrote that, " *It is only the impossible that is possible for God. He has given over the possible to the mechanics of matter and the authority of his* *creation* [696].*"* It is no wonder then that Nietzche considered that,*" A subject for a great poet would be God's boredom after the seventh day of creation* [697].*"* However this view would quickly leave God no role at all since as Charles Coulson pointed out, *" There is no 'God of the gaps' to take over at those strategic places where science fails; and the reason is that gaps of this sort have the unpreventable habit of shrinking* [698].*"* Even invoking God to be the original creator of the universe is questionable since, as Davies stated, *" If you are using God to explain the universe you get into the problem of who created God* [699].*"* It always comes back to that annoying tower of turtles[110]. It is perhaps no wonder then that the theological implications of Hawking's cosmology [94], as summed up by Carl Segan, show *"…: a universe with no edge in space, no beginning or end in time, and nothing for a Creator to do* [700].*"* This seems a bleak epitaph for God.

The cosmology of this dissertation shows that nature's evolution is purposeful in terms of seeking to overcome its flaws, but that it proceeds by trial and error without the need for wilful acts or predetermined design. But it also demonstrates that the story of the origin of the universe is not yet complete, all that can be known of it at this point along the evolutionary timeline is what motivates it and what actions are being taken right now to satisfy this motivation. This universe is not the final product sought by evolution, but a place to develop the tool that will make creation possible. The ultimate origin of a universe without flaws has yet to be determined. The question of whether this will involve a sentient being is unresolved, not because different human beings cannot agree, but because this event has not yet occurred. The story of the origin of the universe is not a history of past events, but instead involves a comprehension of current difficulties and desires.

However in terms of overcoming nature's flaws this cosmology traces the evolution of physical processes and nature's growing dependence on them and therefore would state, in a manner similar to Weil, that nature has *given over the possible to the mechanics of matter*, since this is how it seeks to establish causality. However physical processes can provide resolutions to nature's flaws that are too simplistic to reflect all that it has learned during the evolutionary process. This leads to the recognition that the questioning itself is more important than the answer.

Davies question: *Who created God?* is based on a false premise, that this must precede the first event of the evolutionary timeline. On the contrary it is the whole of evolution that is the answer to this question. That the evolutionary process can result in the existence of conscious beings is self-evident. The question is whether this process has a function beyond the establishment of human life. It would come as no surprise to most conservationists that the existence of human beings does not solve nature's problems. However what humanity demonstrates is that there is an alternative to cause – choice.

There is no predetermination of which evolutionary progressions will be successful, only a compulsion to attempt everything that is possible. To that end this universe serves as a place where the exploration of possible resolutions of nature's flaws will have no immediate affect on it. It is a place to experiment. Human existence is part of this process, demonstrating what can be achieved by wilful choice and what dangers are inherent in this process. What can be achieved is the resolution of over-specification independent of physical process. But even more important is that these choices can be made independent of past precedents. The universe need not simply be the sum of its past, but can be redesigned by new

[110] See Chapter One: 6a. *A Reconsideration of the Problems of Defining the Initial State and First Cause*.

choices made now. The danger inherent in wilful choice is that it can replace past precedents that have evolved over countless millennia to serve a complex purpose with a chaotic whim. To prevent this humanity must gain an attribute that is the equal of a cumulative past – the capacity to dream, to imagine a complex future that can guide present choices. However this does not overcome the other danger inherent in wilful choice, that different people can make different choices leading to an inability to introduce any coherent design. For a diverse humanity to posses the capacity for wilful choice is not enough.

It has been said generation after generation, civilization after civilization: *God created the world.* But just saying it is not enough there is work that must be done. Science's re-examination of nature's evolutionary history serves two functions; it fills in gaps in nature's memory and adds to these events a comprehension of intent that was not originally present. Moreover it strives to express these concepts in terms of a mathematics that is compatible with nature's generalised memory. This can potentially replace ignorance with comprehension in terms of consciousness. The religion versus science debate might be considered to involve whether consciousness was present at the beginning of all things or whether its evolution is a recent occurrence. But given that nature's generalised memory always occupies the initial instant of time and is not cumulative but assimilative, even this question is quite moot. Even if consciousness was not originally present at $t = 0$, it can be later.

Voltaire said that, *" If God did not exist, it would be necessary to invent Him* [701]*,"* to which we would add: *'…using humanity as a catalyst in this process.'* There is nothing mysterious about this it is just a practical solution to a real problem. There need never be a first cause as such, instead there can be the wilful choice of a conscious being. Many scientists find the concept of God objectionable, but nature sees God as a perfectly practical way to overcome its flaws.

But if cosmology is to bridge the gap between an impersonal nature and consciousness, nature must believe its assertions. The scientific method demands empirical proof, nature demands the demonstration of a cause. Both requirements can be satisfied by a scientist's experiment. There should be no conflict between science and religion since in a real sense it is science that must give birth to God.

The evolution of the universe and the birth of God are aspects of the same event. It is not a matter of one explaining the other, but that it is necessary to understand both in order to have a full comprehension of either. Henry Drummond, who is credited with introducing the concept of a *'God of the gaps,'* argued that, *" …an immanent God, which is the God of Evolution, is infinitely greater than the occasional wonder-worker, who is the God of an old theology* [702]*."* Such an immanent God cannot be equated to an old man whose task is already complete leaving Him bored and purposeless, instead it reveals a God more like a child, driven by evolving questions and a clear purpose, who is taking His first faltering steps towards maturity. For such a God there is no *seventh day of creation* since the process of creation, both of the universe and Himself, is an ongoing one. There would always be much to do, with each new day bringing change and growth. But a God who evolves along with nature need not act in contradiction to it, but would instead promote structures within it to be the instruments of His will. In this way all that God does falls both within human comprehension and the domain of science.

Steven Weinberg, who wrote the definitive popularisation of the big bang theory [89], stated that, *" It would be wonderful to find in the laws of nature a plan prepared by a concerned creator in which human beings played some special role. I find sadness in doubting that we will. There are some among my scientific colleagues* *who say that the contemplation of nature gives them all the spiritual satisfaction that others have traditionally found in a belief in an interested God. Some of them may even really feel that way. I do not. And it does not seem to me to be helpful to identify the laws of nature as Einstein did with some sort of remote and disinterested God. The more we refine our understanding of God to make the concept plausible, the more it seems pointless* [46].*"* The more fundamental science's understanding of nature's evolution the more clear it will become that this must include the evolution of consciousness and its application to overcome nature's most fundamental flaw, the lack of a first cause. This makes the concept of God plausible but hardly pointless. God maintains a single truth while allowing the expression of all potential. The role that humanity must play in establishing God's existence could not be more special.

Marianne Williamson stated that, *" Our deepest fear is not that we are inadequate. Our deepest fear is that we are powerful beyond measure* [703].*"* Physicists have sought to find humanity's place in the world by studying nature and trying to unravel all of its intrigues. In this cosmology nature has been stripped bare so that its flaws and failures lay within our comprehension. We can see what nature's intent is and just how limited its capacity to achieve these goals has proven to be. But we have also learned that what has grown up within nature has come to exceed its original intent. In this way nature learned that there is an alternative to a first cause, a first choice. But to this must be added one more attribute, the capacity to dream, the capacity for the self-generation of the future. Absolute power can still achieve nothing independent of knowledge. Previously this has been gained through the enactment of events, the evolution of the physical universe, but this has proven to be a slow and cumbersome process, which teaches only what can be. Better that knowledge is based on dreams that exceed the possible and establish not what can be but what nature would have be. This is not some impossible aspiration but the day-to-day experience of humanity. We do not go where we are pushed by the weight of the past, but where our dreams lead us. We do not seek a cause to justify our actions, but simply choose. The nature of the universe need not be determined by the meagre causality of physics, instead its future can be mapped out by our dreams and made manifest by our choices. We are not small creatures bound by the laws of physics; we are quite literally the alternative to this schema.

It is time to recognise that the answers do not lie in understanding the material structure of nature, but in our own determination to develop our imaginations and wills.

A3. Science and Religion

Pope John Paul II, before the Pontifical Academy of Sciences, stated that, *" I hope that theologians, scholars and historians, animated by a spirit of sincere collaboration, will study the Galileo case more deeply and, in frank recognition of wrongs, from whichever side they come, will dispel the mistrust that still forms an obstacle, in the minds of many, to a fruitful concord between science and faith* [704].*"* The controversial opinion that Galileo expressed was that, *" Religion teaches men how to go to heaven, not how the heavens go* [62],*"* simply that science is necessary if we are to understand how the universe works. We would go further; science cannot only tell us about the workings of the physical universe, it can make comprehensible God's existence and purpose, as well as our role in it. God's interest in human affairs cannot be a whim, but must exist because humanity is the instrument raised up within an evolving physical universe to fulfil His purpose.

Nature's evolution makes sense in terms of the need to overcome specific flaws, so too does humanity's role within it. Given this it is clear both why humanity possesses free will and why it has been asked to use it not for his own benefit but to serve a greater purpose. While religion could not tell us why God cares about the choices we make, science has.

Weinberg had to admit that he is atypical in his desire for a reconciliation between science and religious belief and that in his experience, *"…most physicists today are not sufficiently interested in religion even to qualify as practicing atheists* [46]*."* We trust that this will not always be the case, since this cosmology demonstrates that the existence of God is as valid an aspect of nature's evolution as Newtonian causality. This will allow a new generation of scientists to understand the concept of God at an intellectual level and thereby expand the very domain of physics. The questions that will be addressable by this new generation of scientists will go beyond anything that previous generations have attempted. We shall ask not merely how the universe functions, but fundamentally what it is and what purpose it serves. We shall do science not for the sake of technology, but to satisfy the most fundamental yearnings of our humanity.

Saint Augustine's [60] declaration that time starts with the creation of the world was made because he did not want to consider that the choice of the moment when creation was initiated was arbitrary. He sought to protect the status of God as eternal and all knowing. But in doing so he denied that God lives. Life is a struggle to overcome obstacles that necessitates change. The God that science reveals is a living God, not omniscient and detached but a being whose life is intrinsically interwoven with the evolution of the world and the lives of human beings. The significant transitions in process along the evolutionary timeline that resulted in the existence of this universe involved incremental progressions in the evolution of consciousness. It is not a matter of a mature and omniscient God making these things happen, but that the evolution of consciousness and the evolution of physical structure are inherently intertwined. If acceptance of God is to be more than an act of faith, believers must have the courage to understand that God's existence is comprehensible. Ignorance is not faith. But equally, less than the whole truth is not science.

As scientists we have been asked to accept the existence of an infinite number of parallel universes, a proposition for which their can be no empirical proof. But since this cosmology can be experimentally scrutinised, that it proposes that nature possesses a generalised self-definition that can evolve towards consciousness can potentially be tested. As scientists we should not accept what we cannot physically evidence, but neither should we reject on the basis of outdated prejudices what can clearly be seen. God asks no faith of you, only that you perform the experiments.

When then experiments are done and certainty established, all that will then be left is a teenager's dilemma, *" How can I know so much of You and You still be my God?* [705]*"* Answering this question will require more faith than ignorance ever asked of us.

A4. The Answer to the Question: *Why?*

As for the question: *Why does the universe exist, what purpose does it serve?* the answer should by now be obvious: *To finalise the birth of God.*

Nothing in this cosmology requires the pre-existence of God, yet we conclude that the answer to the question *Why?* is to finalise God's birth. This may seem to be a contradiction but it is not. The use of conscious choice at $t = 0$ to overcome the flaw that there is no first cause is a perfectly practical resolution, but it is not a necessitated one. Nature could evolve a capacity for causal resolution that would set aside the need for consciousness. But if cosmologists are to play the role of Alfonso the Wise and give, *"…some useful hints for the better ordering of the universe* [69],*"* should we seek solutions that set aside the need for consciousness, or those that will ensure its predominance for all of time?

A5. Concluding Comments on …and God

The function of this dissertation is to challenge all questions placed in the *'Too Hard'* basket and attempt to dislodge them and thereby rekindle debate. The apparent irreconcilability of science and religion is one such problem. In including this afterword we have simply taken Einstein's advice that, *" The right to search for truth implies also a duty. One must not conceal any part of what one has recognized to be true* [706]*."* But have we gone too far in these conjectures? No, conjecture can never go too far. We must explore to the ultimate degree the implications of any knowledge we acquire. This is at the very heart of both our science and humanity. It must never be constrained.

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