Unity Theory

A New Paradigm for Physics

Giles Hayter

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Abstract

We propose a theory of broad scope. Having laid out an axiomatic foundation for this theory, we establish its value by deriving, from its first principles, the major structures of mathematical physics. In quantum mechanics, we generate, among other results, the precise form of the Schrödinger equation, Pauli exclusion, the Planck-Einstein relation, special relativity, the Klein-Gordon equation and the full Dirac theory. We explain the mechanism behind quantisation itself, giving precise meaning to the Planck constant and wave-particle duality. We describe the physical nature of fermions and bosons. In quantum field theory, we derive, and hence interpret physically, the symmetries of the electromagnetic, strong and weak interactions, producing simple, first-order approximations for proton mass and the weak mixing angle. Neutron structure is elucidated. We analyse the quark model, and observe that it applies only in a hazy sense to stable nucleons; these are seen to be beyond its sphere of empirical validation. Confinement is proved theoretically, in elementary terms. From the same axiomatic foundation, we then derive the Hilbert action and thus general relativity, establishing, in the process, a precise domain of validity for Einsteinian gravity. This is seen not to extend to either the distant past or to regions of very high gravity, rendering significant quantities of current cosmological theory obsolete. Dark matter, dark energy and inflation are seen to be unnecessary. The graviton, however, emerges naturally to resolve the conundrum of flat galactic rotation curves, without recourse to ad hoc hypotheses. The phenomenology of MOND is seen to appear in the Unity paradigm. Having established the theory beyond reasonable doubt, in both microscopic and macroscopic domains, we then consider its broader implications; in particular, we address the origin and fate of the universe. The model that emerges differs radically from the incumbent view, as crystallised in the ΛCDM model. We determine, with a high degree of confidence, that the universe is spatially closed, temporally infinite and cyclic. The usual thermodynamic objections to this idea are seen not to apply. In the new paradigm, we then resolve a number of major cosmological questions, among them the horizon problem, baryogenesis, symmetry breaking and large-scale structure formation. Concluding, we discuss falsifiability, and lay out a number of tests of the theory, both current and potential.

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1 Introduction

Unity theory, as laid out in this book, represents a very different take on reality to the one that currently holds sway. As such, we must necessarily make bold hypotheses, the plausibility of which may be questionable to the first-time reader. There is no way of tiptoeing around this. To prejustify the axioms of Unity theory would occupy us with too much extraneous detail too early. This is a long enough work as it is. So, as is commonplace in the construction of theories, we first lay out an axiomatic structure, and then we analyse its theoretical predictions. While this does entail some suspension of disbelief on the part of the reader, that suspension is temporary. The numbers soon emerge. In the end, a scientific theory stands or falls by its *content*, i.e. whether its mathematics aligns with experiment, not by the particular and necessarily imperfect methods used to convey that content.

There is, however, one element of logic that is just as important as any subsequent, quantitative analysis. That is the *first principle*. A theory that rests on a clearly defined axiomatic structure is rendered much the stronger for it, because that axiomatic structure forces the physicist's hand. A building must have sturdy foundations. The mathematics must also fit experiment, of course, but an axiomatically defined theory has a priceless boon: the theory itself guides the mathematics that emerges from it. Such a theory cannot be subsequently fine-tuned. Einstein recognised this strength in general relativity, and his confidence in the theory stemmed from it, in combination with its empirical verification. General relativity does not permit tinkering with: any alteration, and the whole thing falls to pieces.

Unity theory, whatever its truth or falsehood, has the same boon, and to a greater degree. The theory laid out in this book rests on what can reasonably be called the simplest not just of all axioms hitherto proposed, but perhaps the simplest that could possibly be proposed. In this book, we work on the assumption that there is precisely *one substance* in the universe. It is an exceptionally stringent restriction; indeed, it is hard to imagine a more stringent one. In proposing that every physical entity is a configuration of one ubiquitous substance, we rule out the existence of protons and electrons, gluons and gravitons, foreground matter and background space as having metaphysical existence of their own; according to Unity, *everything* follows the same laws. Unlike in the current paradigm, we can't propose dark matter to sort out galactic rotation curves, nor dark energy to deal with cosmological acceleration, nor the Higgs boson to sort out weak boson mass, because Unity, from the outset, bans all ad hoc hypotheses. Substance is substance, and that's all we get. Hence, the suspension of disbelief asked for in the early stages of this book, while not inconsiderable, is justified.

This book can be read, then, as an analysis of the theoretic[1] implications of the

[1] In this book, we make a distinction between the words "theoretic" and "theoretical". With "theoretic", we refer to the mathematical elements of theories, which, as pieces of pure mathematics, require no uncertainty or doubt; with "theoretical" or "theoretically", we refer to the tentative application of those mathematical elements to reality. Hence, $F = ma$ is a *theoretic* element of Newton's mathematical system, while "a hammer and a feather fall at the same rate" is a *theoretical* prediction.

axiom of Unity. Unity is not the only principle we need—it doesn't, for example, address the dimensionality of the universe—but it is by far the most important one. Everything in this book stems from the attempt to reconcile the seemingly impossible axiom of Unity with the empirical phenomena of reality. We ask: is there any way Unity can be true? Secondary principles are then introduced when and where they are necessary, in order to match experiment, but only if they also obey the strictures of the axiom of Unity. So, for example, the axiom itself says nothing about the three-dimensionality of space. It would be theoretically possible, in agreement with the axiom of Unity, for space to have two or four dimensions. It is only our eyes and our laboratories that tell us that the domain in which we live is voluminous. Hence, it represents no weakness on the part of Unity that we must introduce secondary principles beyond it; every empirical theory must do this.

The axioms and principles laid out in the first section of this book are given with minimal justification. However, it is only the axiom of Unity that is assumed by *choice*. Having chosen the axiom of Unity, on aesthetic and philosophical grounds, the other foundational principles are, in fact, dictated to us by the evidence of experiment, with minimal wiggle room. They don't follow from the axiom of Unity alone, but they do follow from a combination of the axiom of Unity and a study of phenomena. As it turns out, we are left almost no choice about their forms. For clarity in construction of the theory, however, these forms are presented axiomatically. This is a pedagogic necessity, given the revolutionary nature of the theory. The justification for the principles so presented, and possible alternatives to a few of them, will then become clear during the course of the work.

This book sets out as an attempt to answer a single question: "Is the universe one substance?" It is binary, qualitative question, with a clear yes/no answer. There is no middle ground. The old paradigm[2] answers with an emphatic no: we are very much accustomed to thinking of the universe as built of this and that type of stuff, to view matter and radiation as different entities moving against something else, space. We disagree. And given the binary nature of the issue, the important question, for the reader, is, in the end, not whether or not the *details* of this book are correct—such is its scope and novelty, it is almost certain to contain a number of half-truths, if not downright errors—but rather: "Does the axiom of Unity hold?" Equivalently, of more practical significance to physicists: "Is there a better version of physics available to us?" While we can, of course, make no claim that the content of this book *is* necessarily that better version, we can nonetheless answer both questions with an emphatic yes. The old paradigm is wrong, and new world awaits.

[2]We will use the nomenclature *old paradigm* to refer to the incumbent Western view of physical reality. Both common sense and science hold that reality is, essentially, three-dimensional space with matter and radiation in it. This view has been almost universally accepted, with only some minor relativistic and quantum modifications, since before Newton's day, and remains ubiquitous in the early years of the third millennium. Even a long century of quantum paradox has not shaken this strongly held belief. Unity theory, in proposing a *new paradigm*, denies its validity.

2 Foundations of Unity Theory

We begin with formal definition of the philosophical first principle. The following is the content of the term *Unity*, in both this book and any other version of Unity theory that may emerge from it. In proposing and assuming this axiom, we are setting to work in a new and very specific paradigm. We propose the axiom in a succinct form, but nonetheless intend it to be taken in its strongest possible sense, free of all exceptions and caveats.

> **Axiom 1.** *Axiom of Unity.* The universe is one substance.

By this axiom, we propose that not only are the foreground players of physics, namely matter and radiation, configurations of the same substance, but so is the background stage of the universe itself. Unity rules out the possibility that an electron or a photon is built of something other than that which space is built of. In Unity theory, there are no exceptions to this rule. Everything that is physical is one substance, whether it be perceptible or imperceptible, foreground or background, massive or massless.

This doesn't signify, however, that every *concept* of physics must necessarily refer to a configuration of substance, because not all physical concepts refer to physical objects. For example, momentum and energy are secondary, non-physical ideas, which describe *changes in* physical configurations such as protons and electrons. Such mathematical concepts are, of course, the lifeblood of physics. All such concepts of variation are then underpinned by the ultimate non-physical concept, *time*. We must consider time carefully before proceeding.

Time, in classical and quantum physics, is a temporal parameter; in relativity, it is a spatial axis. This contradiction, which is philosophically puzzling in the old paradigm, is known as the "problem of time". In Unity theory, there turns out to be no problem: the spatial time axis of relativity arrives naturally, offering no contradiction to the quantum view. We end up, in fact, with no need of negative metrics or Lorentz covariance; the relativistic behaviour of clocks stems from the axiom of Unity. This is good news, because it means that, in Unity theory, we are free to define the concept of time in its simplest possible guise, that is to say, as Newton's absolute.

> **Axiom 2.** *Axiom of Temporality.* Time t is a temporal parameter, not a spatial axis, whose continuous rate of passage is unaffected by material reality.

By this, we mean that there is no sense in which time t is tangible.[1] It is simply the timescale along which things happen. Physical clocks slow down and speed up, but time itself ticks on regardless. In this, Unity theory's version of time is that of

[1] In Unity theory, there is a space-like dimension related to time, which we notate w. However, t has units of seconds, w units of metres. According to Unity theory, these are categorically different.

common sense. Time is a measure of *when*, not a physical thing that can be stretched or compressed. Hence, there is no disagreement with the axiom of Unity when we say that time is not made of substance. In Unity theory, time is not a physical aspect of the universe, as general relativity suggests it to be. As we will see, the equations of GR emerge from exactly this formulation, without any need for temporal substance.

So, the theoretic elements of Unity are ① a single substance that ② varies. We are led immediately to an important physical fact regarding such variations, Continuity, which we capitalise to distinguish it from the closely related mathematical concept.

⦿ Definition: *Continuity.* The fact that nature makes no jumps.

At first glance, this seems to sit in stark disagreement with the evidence of a long century of quantum physics[2] and some millennia of atomism before that. Nevertheless, this classical principle—*natura non facit saltus*—has a long history. Here, we resurrect it to its former glory. The principle of Continuity is logically equivalent to the axiom of Unity, and it is a matter of aesthetic taste which of the two is taken to be the prior fact. A perfectly continuous universe cannot contain more than one substance, since it has no hard dividing lines, and a universe of precisely one substance cannot contain discontinuities, for the same reason. As with the axiom of Unity, the principle of Continuity, despite its succinct definition, should be assumed in its strongest possible sense: in nature, there are no singularities, boundaries, edges, step changes, or discrete time ticks.

With the philosophical axioms defined, we proceed with two mathematical laws, one topological and one geometric, which take their form to agree with the phenomena of experiment. These axioms are not fundamental to Unity theory as pure mathematics, but they are nonetheless fundamental to its application to the physical world of the present day. Any adjustment to the forms given below is greatly restricted by the requirement of agreement with both particle physics and cosmology. Empiricism dictates either the structure given below, or else one very similar to it, or else one containing it as a limiting case. Firstly, we consider the global[3] structure of the universe. We define a Lie group U as follows:

⦿ Definition: *The Unity group.* The Lie group $U = (S^1 \times S^3)^2$.

This group is then taken to represent the global structure of the universe. Now, in fact, the axiom of Unity dictates that the structure of the universe isn't a trivial product space, since such spaces have holes in them, and holes, being non-substance, don't exist in Unity theory. However, since physics is local, this fact is only of concern with reference to a limited number of phenomena: primarily cosmological expansion and

[2]It has been too long overlooked that discontinuity in physics destroys the mathematical consistency of *any* theory used to describe it. Discontinuities require infinite rates of change, and are, as such, beyond description by consistent numerical laws. Truly *quantum* physics can never be consistent.

[3]Throughout this book, we use *global* and *local* to refer to the behaviour of a global, topologically closed space (Lie group) and its local, topologically open tangent space (Lie algebra). The prototype is the global Lie group S^1, a circle, and its local tangent space, the Lie algebra $\mathbb{R}$.

symmetry violation. We will address these, in the language of fibre bundles, at the appropriate time. For most results in Unity theory, and for everything in the first half of this book, we can work with the local product structure given below:

Axiom 3. *Topological Structure.* The universe has the structure $U = (S^1 \times S^3)^2$.

To a large extent, the mathematical content of this book consists of analysing the above structure and its relationship with experiment. Here, we note in passing that the Unity group is the simplest symmetrical closed group containing one- and three-dimensional components, i.e. if we assume symmetry and a finite $3 + 1$ universe, then U is minimal.

Having proposed this topological structure, we now consider local geometry, which is defined in the tangent space[4] of the Unity group, viz. the Lie algebra $\mathfrak{U} = \mathbb{R}^8$. In this, it is primarily agreement with general relativity that dictates the Riemannian form of our equation. Some notation first:

⦿ Definition: R_8 denotes the Ricci scalar in eight dimensions.

Besides agreement with general relativity, and hence experiment, there are also very good theoretic reasons for proposing Riemannian geometrical structure. The Ricci scalar is a measure of the size of a local volume element, or, in our case, eight-dimensional hypervolume element. Hence, R_8 is a mathematical translation of the philosophical idea "The local density of the substance of the universe". It is expressed in departure from average, defaulting to zero. And, according to Unity, it must be *everywhere* zero. Increases in density require fluidity, which requires discrete foreground particles moving past one another in background space. But Unity permits no such scenario. In a universe of one substance, there is no background and no foreground. Which tells us that the substance of the universe should have constant density. Now, $R_8 = 0$ is not the only equation that could be taken as the mathematical translation of this idea, but it is by far the simplest. Furthermore, it contains the equation that, according to general relativity, the fabric of space obeys in vacuum. Hence, $R_8 = 0$, or the *substance equation*, contains the full local mathematics of Unity theory.

Axiom 4. *Geometric Structure.* Locally, the universe obeys $R_8 = 0$.

This concludes the axiomatic structure of Unity theory, as presented in this book. Proceeding from this point, we can begin to derive logically necessary concepts and equations, and to relate those concepts and equations to the facts of experiment. From this point, we begin a process of *validation* of the assumptions hitherto given.

[4]Formal notation can make this idea appear more complicated than it really is. The theory of Lie groups and Lie algebras is based around a simple question: *What does a global space look like locally?* For example, locally, a circle $C = S^1$ looks like a straight line $\mathfrak{C} = \mathbb{R}$. Locally, the Unity group $U = (S^1 \times S^3)^2$ looks like eight-dimensional Euclidean space $\mathfrak{U} = \mathbb{R}^8$. Gothic font signifies locality.

2.1 The Wave Equation

The substance equation $R_8 = 0$ is nonlinear. But it leads immediately to a linear wave equation. As is well known in the context of general relativity, small disturbances h in the metric, commonly called gravitational waves, obey $\Box h = 0$. The same argument that applies to those small disturbances in the three-dimensional vacuum also applies to small disturbances Ψ in eight-dimensional substance. So, $R_8 = 0$ generates a linear wave equation. To describe this, we introduce a piece of notation, the *diamond operator* $\diamondsuit$, to generalise the d'Alembertian box operator into higher dimensions. The familiar box operator is

$$\Box = -\frac{1}{c^2}\frac{\partial^2}{\partial t^2} + \sum_{i=1}^{3} \frac{\partial^2}{\partial x_i^2},$$

where c is the speed of propagation through space. Now, in generalising this, we cannot assume, at this early stage of modelling, that c is the speed limit of the universe. Indeed, rather surprisingly, this turns out to be incorrect.[5] All we know, mathematically speaking, is that the speed limit of the universe is *at least* c. We notate the true speed limit of the universe, which we will determine later in this book, as a. In Unity theory, both wave speeds are important, so, when a distinction needs to be made, we will use a subscript, as $\diamondsuit_c$ or $\diamondsuit_a$. The latter is given by

⦿ Definition: *Diamond operator*

$$\diamondsuit_a = -\frac{1}{a^2}\frac{\partial^2}{\partial t^2} + \sum_{i=1}^{n} \frac{\partial^2}{\partial x_i^2},$$

where $n \leq 8$. We will need various versions of this, with $n = 2, 3, ..., 8$, depending on the modelling scenario. Conceptually, the diamond operator can be thought of as identical to the box operator, but the notation $\diamondsuit$ serves to highlight one key fact, essential throughout Unity theory, namely wave motion in at least one space-*like* but nonetheless non-spatial dimension.

With this notation in place, we can state a fundamental result of the Unity model. This has a limited domain of validity—small disturbances in substance—and can be read simply as the linearisation of the substance equation $R_8 = 0$.

Theorem. *The wave equation.* Small disturbances Ψ in the substance of the universe obey the eight-dimensional wave equation

$$\diamondsuit_a \Psi = 0.$$

In $\diamondsuit_a \Psi = 0$, the function Ψ can be taken to be real- or complex-valued. Irrespective of the polarisation dimensionality of the modelled wave, the equation $\diamondsuit_a \Psi = 0$, or else its perceived effect $\diamondsuit_c \Psi = 0$, holds.

[5] In Unity theory, the universal speed of propagation of waves is greater than c, but the speed limit of matter and radiation remains precisely c, in agreement with experiment. The resolution of this apparent contradiction lies at the heart of the theory. It turns out to unify proton structure, proton mass, and Weinberg's electroweak theory.

2.2 The Inner Dimensions

According to the axioms of Unity theory, all small disturbances in substance must propagate away from their source. So, an important question arises: how do things sit still? Or equivalently, what is matter? We cannot, as is currently done, simply give things like protons the property "mass", and hence claim their ability to lie at rest. The new paradigm is far more rigorous than the old. Even at this early stage of modelling, we are severely restricted in our possible explanations of the phenomenon *matter*. Ad hoc hypotheses such as "having mass" are ruled out, and Unity brooks only one possibility:

Matter is constructed of resonant waves propagating around closed dimensions.

Given the rapid changes that matter can undergo, the journeys around these closed dimensions must be very short. Hence, these dimensions are far smaller than those of space. We propose, therefore, that the Unity group $U = (S^1 \times S^3)^2$ is the product of two components, one of which is microscopic and the other macroscopic.

⦿ Definition: *Inner dimensions.* Dimensions of the universe whose circumferences are significantly smaller than the length scales of human beings.

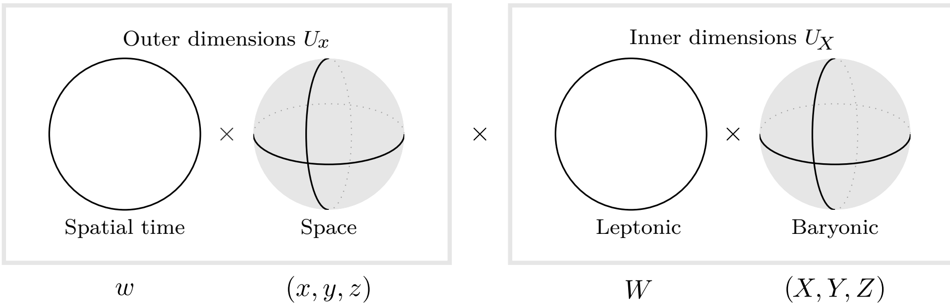
⦿ Definition: *Outer dimensions.* Dimensions of the universe whose circumferences are significantly larger than the length scales of human beings.

Now, some notation. The outer dimensions consist of a spatial axis related to relativistic time, which we notate w, and the three dimensions of space, which we notate (x, y, z) as usual. The inner dimensions, then, consist of a matching but physically much smaller set, which we capitalise to bring out the symmetry. With W, we denote a coordinate axis around the S^1 component of the inner dimensions, and with (X, Y, Z), we denote a local coordinate system in the S^3 component. This gives a local coordinate system, relative to substance, of

$$(w, x, y, z, W, X, Y, Z),$$

where the first four coordinates describe position in the macroscopic outer dimensions and the latter four describe position in the microscopic inner dimensions.[6] The Unity group factorises, then, into the *outer group* $U_x = S^1 \times S^3$ and the *inner group* $U_X = S^1 \times S^3$, where the x and X subscripts denote four-vectors. U_x and U_X are topologically identical, but differ geometrically: the outer dimensions are the size of the cosmos, and the inner dimensions are quantum-scaled. For reasons that will become clear, we name the S^1 component of the inner group *leptonic* and the S^3 component *baryonic*. Hence, W is the leptonic inner dimension, and (X, Y, Z) are the three baryonic inner dimensions.

[6] This coordinate system is only well defined in the linear approximation, in which we assume no large-scale deformations of substance. Technically, it is a coordinate system of the local Lie algebra $\mathfrak{U} = \mathbb{R}^8$, which implies that, as a frame, it moves with macroscopic variations in substance.



According to Unity theory, it is the presence of the inner dimensions that allows for the existence of matter, that is to say, the existence of mass. By travelling around the inner dimensions, a wave obeying $\Diamond_c \Psi = 0$ can be "at rest", as far as larger-scale beings such as ourselves are aware. The underlying wave, which is more fundamental than the perceived particle, is propagating at speed, but the overall configuration rests, just as a car may be perceived to be stationary while its engine ticks over beneath the bonnet.

"Perception" is a much neglected and much maligned term in the hard sciences. For the avoidance of doubt, *perception*, as we use the notion in this book, has nothing whatsoever to do with psychology, sense-data or mental interpretation. Perception is more fundamental than that: it falls into the domain of pure mathematics. The relevant fact is this: no entity can perceive a dimension in which it is symmetric. Why not? Because perception is based on *distinctions* between things—this object here rather than that object there—and an entity with symmetry in an inner dimension cannot, mathematically speaking, make any such distinction with regard to contents of that dimension. Nor, as a result, can the entity perceive the dimension itself: there is simply no physical mechanism by which the relevant data can enter the would-be perceiver.

For future reference, we state this key idea in its most general form, noting once again that what follows, regarding perception, is a theorem of pure mathematics, not a question of psychological interpretation.

Theorem. *Imperceptibility Theorem.* A subject perceives an object only in those dimensions in which a) object, b) subject, and c) the relationship between them vary.

This theorem underpins much of the Unity model, and a comprehensive understanding of it is a prerequisite for what follows. It has three facets. Firstly, a subject may fail to perceive an object, because the *object* has no variation. This is trivial. If there's nothing to be perceived, as on a pitch dark night, then nothing is perceived. Secondly, a subject may fail to perceive an object, because the *subject* has no variation. A single photoreceptor the size of a football field cannot track the movement of the football across the field. While this is obvious in analogy, it is not trivial in general, and is of paramount importance to understanding the nature of our physical reality. As such, it warrants a name.

⦿ Definition: *Subject-symmetric imperceptibility.* The fact that a dimension in which a subject has full symmetry is imperceptible to that subject.

Thirdly, a subject may fail to perceive an object, because subject and object have the *same* variation, as when both measuring ruler and measured object stretch by the same factor. No stretch is perceived. This is not trivial either, and also warrants a name.

⦿ Definition: *Matched-variation imperceptibility.* The fact that a dimension in which subject and all possible objects have the same departure from symmetry is imperceptible to that subject.

What happens when matter (us) perceives matter (our surroundings)? Well, matter is constructed of waves travelling around the inner dimensions; this requires that matter waves resonate in the inner dimensions; in turn, this requires that matter waves have inner-dimensional symmetry. So, according to subject-symmetric imperceptibility, the inner dimensions must be imperceptible to any entity built of matter, whether it be a human being or a piece of laboratory equipment. Hence, while it may seem, at first glance, reasonable to question the whole affair, asking, "Why has no one ever seen these extra dimensions?", the question itself is, in fact, a misunderstanding of the relevant mathematics. The very act of perception is, by definition, matter-based, so any dimension or dimensions that go symmetrically into the generation of the phenomenon "matter" are automatically imperceptible.

2.3 Observables

Subject-symmetric imperceptibility has a profound impact on what is observable in both an everyday and a laboratory context. The following reasoning applies to both. According to the axiom of Unity, matter must be constructed of waves travelling around closed inner dimensions. And we, of course, are matter-based beings. Hence, since matter itself cannot perceive the inner dimensions, neither can we. This generates a precise mathematical form for observables in Unity theory.

Consider a slow-moving particle resonating stably in the leptonic W dimension. Unsurprisingly, given the choice of nomenclature, such a particle turns out to be an electron. For future use, we assign it that name here. Note, however, that we lose no generality by doing so; for now, "electron" is simply a name for the type of wave under consideration; correspondence with the laboratory electron will become obvious in subsequent derivations. So, our modelled electron, as a perceived particle, is moving slowly through space. If the underlying wave is to obey the wave equation, then, it must have a wavevector that is almost exclusively in W. Indeed, for an electron at rest as far as space goes, its wavevector must be *exclusively* in W. Such a stable wave, travelling around a closed inner dimension, cannot fail to resonate. It must, therefore, be symmetrical in W. Now, every piece of equipment we use to observe matter, whether it be biological or mechanical, is built of electrons.[7] Those electrons are symmetrical in

[7]Matter is built of nucleons too, of course, but they aren't relevant here. Protons aren't directly involved in photoabsorption and photoemission; however, *all* scientific observation involves electrons.

W, which means, due to subject-symmetric imperceptibility, that they are incapable, mathematically speaking, of distinguishing variations in W. They and therefore we are only capable of distinguishing variations in x. Hence, any electron wave $\Psi(x, W, t)$, regardless of its mathematical form, can only be observable insofar as it separates into factors that are independent of W and x respectively, as in

$$\Psi(x, W, t) = \psi(x, t) f(W, t).$$

Taking the appropriate names from quantum physics, we call ψ the *amplitude* and f the *phase factor*. The motion of the wave through space lies exclusively in $\psi(x, t)$, while the resonance lies exclusively in $f(W, t)$. Hence, assuming a constant circumference for the W dimension, the phase factor $f(W, t)$ must have a consistent form independent of kinematic behaviour. This is a fact of far-reaching consequence in all branches of physics: indeed, it is what allows us to *do* physics in the first place.

Theorem. *Separability Theorem.* A substance wave Ψ is observable to matter-based entities if and only if it is separable into an amplitude ψ, independent of the inner dimensions, and a phase factor f, independent of the outer dimensions. The amplitude is then observable; the phase factor is not.

Fortunately for physics, the inner dimensions are orthogonal to the outer, which means that everything worthy of being called either "matter" or "radiation" satisfies the conditions of this theorem. Matter resonates in the inner dimensions, which requires a phase factor independent of space. So, separation into $\Psi(x, W, t) = \psi(x, t) f(W, t)$ is always viable. Radiation, on the other hand, which travels exclusively in space, cannot resonate in the inner dimensions, so has negligible W dependency. With no inner-dimensional component, radiation is immediately expressible as $\Psi(x, W, t) = \psi(x, t)$. Both of these forms have observable amplitudes ψ.

Despite its relative triviality, the separability theorem defines quantum mechanics. Hitherto, Unity's terms have not been used, as the old paradigm makes no consistent mention of imperceptible inner dimensions, but observable amplitudes and imperceptible phase factors are nevertheless ubiquitous. They are the essence of quantum mechanics, as enshrined by Dirac and von Neumann in their axiomatic foundations [1][2]. As it stands, however, they are either taken as mere artefacts of the mathematics, or, more commonly, as expressions of the inherently probabilistic nature of physical reality. We are led to disagree most strongly with both views. To anyone thinking clearly, as Einstein did, there is no such thing as "inherent probability". God does not play dice. Probability is only ever an expression of one's information (and lack of it) regarding a certain scenario. The phase factors of quantum mechanics do not express the probabilistic nature of reality—that is essentially a naive view—rather, they express the probabilistic nature of reality as *perceived* by matter-based beings such as ourselves.

This is not an easy idea to grasp, which is why so many have fallen into the trap of assuming that quantum physics, with its "inherent probabilities", is the last word on reality. The key realisation, which emerges from, and is necessary for any understanding of, Unity theory, is that the three-dimensional space we perceive is only a *dimensionally reduced subspace* of the physical reality of the universe. This is not due to any failure to look in the right direction, nor is it due to us not having yet built a big enough collider. It is more fundamental than that. Quantum probabilities stem from the fact that matter-based entities such as ourselves cannot, and could never, perceive those inner dimensions which host the symmetrical structure of matter.[8]

2.4 Scales and the Cline Concept

Over the last hundred years, physicists have had to make a distinction between the perceptible and the imperceptible. The facts have left no other option. But the relationship between physics and imperceptibility has been and remains strained: by history, culture and indeed definition, physicists are resistant to the notion that there are elements of physical reality that are beyond the ken of the lab. In the end, however, that's just the way things are. There is no point pining for some classical utopia. Built into the very fabric of our material existence is a sharp line, enshrined in mathematical law, that divides the perceptible and the imperceptible. And a great deal of the iceberg is below the surface.

In Unity theory, we set aside half measures and embrace this idea wholeheartedly. This is the only hope for a way out of the current muddle, which rests on an outdated Newtonian idea: the assumption that space is the backdrop of reality. The physical universe, it turns out, is dimensionally deeper than space, by at least eight dimensions to three. So, we must make a sharp distinction between the eight dimensions of Unity's reality and the three dimensions of everyday perception, that is to say, between what is and what is observed. But, because of the long years, up to and including the present day, of confusing or even equating the two concepts, we must pay careful attention to the words we use. Here, we define two important terms.

⦿ Definition: *The universe.* The imperceptible eight-dimensional domain of existence, as modelled by the Unity group $U = (S^1 \times S^3)^2$. Also described, in this book, as *reality.* This is reality-as-is, or more accurately reality-as-theorised. The universe cannot be directly perceived, but can nevertheless be inferred from empirical data, and hence described mathematically.

⦿ Definition: *The cosmos.* A three-dimensional entity-in-perception, containing matter and radiation of various descriptions, modelled (usually) against a backdrop of either Newtonian or Einsteinian space. The subject of cosmology. Also described, in this book, as *perceived reality.* This is reality-as-experienced: the reality that presents itself, after a loss of dimensional information, to the perception of matter-based beings.

[8]Analogies such as "We do not see our own optic nerves" are useful, but must be treated with caution. While perception is certainly analogous to sight, it is more fundamental. If the relevant organs are working effectively, we don't see our optic nerves, hear our eardrums, taste our tongues, smell our nostrils, or feel our fingertips. Yes. But, underlying all that, the structure of matter also ensures that matter can *never* perceive its own structure, regardless of the equipment employed.

Now, a key aspect of Unity theory is the transition from the one to the other. How, in both mathematical and physical terms, does the universe proper become the perceived cosmos? In particular, what does the transition between the two mean for physics, that is to say, for the study of the physical world we see around us? To aid us in answering this question, we need some further terminology with which to analyse the transition itself. The simplest way of thinking about this is in terms of *scale*.

On the largest scales, the universe must be considered as $U = (S^1 \times S^3)^2$. However, scales at which space itself curves around into an observable sphere are beyond measurement, perhaps permanently. So, on any practical scale, the universe must be modelled not by the Lie group $U = U_x \times U_X$, but rather by the product of the Lie algebra $\mathfrak{U}_x = \mathbb{R}^4$, the tangent space of the outer dimensions, and the Lie group U_X of the inner dimensions. This gives, on all scales from the atomic up to the cosmological, $\mathbb{R}^4 \times (S^1 \times S^3)$. But, while we can, for now, set aside the very largest scales of the universe, we cannot do the same for the very small. Although the practical difference between space (x, y, z) as the Lie group S^3 and space (x, y, z) as the Lie algebra $\mathbb{R}^3$ is negligible everywhere but in grandest-scale cosmogony, the difference between the topologically closed leptonic S^1 dimension and its tangent space $\mathbb{R}$ is huge. Matter could not exist in the latter. Nevertheless, the waves that construct matter in perception must move *locally* through substance, which means that, at the highest levels of magnification, we must consider them as moving through the Lie algebra $\mathfrak{U} = \mathbb{R}^8$. In other words, at small enough scales, the universe is a perfectly symmetrical space of eight Euclidean dimensions.

In between these scales—the material and the substantial—there are two transitions. These occur at the topological scales of the leptonic S^1 and baryonic S^3 components of the inner dimensions. We notate these transitions here because, just as a word like "universe" was not precise enough in its former usage to be applied blindly in Unity theory, physical concepts such as energy, momentum and mass actively *change* their meanings at different levels of modelling.[9] This is most obvious in the case of mass, which we will define precisely in the section on quantum mechanics.

At a human scale, the concept *mass* corresponds to an "amount of stuff", an inertial resistance to motion, a generator of gravitational force, or a rest energy. Considered at the substance level of $\mathfrak{U}$, however, it cannot be so. On that scale, there is no matter. *Perceived* matter, sitting in space, only emerges in the dimensional imperceptibility of the inner dimensions. Below that level, there are only local waves. Mass does have a precise meaning down there, which we will elucidate in due course, but it is nothing like the everyday sense in which we think of mass. So, the word "mass" has a consistent meaning from cosmological scales down to atomic scales, but *not below.* At the scale of the W dimension, the meaning of the word "mass" changes.

[9]The notion of "levels of modelling" is closely related to that of physical scale, but is not identical to it. The same electron, at one scale of magnification, may be modelled, on one level, as a wave propagating through substance, and, on another, as a particle at rest. Certainly, if we zoom in far enough, all particles become waves, and if we zoom out far enough, all waves become particles. But not all transitions take place at the same scale of magnification. Hence, care is needed.

⦿ Definition: *Cline.* A scale at which the meanings of concepts change rapidly.

So, the leptonic or W-cline is the length scale, and hence mass-energy scale, of the leptonic W dimension, and the baryonic or X-cline is the length scale, and hence mass-energy scale, of the baryonic (X, Y, Z) dimensions. Now, it is obvious, since the electron has a far smaller mass than the proton, that, as we zoom in, we reach the leptonic cline long before we reach the baryonic. In other words, the W dimension is much bigger than (X, Y, Z). Summarising these transitions, zooming in rightwards through the scales of the universe, we have:

$$\underbrace{(S^1 \times S^3)^2}_{\text{Universal scale}} \overset{\text{Universal Cline}}{\longrightarrow} \underbrace{\mathbb{R}^4 \times (S^1 \times S^3)}_{\text{Human scale}} \overset{\text{Leptonic Cline}}{\longrightarrow} \underbrace{\mathbb{R}^5 \times S^3}_{\text{Subatomic scale}} \overset{\text{Baryonic Cline}}{\longrightarrow} \underbrace{\mathbb{R}^8}_{\text{Substance scale}}$$

$\longrightarrow$ Increasing magnification $\longrightarrow$

The cline concept allows us to understand many features of quantum physics that have hitherto proved paradoxical, such as *wave-particle duality.* An electron, when viewed at a human scale, is a particle moving around in space, but, when viewed at a subatomic scale, it is a wave moving in (x, y, z, W) space-plus. This is no paradox. The problem has arisen from a misapplication of theory, specifically, the use of concepts beyond their domains of validity. For an electron, the concept "particle" has no meaning below the W-cline; a "particle" is something an electron is when it is viewed in perception. Below the W-cline, an electron is a wave. In Unity theory, which is Continuous by definition, the concept "particle" is a secondary one, which only emerges at certain relatively wide scales of magnification. Particles are perceived entities that live in space; the waves that generate them are more fundamental.

The "paradox" of wave-particle duality is analogous to what we might term the *sandcastle paradox.* An enthusiastic child builds a huge sandcastle. Sometime later, a physicist walks up the beach, and sees the sandcastle from far off. It is an eminently recognisable thing. "A sandcastle!" he exclaims.[10] And the edifice remains recognisably attachable to that same word as he approaches. It remains so at every scale of magnification, until, that is, he zooms in closer than the scale of the castle itself. Confusion over wave-particle duality is the confusion of the physicist as he thrusts his face into the sand, crying "The castle must be in here somewhere!"

But the mistake, of course, is assuming that the word "sandcastle" has a meaning at all levels of magnification. It doesn't. Close enough in, there is no sandcastle. It is not that anything has vanished—the sand with which the child built the castle still exists—but simply that the *configurations* of sand to which the word "castle" refers have no detail below a certain level. Wave-particle duality is very real, and there is as much paradox in it, i.e. none, as there is in the sand-sandcastle duality on the beach.

[10] At various points, gendered pronouns are used in this book. Masculine pronouns are used exclusively to refer to the *problems* associated with our society's patriarchal way of thinking, such as the hypostatising of concept described here. The implication is that the biggest fools are mostly men.

2.5 The Fine-Structure Constant

The existence of two inner components, the leptonic S^1 and the baryonic S^3, implies the existence of a dimensionless constant reflecting the difference in scale between the two. There is only one viable candidate for this: the fine-structure constant $\alpha \approx \frac{1}{137}$. As many physicists have noted, α appears so frequently in fundamental equations that it must have some major physical significance. We propose here, with a large degree of confidence, that, at low energies, the leptonic W dimension has a circumference some 137 times larger than the baryonic (X, Y, Z) dimensions.

Conjecture. *The fine-structure constant.* The constant α represents the scale factor between the circumferences of the S^1 and S^3 components of the inner dimensions:

$$\alpha = \frac{|X|}{|W|} \approx \frac{1}{137}.$$

There are many reasons for proposing this conjecture. First among them, and enough to inspire considerable confidence on its own, is the ratio of the strengths of the electromagnetic and strong interactions, which is $\alpha \approx \frac{1}{137}$. Since Unity dictates that these interactions are, at the local substance level, the same, their relative strengths can only stem from the sizes of the relevant inner-dimensional components, i.e. from global rather than local considerations. Electromagnetism is the force associated with the leptonic S^1 component; the strong interaction is the force associated with the baryonic S^3 component. The ratio of strengths, we are bound to conclude, is the ratio of sizes.

Further corroboration comes from the masses of the particles of the Standard Model, in particular the electron-pion and electron-proton mass ratios. We will investigate these fully later in this book, and can consider them tests, enacted at that stage, of the conjecture presented here. The conjecture will be seen to pass the tests, hence our confidence in it. The only reason for its conjectural nature is that, as in all quantum calculations involving spinors, it is not beyond the realms of possibility that, for example, a factor of two sneaks in somewhere, and that the ratio of circumferences is, in fact, $\frac{1}{2}\alpha$. This is highly unlikely, but it should be noted, for future work, as a possibility. Either way, it makes little difference to the fundamental content of the conjecture. In Unity theory, it is more or less certain that the fine-structure constant represents a circumference scale factor between inner-dimensional components.

The predicted and measured "running" of the fine-structure constant, in which the value of α is higher at high energies, is in agreement with this conjecture. While we may assume that the inner dimensions are consistently sized in *vacuum*, we also know that energy disturbs substance. Indeed, energy *is* the disturbance of substance. At low energies, those disturbances are approximately linear, following $\Diamond\Psi = 0$. They are small ripples on a pond. But at high energies, they are nonlinear, and the global structure of the dimensions must be affected. Since the leptonic and baryonic components differ in their topology, it is to be expected that such nonlinearity will affect them differently, thus altering the scale factor between the two. This must manifest as a running of α.

2.6 The Wave of the Present

There is one more major conceptual element of Unity theory which we must address before we can proceed with a derivation of quantum mechanics. This is the spatial time axis w, which we have so far set aside. We have proposed that, at the scale of matter, the universe manifests as $\mathbb{R}^4 \times (S^1 \times S^3)$. The outer dimensions, at this scale, are Euclidean: $\mathfrak{U}_x = \mathbb{R}^4$. But space, as we know, has *three* dimensions, not four. Now, the reason for inner imperceptibility is obvious, in light of the symmetry of matter. It is less obvious, however, how a *large* dimension could come to be imperceptible. If the outer dimensions are (w, x, y, z), how come we only perceive (x, y, z)?

It turns out that the existence of an outer w dimension is every bit as structurally necessary for, and hence entirely imperceptible in, our everyday experience as the inner dimensions are. We will see how shortly. But the underlying fact is exactly the same one as before: any dimension which goes into the *construction* of the phenomenon "matter" cannot be perceived by entities built of it. A sandcastle is no use as a piece of perceptual apparatus, if the task is to measure sand.

Matter-based beings cannot perceive matter itself, only ever *variations* in matter.

We know that we, as matter-based beings, cannot perceive the inner dimensions, because we are symmetrical in them. However, matter cannot be symmetrical in a macroscopic outer dimension. This is clear from the fact that matter is capable of acceleration. To be symmetrical in the w dimension, we would need to stretch all the way around the universe. Clearly, we don't. Our extent in w cannot be large. But it is also physically impossible, due to Continuity, for us to have no extent in the w dimension. Nothing is infinitely thin. So, according to Unity theory, only one option remains: we must have a *finite but small* extent in the macroscopic outer dimension w. We denote this small extent δw.

But how is it possible for this dimension to be imperceptible to us? There is exactly one way. If we have an extent and therefore variation in w, our lack of awareness cannot be due to subject-symmetric imperceptibility. Nor, trivially, can it be due to object-symmetric imperceptibility. So, it must be due to *matched-variation* imperceptibility. The only formulation in agreement with the phenomena is if every piece of stable matter in the cosmos has the same variation in w, i.e. the same finite but small extent δw.

Now, remember that matter, at the substance level, is a wave. And our perceived reality is made of matter. And all matter has the same small extent in the w dimension. Together, this tells us that there is a macroscopic disturbance of substance, cosmic in extent, containing all observable matter and radiation, with a consistent front-to-back thickness δw. In other words, everything we see, everything we can possibly perceive, must be part of a single wave.

Theorem. *The wave of the present.* Assuming the axioms of Unity theory and the evidence of perception, all stable matter and radiation must form a single wavepacket, whose profile in w is, to a good approximation, consistent.

⦿ Definition: *The present.* A physical wave with a thickness modelled initially as δw, progressing in the w direction. In Unity theory, the present is a physical entity existent in exactly the same way a proton or electron is existent: as a configuration of substance. The present is the non-static physical entity that is subsequently perceived, by its sub-configurations, as a static cosmos.

⦿ Definition: *Progress.* As distinct from motion. Progress is movement in w, motion is movement in (x, y, z).

To grasp this concept takes some effort, but not all that much. After all, we are quite used to the idea that we don't perceive consistent motion. We don't feel the movement of trains in which we are sitting still. We don't feel the spinning of the Earth, despite the fact that we are whipping around at some thousand miles an hour. So why should we feel the movement of all matter in w? The answer is, we shouldn't. Space itself, as it turns out, is the most almighty of train carriages.

However, while it's obvious why the *progress* of the wave of the present, as a speed, should be imperceptible, it's less obvious why the *dimension* of progress should be so. After all, in a train, while we are unaware of motion, we aren't unaware of the parallel-to-track dimension of the carriage. The challenge, as ever, is to step outside one's own perception, and to infer, recognise and take on a broader point of view. This is the challenge that human beings so regularly fail to attempt; it is very far from biologically natural to think in this way.

Let us endeavour to do so. Suppose, in line with our reasoning so far, that every proton, neutron and electron has the same wave profile structure in w. Could protons, neutrons and electrons ever perceive that profile? Simply, no. How could they? It would be like a barley stalk, two feet tall in a field of barley stalks two feet tall, trying to find out its height by looking at its neighbours. The relevant information simply isn't to be had that way. Barley cannot measure barley; only something external can. And we are emphatically *not* external observers of the wave of the present. We and it are built of matter. We are its crests. We are it, no less. And, since any trait shared by all matter is imperceptible to us, so the dimension of progress w is imperceptible to us.

Now, the above argument doesn't guarantee that the wave of the present exists. There are, in fact, many pressing reasons which we will come to soon supporting our assumption of the existence of the wave of the present. But, as yet, we have offered no such justification. The discussion above simply serves to show that the existence of such a wave, while undoubtedly surprising, is entirely commensurate with the facts of everyday perception. It may be difficult to imagine the wave of the present, yes, but denial by incredulity—*Clearly there are only three macroscopic dimensions!*—just isn't logically valid.[11] In fact, a coherent wave of the present is precisely the formulation that *reconciles* the data of everyday perception with the existence of a macroscopic outer dimension beyond the three of space.

[11] David Bohm gave a careful analysis of the emergence of perceived reality *as a model* in an appendix, entitled "Physics and perception", to his book The Special Theory of Relativity [3].

The wave of the present is an essential part of Unity theory. Indeed, it is the concept of the wave of the present that resolves many of the conundra of modern physics: the existence of the quantum itself, the classical transition, the nature of the weak interaction, symmetry breaking, proton mass, the value of the weak mixing angle, the generations of the Standard Model, matter/antimatter asymmetry, chirality and $\mathcal{CP}$-violation. In fact, such is the level of validation that the concept of the wave of the present receives from experiment that, even were the axiom of Unity falsified, it would stand regardless.

2.7 Speed of Propagation

The existence of the wave of the present necessitates an immediate rethink of the speed limit of the universe. It is established beyond all reasonable doubt that the speed limit of the perceived cosmos is c, the speed of light. However, this doesn't mean that the speed limit of the *universe* is c. Indeed, the progress of the wave of the present implies that it cannot be so.

⦿ Definition: *Coprogression.* Progress at the same speed as the wave of the present.

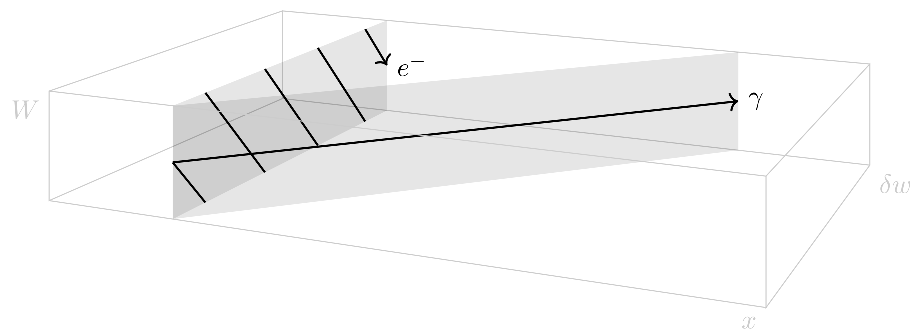
We know that all stable matter and radiation coprogresses, as only this fact can ensure the imperceptibility, such as is evident, of the dimension of progress. Hence, for the hypothesis of the wave of the present to function at all, there must be a specific value of speed of progress which is shared, to very high levels of consistency, by all stable matter and radiation. We denote this speed of progress b. The approximate value of b will be determined in subsequent derivations.

Consider a light wave, travelling through the cosmos at c. According to Unity theory, this velocity c is, in fact, a *relative* velocity, relative to the wave of the present. The present itself moves orthogonally to the cosmos. Setting aside the inner dimensions for now, its wavevector is in $\hat{w}$, denoting a unit vector in the positive w direction, while its wavefront is in (x, y, z). The former is the imperceptible dimension of progress, the latter are the perceptible dimensions of space. Light moves at c through space, and space moves at b through substance. As a substance wave, light must move at the universal speed of propagation a. Hence, we know that $a^2 = b^2 + c^2$. The true speed of light is in fact a, but the b component of this speed is imperceptible; it is shared by all observers, who necessarily coprogress.

Again, despite the seemingly revolutionary nature of the claim that the speed limit of the universe is greater than c, this is in perfect agreement with the experimental fact that elements of the cosmos have an upper speed limit of c. All waves travel faster than c, at a, but, in order to remain within the present, a coprogressing speed of b is required, orthogonal to space. This is equally true of matter as of radiation. To coprogress, light must travel through space at c; likewise, to coprogress, a resting electron must travel in the leptonic W dimension at c. So, according to Unity theory, all coprogressing waves must travel at c within $\mathbb{R}^3 \times U_X$, which is the wavefront space of the wave of the present. This is in full agreement with the empirical facts.

In theoretic terms, the progress of the present necessitates two modes of modelling. Firstly, we may work relative to the substance of the universe. In that mode, the universe is $\mathbb{R}^4 \times U_X$, through which domain all waves travel at a. Secondly, we may work relative to the present. In that mode, the universe is $\mathbb{R}^3 \times U_X$, through which domain all waves travel at c. Note that this choice of mode has nothing to do with physical scale, unlike the cline concept. The choice of mode depends on the topic under consideration. Now, it turns out to be the theory of the neutral-current weak interaction that describes the w dimension; hence, when it comes to discussing that interaction, we must work against a backdrop of $\mathbb{R}^4$, with a raised speed limit a. However, if we are considering the other interactions, then we can safely ignore the dimension of progress, working against a backdrop of space $\mathbb{R}^3$, with the standard speed limit c.

Below is a view, looking broadly in the direction of progress w, of the substance waves underlying an electron and a photon. The entire cuboid can be thought of as a representation of the wave of the present, moving into the page. Space is laid out across the page in x, the dimension of progress w stretches forwards, and the inner dimensions, here represented by W, are represented in the vertical thickness of the cuboid. We will use this type of visualisation, from the point of view of a hypothetical non-material observer, extensively.



The grey rectangle within which the wavevector of the electron travels is experienced as a single point in space x. The electron is perceived to be at rest, while the photon is perceived to travel rightwards through space x. Both waves travel at the same speed, and have the same component in w. The two unit wavevectors $\hat{e}$ and $\hat{\gamma}$ are defined by

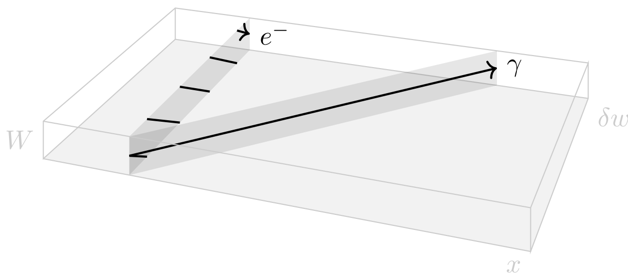
$$a\hat{e} = b\hat{w} + c\hat{W},$$
$$a\hat{\gamma} = b\hat{w} + c\hat{x}.$$

In Unity theory, all stable matter and radiation must share the same component in w, defined by the ratio between the speeds of progress b and propagation a. This commonality prompts a further definition.

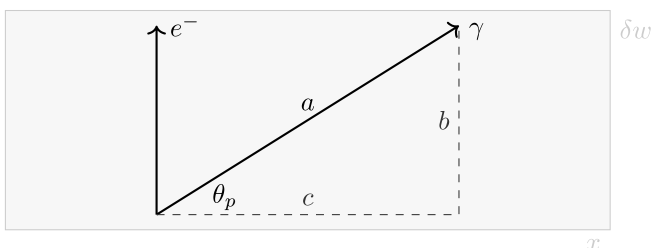
⦿ Definition: The *angle of progress, θ_p*, is defined such that

$$\sin\theta_p = \frac{b}{a}.$$

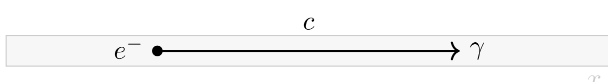
The angle of progress is the angle at which a particle's wavevector is angled towards w. This angle is shared by all coprogressing matter and radiation. It defines the transition between the modes of modelling $\Diamond_a\Psi = 0$, as represented in the above diagram, and $\Diamond_c\Psi = 0$, which is a dimensionally reduced version of the same. It allows us to express the wavevectors of electrons and photons succinctly, as $\hat{e} = \sin\theta_p\hat{w} + \cos\theta_p\hat{W}$, and $\hat{\gamma} = \sin\theta_p\hat{w} + \cos\theta_p\hat{x}$. To bring it out, we can visualise ourselves rising above the wave of the present, like birds above an ocean swell.



Completing the transition, we eliminate the inner W dimension entirely, yielding a plan view of the (w, x) plane, i.e. a picture of the outer dimensions. The photon is now like a surfer, traversing the wavefront of the present at speed c, while the "resting" electron ticks over in W. The photon's energy moves it through space, while the electron's gives it mass.

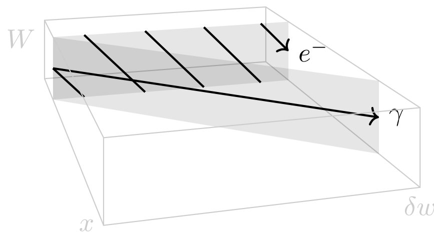


Equivalently, if w is seen as running along a motorway, then kinetic energy, such as the photon has, is that of a car changing lanes, while rest mass, such as the electron has, is the constant inner whirring of the engine. Both photon and electron have energy in w—progress forwards along the road—which, being shared by all stable waves, is imperceptible to matter-based beings such as ourselves; this is the energy that we ignore when we subsequently project out the w dimension, to work in the $\Diamond_c\Psi = 0$ mode. Finally, when W is lost in perception, the cosmos is flattened into $\mathbb{R}^3$:

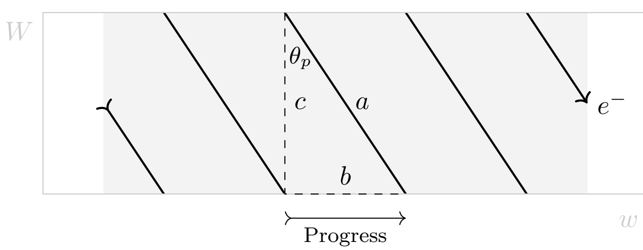


Much of the cognitive load involved in working with Unity theory is that of transitioning between levels of modelling, as above. The real challenge is *reversing the process*, inferring back from the dimensions of space to the broader pictures beneath.

Another important projection is that which removes space from the picture altogether, thus bringing out the structure of resting matter. We visualise ourselves sinking into the wave itself, taking a cross-section and hence looking at the wave of the present laterally, as if through the glass of a wave tank.



Completing this projection, we get a picture of the inner/outer structure of a perceived zero-dimensional point in space. A photon, which has no single location in space, cannot be depicted on such a diagram, but an electron at rest can. The resulting picture goes a long way to bringing out the structure of the wave of the present, as it pertains to matter-based entities such as ourselves. It is conceptually accurate to visualise the below not just as a diagram of an electron, but also as a diagram of a human being. It contains all of the essential features generating human perception.[12]



The limitations of our matter-based perception are seen most clearly when we continue the projection, and recast the above picture of the physical nature of the electron as it appears to us in perceived reality. Subject-symmetric imperceptibility projects out the W dimension; matched-variation imperceptibility projects out the w, and what is left? A two-dimensional plane becomes a zero-dimensional point, i.e. a "fundamental" particle, such as has been the basic element of study in physics for some centuries now:

$$e^- \bullet$$

Our task is to go backstage, beyond perception. The vast majority of the mathematical work in this book lies *within* the zero-dimensional dot depicted above.

[12] In these diagrams, while we may depict wave motion with arrows representing the substance-level wavevectors of particles, note that there is no sense in which the waves are only present at the transverse locations of those arrows. In these diagrams, the electrons fill the grey rectangles. An electron wave has a beginning and an end in w (smoothly continuous in reality, although stylised here to sharp-edged), but fills the (w, W, X, Y, Z) thickness of the present in between.

3 Unity and Quantum Mechanics

Quantum physics provides some of the most telling evidence for the validity of the Unity paradigm. In this section, we aren't looking for new results; rather, we are attempting to derive quantum mechanics from the first principles hitherto set out. This can be seen as a stringent test of entire structure of Unity theory. As it stands, the equations of quantum mechanics (and, therein, special relativity) have no prior justification. The Schrödinger equation, as Feynman said, "came out of the mind of Schrödinger" [4]. Special relativity and the Dirac equation arrived in a similar manner. Einstein gave the Lorentz transformations a philosophical footing, and that footing led, in time, to Dirac's famous equation. But none of these results are justified in theoretic terms. There is no *a priori* reason why the speed of light should be measured to be the same by all observers; hence, special relativity is itself without real justification. Mathematically, it is certainly correct, yes—at least in its proper domain of validity—but that is another matter. It is the *why* of things that is missing in QM.

Why is matter quantised? What is the physical meaning of the Planck constant? What is mass? What is spin? What is a wavefunction? What is antimatter? What is *Zitterbewegung*? Why does the Schrödinger equation hold? Why does $E^2 = p^2c^2 + m^2c^4$ hold? Why does the Dirac equation hold? Precisely *when* do these things hold? There are no satisfactory answers to these questions in the old paradigm. Indeed, there are really no answers to them at all.

So, the first test of Unity theory is this: we must produce coherent answers, based on the first principles already described, to all of the above. This won't, of course, produce "new physics", viz. new equations that can be tested in the lab. That will come later. For now, our task is to derive quantum mechanics, in the form—exceptionally well validated—in which has existed for nearly a hundred years. This is not a test of the type physics has recently tended to set itself, but it is nevertheless an extremely tough one. Consider, for example, a) the Schrödinger equation of non-relativistic quantum mechanics and b) special relativity. These, in the current paradigm, are unrelated: the Schrödinger equation is what you get when you *ignore* the effects of Einstein's special relativity. But, as we will see in this section, the axiom of Unity and the wave equation $\diamondsuit_a \Psi = 0$ produce *both*, in precise mathematical form. To ascribe that to coincidence would be most unscientific.

The theoretic structure proposed hitherto in this book is not fine-tunable. Indeed, adjustment of any kind is almost impossible; Unity explicitly outlaws tweaking. Likewise, the topologically nontrivial nature of matter which emerges is fixed. Given Unity, the electron configuration proposed in the last section is the only logically viable one. And that structure, as we will now show, generates and therefore makes sense of relativistic quantum mechanics in its entirety. In light of this fact, it really makes no difference whether Unity theory makes any new predictions or not. Current physics has no quantum derivations: the equations must simply be quoted. Therefore, if the arguments given in this section have any kind of validity, then Unity theory, in its overall structure, should be considered verified at the expense of the spatial paradigm.

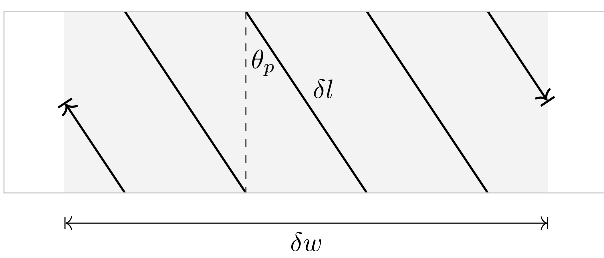
3.1 The Quantum

At the substance level, an electron is a wave. It has a specific resonant frequency, which is dictated by the size of the W dimension, and, just as with light, the energy of the electron wave must be proportional to this frequency. As with all waves, the higher the frequency, the more energetic. In mathematical terms, energy is proportional to the time derivative as an operator, as in $\hat{E}^2 = k^2 \frac{\partial^2}{\partial t^2}$. The squares allow us to model all waves, whether real- or complex-valued. At the substance level, before attempting any link with the classical lab, we set $k^2 = -1$, thus giving energy units of frequency, Hz. This is the substance-level definition:

$$\hat{E}^2 = -\frac{\partial^2}{\partial t^2}.$$

Such substance-level frequency isn't observable, however. We humans can only observe things at the classical level, as particles. The electron wave's energy, at that stage, has become a "potential to do classical work", or else something equivalent, given in Joules. This classical energy is no longer a rate of change; it is an amount. The transition between the two is the transition up above the leptonic cline, as defined earlier, and the word "energy" changes its meaning in the transition. To answer the major question of quantum physics—*What is the quantum?*—we must see how this transition generates seemingly hard quantisation.

In Unity theory, it becomes clear why this change happens in a consistent way not only between electron and electron, but between all matter and radiation. According to the theory of the wave of the present, every stable matter wave and every stable radiation wave has the same wavetrain length δl, which, to a first approximation, is defined by the thickness of the wave of the present δw and the angle of progress θ_p. The same length δl appears in all stable and metastable matter and radiation, because all such coherent energy must coprogress, sharing the same angle θ_p. Depicted here is the case of a resting electron:



Since every stable and metastable particle has the same length δl, we know that, for any given substance level energy, as defined by the differential operator $\frac{\partial}{\partial t}$, there is a specific quantity of wave, defined by the length δl and $|U_X|$. The thickness of the present, front-to-back in the direction of progress w, dictates that every single subwave of the present partakes of precisely the same energetic scale factor. In other words, the thickness of the wave of the present dictates energy *quantisation*.

Now, this quantisation is not, as we have depicted it here, due to a step function's hard cutoff. There are no such things in nature. In fact, our electron wave rises from and sinks back into substance continuously, in exactly the manner of an ocean swell passing under a fishing boat. Nevertheless, the *integral* of the substance-level energy of the electron over δl must be finite. The precise details of the wave profile are of no consequence here, because 1) all stable matter partakes of precisely the same structure, and 2) that structure is summed in perception. In proportion to frequency, all matter and radiation must sum identically. The total amount of classical energy in such waves must, therefore, be proportional to time-derivative energy, with a common constant of proportionality, shared ubiquitously. It was, of course, Planck who first identified this phenomenon. The quantum energy operator, for either real- or complex-valued waves, is duly given by

$$\hat{E}^2 = -\hbar^2 \frac{\partial^2}{\partial t^2}.$$

So, what is the physical interpretation of $\hbar$? Simple. The Planck constant is an expression, in appropriate units, of the w-extent of the present. Were the present deeper in w, the Planck constant would be larger. Indeed, the Planck constant is the answer, in a certain sense, to an old riddle in the philosophy of time: "For how long does the present last?" The answer, in purely temporal terms, is, of course, no time at all: now is instantaneous. But in w? In the *spatial* time dimension? That's a different matter. Physically, the present has a small but non-zero extent in the dimension of progress. The Planck constant, it turns out, is the orthogonal *thickness* of our perceived reality.

3.2 Fermions and Bosons

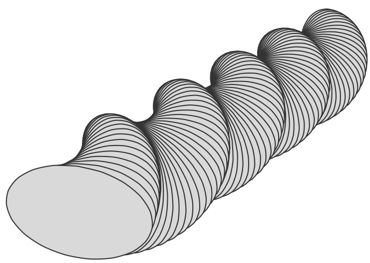
The presence of the complex unit i in the fermionic definition of energy $\hat{E} = i\hbar\frac{\partial}{\partial t}$ has long been a bone of contention in attempted interpretations of quantum mechanics. That is because, in the old paradigm, it has been impossible to tell what a quantum wavefunction *is*. Hence, discussions of its complex-valuedness have mostly gone round in circles. Quantum mechanics *assumes* complex value axiomatically, which of course denies it any opportunity of giving a reason for complex value. Unity theory, however, is restricted by no such problem.

To address the complex- or real-valuedness of $\Diamond\Psi = 0$, we must step outside the linear model represented by $\Diamond\Psi = 0$, and consider the underlying nonlinear substance equation $R_8 = 0$. The linearity of quantum mechanics is, after all, only an approximation: nothing in the universe is truly linear. So, precisely what types of wave solution does $R_8 = 0$ permit? Well, the Ricci scalar R_8 expresses, as a single real number, the size of a local, eight-dimensional hypervolume element, and the substance equation $R_8 = 0$ duly says: "There is a constant density of substance everywhere." So, we are looking for propagating disturbances of substance that conserve local density. There are two main families of solutions, which we lay out here.

The first involves dimension-wise expansion and contraction. $R_8 = 0$ doesn't rule out dimension-wise changes in density, since it sums locally over all dimensions.

Expansion in one dimension is permitted, so long as it is offset by contraction in another. This type of solution is already well known in physics: the gravitational waves in general relativity. Gravitational waves are the prototype of the first kind of waves, in which dimension-wise expansion and contraction of substance are traded off against one another.

⦿ Definition: *Exchange wave.* A disturbance of substance involving expansion and contraction, which forms a solution to $R_8 = 0$ by dint of a trade-off between the two. General-relativistic gravitational waves are examples of exchange waves.



Here, the nearest ellipse represents an area element at a single location. The trade represented is an expansion of substance horizontally, exchanged against a contraction of substance vertically. The same cross-section is repeated everywhere, with subsequent rotation. For small disturbances, in the linear approximation, $R_8 = 0$ is satisfied.

How is such a wave described mathematically? Well, since it has two dimensions of polarisation, it requires two codomain/output dimensions. The obvious representation is as a complex-valued function. Hence, the above diagram, if taken as propagating in space, depicts the physical reality underlying a standard quantum amplitude $\psi : \mathbb{R}^2 \to \mathbb{C}$, with the complex plane of the outputs giving the orientation of the expansion/contraction axes. Such an amplitude is given algebraically as

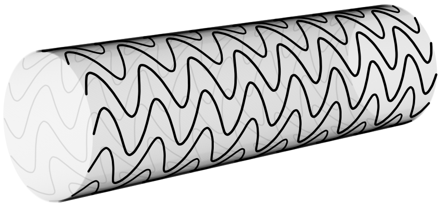
$$\psi(x, t) = e^{i(px-Et)/\hbar}.$$

Alternatively, there are waves that involve *no* expansion or contraction. Here, the possibilities are fairly limited. If substance is to shear—the type of transformation that turns a rectangle into a parallelogram—without incurring any expansion/contraction, then every point in a given dimension must shear identically. This is only possible with polarisation in the closed inner dimensions.

⦿ Definition: *Shear wave.* A substance wave involving no expansion/contraction.

In such a wave, substance is displaced around a closed, inner dimension. Such waves form solutions to $R_8 = 0$ by dint of the fact that, in displacing entire inner dimensions, substance undergoes no expansion, even component-wise. The substance equation is satisfied by default. There are no stretched area ellipses, as shown in the exchange wave above; rather, there are shearing *displacements* of substance.

We can depict such shear-rotational displacements by drawing gauge markers on the relevant inner dimension. In the context of quantum mechanics, that dimension is W. At zero energy, these gauge markers are straight lines, $W = 0$. They then curve as a wave passes. Nothing expands; substance only bends. These waves have one-dimensional polarisations, as opposed to the two-dimensional exchange waves, and are, therefore, described mathematically by real-valued sinusoids. Below, we represent a *light wave*, which is a shear wave rotating the leptonic W dimension:



Exchange waves tend to require polarisation in open outer dimensions, while shear waves require polarisation in closed inner dimensions. Hence, by the orthogonality of transverse waves, exchange waves tend to have wavevectors in the inner dimensions, while shear waves tend to have wavevectors in the outer dimensions. Exchange waves, therefore, tend to be massive, while shear waves tend to be massless.[1] We are brought to a conjecture, of whose validity we can be more or less certain:

Conjecture. *Fermions and bosons.* Single exchange waves manifest as fermions; single shear waves manifest as bosons.

This fact solves a number of longstanding puzzles regarding the characteristic behaviours, both mathematical and physical, of fermions and bosons. We lay them out explicitly here, as they constitute verification of the conjecture given above. For clarity, we refer to the prototype examples of the electron and the photon, but the arguments generalise easily.

Electrons

1. Electrons are massive and charged because their wavevectors have components in W, which resonate. With wavevectors in the inner dimensions, electrons must be polarised in space.

2. Electrons do not superpose linearly, as their waves undulate the fabric of space. Two electrons feel a mutual repulsion, because their outer-dimensional polarisations destroy each other's coherence, making approach energetically unfavourable.

3. Electrons, considered as particles in space, have nontrivial topologies, because their wavevectors wind around the W dimension. Since they are topologically nontrivial, Dirac's tethering argument applies. Hence, electrons have half-integer spin.

4. Summarising the above, electrons are massive, charged, spin-$\frac{1}{2}$ particles, which obey the Pauli exclusion principle.

[1] There are exceptions to both of these rules, which we will analyse in due course. Most matter is constructed of fermionic exchange waves, but, as it turns out, not all. In particular, we will propose a massive, negatively charged *boson*, closely related to the electron, which, bound to a proton, contains the negative charge of a neutron. This particle defies simple classification in the old paradigm.

Photons

1. Photons are massless and neutral because their wavevectors are spatial, allowing no resonance. As shear waves, photons are polarised in the inner dimensions.

2. Photon waves superpose linearly, as they do not warp the fabric of space. Two photons feel no mutual repulsion, because their inner-dimensional polarisations are orthogonal to space, making approach energetically neutral.

3. Photons, considered as particles in space, have trivial topologies, because their wavevectors do not wind around the W dimension. Since they are topologically trivial in space, Dirac's tethering argument does not apply. Hence, photons are spin-1.

4. Summarising the above, photons are massless, neutral, spin-1 particles, which don't obey the Pauli exclusion principle.

The above facts, generalised to all relevant wave-particles, dictate that massive exchange waves, which are spin-$\frac{1}{2}$, obey the Pauli exclusion principle and therefore follow Dirac-Fermi statistics, while massless shear waves, which are spin-1, don't obey the Pauli exclusion principle and therefore follow Bose-Einstein statistics. This is the content of the spin-statistics theorem of quantum mechanics.

3.3 The Schrödinger Equation

The Schrödinger equation governs the motion of slow-moving electrons [5]. We now know the structure of such particles. Working relative to the wave of the present, a slow-moving electron is formed of an exchange wave, polarised in two dimensions of space, whose wavevector is almost exactly in the W direction. According to $\Diamond_c \Psi = 0$, the electron wave must be moving at c, and only a very small component of that speed can be in space x. Now, the wavefunction describing the electron's behaviour must, as described above, be a complex-valued helix. Working in one dimension of space for ease of visualisation, this is a function

$$\Psi(x, W, t) : \mathbb{R} \times S^1 \times \mathbb{R} \longrightarrow \mathbb{C}.$$

The separability theorem tells us that such an electron wave is only observable insofar as it can be expressed as $\Psi(x, W, t) = \psi(x, t) f(W, t)$, where ψ is the perceptible amplitude and f the imperceptible phase factor. Furthermore, since our wave must travel almost exclusively in W, at the speed of light c, the phase factor must take the form $f(W - ct)$. And this phase factor must be resonant in W. This requires the form

$$\Psi(x, W, t) = \psi(x, t) e^{i\mu(W - ct)},$$

where μ is an angular frequency dictated, in order to achieve resonance, by the circumference of the W dimension. Clearly, μ is a measure of the electron mass, and must be proportional to it: the smaller the circumference of W, the higher the angular frequency and the higher the rest energy of the resonance. The particular value of this constant of proportionality must be dictated by experiment. Naturally, it contains the Planck constant $\hbar$. In fact, $\mu_e = mc/\hbar$. Overall, then, our electron wave is given by

$$\Psi(x, W, t) = \psi(x, t)e^{imc(W-ct)/\hbar}.$$

This wave must satisfy the wave equation $\diamondsuit_c\Psi = 0$, which, in this case, is

$$-\frac{1}{c^2}\frac{\partial^2\Psi}{\partial t^2} + \frac{\partial^2\Psi}{\partial x^2} + \frac{\partial^2\Psi}{\partial W^2} = 0.$$

First, we calculate the derivatives. Using the chain and product rules, the second time derivative is given by

$$\frac{\partial^2\Psi}{\partial t^2} = \frac{\partial^2\psi}{\partial t^2}e^{\bullet} - \frac{2imc^2}{\hbar}\frac{\partial\psi}{\partial t}e^{\bullet} - \frac{m^2c^4}{\hbar^2}\psi e^{\bullet},$$

where $e^{\bullet}$ represents the exponential phase factor. The x and W derivatives are easier, as each variable appears only once. The second space derivative is

$$\frac{\partial^2\Psi}{\partial x^2} = \frac{\partial^2\psi}{\partial x^2}e^{\bullet},$$

and the second inner-dimensional derivative is

$$\frac{\partial^2\Psi}{\partial W^2} = -\frac{m^2c^2}{\hbar^2}\psi e^{\bullet}.$$

When we substitute all of these into the wave equation, the phase factors go, and with them all trace of the inner W dimension. We are left with

$$-\frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2} + \frac{2im}{\hbar}\frac{\partial\psi}{\partial t} + \frac{m^2c^2}{\hbar^2}\psi + \frac{\partial^2\psi}{\partial x^2} - \frac{m^2c^2}{\hbar^2}\psi = 0.$$

The terms in ψ cancel as expected, yielding

$$-\frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2} + \frac{2im}{\hbar}\frac{\partial\psi}{\partial t} + \frac{\partial^2\psi}{\partial x^2} = 0.$$

But only one term in this equation makes mention of c. For slow-moving matter, the left-hand term, with its factor of $\frac{1}{c^2}$, must be negligible compared to the other two. Removing it, and rearranging a little, we get

$$i\hbar\frac{\partial\psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2},$$

which is the Schrödinger equation for a free particle in one dimension. From here, no further justification is required to extend to three dimensions with ∇ and import a $V\psi$ term representing any external potential. This yields the full Schrödinger equation:

$$i\hbar\frac{\partial\psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\psi + V\psi.$$

3.4 Operator Definitions

The algebraic form of the Schrödinger equation brings out the operator definitions of energy and momentum, which are so central to quantum mechanics. For fermionic exchange waves, the energy in a stable particle is given by the operator

$$\hat{E} = i\hbar\frac{\partial}{\partial t},$$

which produces the energy of a helical wave as an eigenvalue, in the manner of

$$i\hbar\frac{\partial\Psi}{\partial t} = E\Psi.$$

For instance, consider our original electron wave

$$\Psi(x, W, t) = \psi(x, t)e^{imc(W-ct)/\hbar},$$

such as generated the Schrödinger equation. Applying the energy operator $\hat{E}$ to the observable amplitude $\psi(x, t)$, we get the Schrödinger equation as before, which can now be seen as expressing the total observable energy (of a non-relativistic wave) in terms of the kinetic and potential energies

$$\underbrace{i\hbar\frac{\partial\psi}{\partial t}}_{\text{Total}} = \underbrace{\frac{-\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2}}_{\text{Kinetic}} + \underbrace{V\psi}_{\text{Potential}}.$$

The above is standard practice. What we can do now, however, beyond standard practice, is to produce a mass operator, by applying the energy operator to the phase factor, which in our case is not merely an imperceptible artefact of the mathematics but corresponds to an element of physical reality. The phase factor is the resonant *engine* of a particle. It contains the mass. It *is* the mass, indeed. Now, we can bring that out with $\hat{E}$, as in

$$i\hbar\frac{\partial}{\partial t}\left(e^{imc(W-ct)/\hbar}\right) = i\hbar \times \frac{-imc^2}{\hbar}\left(e^{imc(W-ct)/\hbar}\right),$$

which simplifies to Einstein's famous mass-energy equivalence

$$E = mc^2.$$

Such is still familiar from old quantum mechanics. But we can now express the same thing as an *inner-dimensional* derivative, mass being simply the energy contained in the inner component of a substance wave. This is the energy, orthogonal to space, that makes matter into matter. In the case of an electron, and in quantum mechanics generally, it is the energy in the leptonic W dimension. Just as momentum and kinetic energy are x derivatives, W-momentum and leptonic mass-energy are W derivatives. Now, alignment with classical physics dictates that the momentum operator $\hat{p}_x$, still working in one dimension for clarity, be defined as

$$\hat{p}_x = -i\hbar\frac{\partial}{\partial x}.$$

Applying the same form, but now with an inner W derivative, yields

$$-i\hbar\frac{\partial}{\partial W}\left(e^{imc(W-ct)/\hbar}\right) = -i\hbar \times \frac{imc}{\hbar}\left(e^{imc(W-ct)/\hbar}\right),$$

which requires that the mass operator be defined as

$$\hat{m}c = -i\hbar\frac{\partial}{\partial W}.$$

Mass, it turns out, is just inner momentum. How very straightforward. And, just like momentum, mass is a vector. The derivative with respect to W is, more precisely, *leptonic* mass m_l, but there are also three *baryonic* inner dimensions (X, Y, Z), which are orthogonal to both space and W. Hence, there is more than one direction of mass. In fact, in Unity theory, mass is a four-vector. The definition of baryonic mass follows immediately, as

$$\hat{m}_b c = -i\hbar\frac{\partial}{\partial X},$$

or, more generally, extending the spatial nabla notation from ∇_x to ∇_X, we have, in all three dimensions of baryonic inner space,

$$\hat{\boldsymbol{m}}_b c = -i\hbar\nabla_X.$$

One operator definition remains. The energy in a small disturbance of substance can be broken into components: kinetic energy in (x, y, z), leptonic mass-energy in W, baryonic mass-energy in (X, Y, Z), and, last but not least, energy in the spatial time dimension w. Now, it is a matter of choice whether we call energy in the direction of progress "mass" or not. In current usage, the word "mass" is used indiscriminately to refer to any energy that is not kinetic or potential. However, as physicists have realised, the "masses" of unstable particles such as the weak bosons are, in fact, better thought of as energies in electron volts, rather than as masses in kilograms. We will follow this procedure, reserving the word "mass" for the property that makes stable matter matter. In the direction of progress, we will refer simply to *progress momentum*, notated p_w, and *progress energy*, notated E_w. This gives our last operator definition as

$$\hat{p}_w = -i\hbar\frac{\partial}{\partial w}.$$

Collecting these together, we can express the eight-dimensional momentum operator as $\hat{\boldsymbol{p}} = -i\hbar\nabla_8$, or equivalently the eight-dimensional energy operator as $\hat{\boldsymbol{p}}c = -i\hbar c\nabla_8$, with components given as follows:

	Progress			Kinetic
Outer	$-i\hbar\frac{\partial}{\partial w}$	$-i\hbar\frac{\partial}{\partial x}$	$-i\hbar\frac{\partial}{\partial y}$	$-i\hbar\frac{\partial}{\partial z}$
	Leptonic			Baryonic
Inner	$-i\hbar\frac{\partial}{\partial W}$	$-i\hbar\frac{\partial}{\partial X}$	$-i\hbar\frac{\partial}{\partial Y}$	$-i\hbar\frac{\partial}{\partial Z}$

3.5 Energy Relations

Let us consider once again the wave equation $\Diamond_a \Psi = 0$, such as governs small disturbances in substance. This is the wave equation in its most general form, relative to substance rather than to the wave of the present. Written out in full, it is

$$-\frac{1}{a^2}\frac{\partial^2\Psi}{\partial t^2} + \frac{\partial^2\Psi}{\partial w^2} + \nabla_x^2\Psi + \frac{\partial^2\Psi}{\partial W^2} + \nabla_X^2\Psi = 0.$$

The structure is clearer if we work, without loss of generality, in one dimension of space x and one dimension of inner space X. Making the time derivative the subject, we have

$$\frac{1}{a^2}\frac{\partial^2\Psi}{\partial t^2} = \frac{\partial^2\Psi}{\partial w^2} + \frac{\partial^2\Psi}{\partial x^2} + \frac{\partial^2\Psi}{\partial W^2} + \frac{\partial^2\Psi}{\partial X^2}.$$

We can then read this as an operator equation. Dispensing with Ψ gives

$$\frac{1}{a^2}\frac{\partial^2}{\partial t^2} = \frac{\partial^2}{\partial w^2} + \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial W^2} + \frac{\partial^2}{\partial X^2},$$

which, upon multiplication by $i^2\hbar^2$, yields

$$\frac{1}{a^2}\left(i\hbar\frac{\partial}{\partial t}\right)^2 = \left(-i\hbar\frac{\partial}{\partial w}\right)^2 + \left(-i\hbar\frac{\partial}{\partial x}\right)^2 + \left(-i\hbar\frac{\partial}{\partial W}\right)^2 + \left(-i\hbar\frac{\partial}{\partial X}\right)^2.$$

Applying this to a coprogressing, stable wave, which is assumed to yield eigenvalues for all of the above operators, we get

$$\frac{1}{a^2}E_{\text{univ}}^2 = p_w^2 + p_x^2 + m_l^2c^2 + m_b^2c^2,$$

where the hatted operator questions, e.g. $\hat{m}_l$ or "what is the leptonic mass?", have now been replaced by their eigenvalue answers, e.g. "the leptonic mass is the number m_l". The subscript on the energy refers to the fact that E_{univ} is relative to the baseline of the universe itself, rather than to the present. E_{univ} is not observable. The observable energy is given by its component within the present

$$E_{\text{pres}} = \cos\theta_p E_{\text{univ}} = \frac{c}{a}E_{\text{univ}}.$$

Hence, the energy equation reduces to

$$\frac{1}{c^2}E_{\text{pres}}^2 = p_x^2 + m_l^2c^2 + m_b^2c^2,$$

where E_{pres} is the familiar energy as used in the old paradigm. At this point, we can add the components of the mass vector to give the familiar mass $m^2 = m_l^2 + m_b^2$, multiply up by c^2, and dispense with the subscripts. This gives

$$E^2 = p^2c^2 + m^2c^4,$$

which is Dirac's famous energy-momentum-mass relation. We can see it now as simply a rewriting of the wave equation $\Diamond_c \Psi = 0$.

3.6 The Klein-Gordon Equation

The analysis in the last section allows us to derive the Klein-Gordon equation and, in doing so, to see the reasons behind its limited domain of validity. The Klein-Gordon equation is also a version of the same wave equation $\Diamond_c \Psi = 0$ (as all quantum mechanical equations are). Consider the operator version, relative to the wave of the present,

$$\frac{1}{c^2}\hat{E}^2 = \hat{p}^2 + \hat{m}_l^2 c^2 + \hat{m}_b^2 c^2.$$

Assume mass eigenvalues with $m^2 = m_l^2 + m_b^2$, but leave the energy and momentum operators be; replace them with their derivative equivalents, in three dimensions of space. Applying this to a wave $\psi(x,t)$, dividing through by $\hbar^2$, and rearranging, gives

$$\left[\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2 + \frac{m^2c^2}{\hbar^2}\right]\psi(x,t) = 0,$$

which is the Klein-Gordon equation of relativistic quantum mechanics. But note that we have made a large and mostly unwarranted assumption here. We have implicitly decided that $\psi(x,t)$ is an *observable* amplitude, with no dependence on the inner dimensions. This is, for most relativistic matter, incorrect. A correct reading of the Klein-Gordon equation requires the reinsertion of the arguments. The equation is really

$$\left[\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2 + \frac{m^2c^2}{\hbar^2}\right]\Psi(x,W,X,t) = 0,$$

where the capital Ψ is used, as elsewhere in Unity theory, to refer to the underlying substance wave, whose domain is the universe, as opposed to its observable amplitude ψ, whose domain is space. The Klein-Gordon equation can only be applied to amplitudes in a very limited set of cases: either in non-relativistic matter, for which it is superfluous to the Schrödinger theory, or in the case of spinless matter, i.e. combinations of waves whose phase factors cancel in the inner dimensions.

3.7 Special Relativity

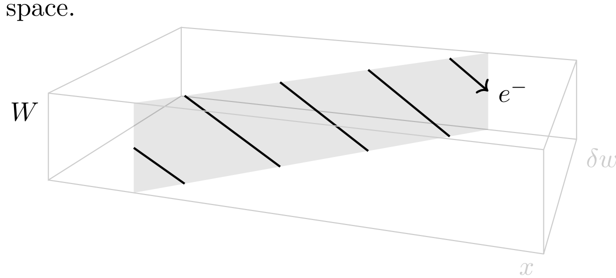
Einstein's special theory of relativity, of which $E^2 = p^2c^2 + m^2c^4$ and $E = mc^2$ are major formulae, is one of the cornerstones of physics. Indeed, the phrase "Lorentz covariance" has come to be spoken in hallowed tones, as a sort of shibboleth: if a theory isn't manifestly Lorentz covariant, then, so the implication goes, it hasn't a hope of being correct. And yet there are elements of physics, namely the virtual particles of QFT, that do not obey $E^2 = p^2c^2 + m^2c^4$. Therefore, the special theory of relativity does not apply to them. So, "Lorentz covariance" has been overstated as a physical principle. It is, in fact, a secondary idea with a limited domain of validity.

In Unity theory, it is clear what that limited domain of validity is. Special relativity only holds for waves that 1) coprogress and 2) have well-defined eigenvalues of mass. In other words, it only holds for matter waves that are present-standardised in the five imperceptible dimensions: coprogressing in w and gauge symmetric in U_X. Otherwise, there is no need for $\Diamond_a \Psi = 0$ to reduce to the energy-momentum-mass relation. And there are a great many waves, known currently in physics as *virtual particles*, that do not have well-defined eigenvalues of progress momentum and/or mass. These are waves that either don't coprogress coherently or don't resonate. They are wavelets strictly *within* the imperceptible dimensions of the present, travelling this way and that.

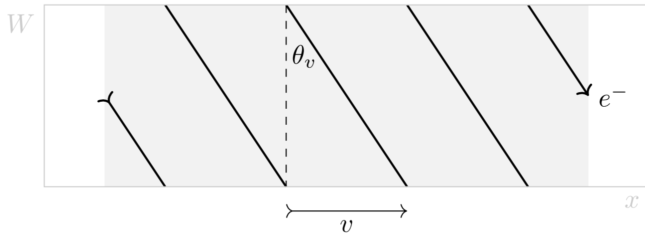
So, we can dispense with the need for Lorentz covariance in a theory. Indeed, we *must* do so. A theory can only be Lorentz covariant if it ignores the progress of the present, which, as we will see later in this book, won't do. There are fundamental behaviours, observable and already observed within space, that depend explicitly on the movement of space through the universe. Often, it is a school of thought's most powerful tools that most powerfully stifle... *thought!*

Special relativity is an epiphenomenon of the topological structure of matter. And, in Unity theory, it can be derived in exactly the same manner as everything else, by considering the deeper substance waves that underlie perceived particles. The mathematics is simple, and can be understood without any reference to negative metrics, which is good, because the negative metric isn't intuitive. It is a mathematical tool, nothing more. When a particle accelerates to near the speed of light, nothing happens to time and nothing happens to the background substance of the universe. Something happens to *space*, of course, but that is because the word "space" refers to a perceived image, not a physical entity.

Things are clearer if we work in absolute terms, against a backdrop of substance, rather than in relative terms, against a backdrop of space. The latter is the view espoused by special relativity itself (the clue is in the name), but working in that way brings confusion. The twin paradox, which we resolve in an appendix, is a prime example. Here, we can bypass the muddle, and establish ourselves, once more, beyond the relativistic paradigm, on firm, almost neo-Newtonian ground. Consider once again an electron, coprogressing with the wave of the present, but this time also moving rapidly through space.



Let us work in the $\Diamond_c$ framework relative to the present; this means projecting out the w dimension. We take an elevation of this diagram looking into the page, giving us a two-dimensional representation of the electron moving in the (x, W) plane. The diagram which appears is very similar to our previous diagram of the (w, W) plane, because all we have done is projected out w rather than x. The result depicts something different, though. Rightwards movement now represents motion at v through space, as opposed to progress at b. Wave speed, along the wavevector, is now c, relative to the present, rather than a, relative to substance, and the angle is now a variable θ_v defined by $\sin\theta_v = v/c$, rather than the fixed angle of progress θ_p. Again, the electron wavepacket occupies all of the grey rectangle.



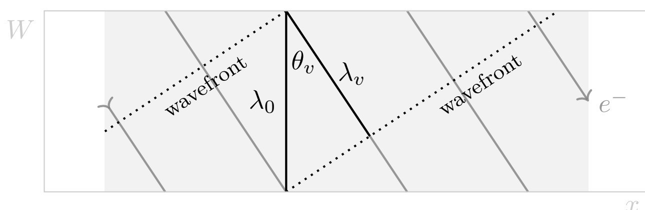
Elementary geometry tells us that the cosine of the angle is given by

$$\cos\theta_v = \sqrt{1 - \frac{v^2}{c^2}} = \gamma^{-1},$$

where γ is the usual Lorentz factor of special relativity. Now, consider the resonance of such a wave. A resting electron has a frequency, and hence an energy, defined by the phase factor

$$e^{imc(W-ct)/\hbar},$$

as introduced in our work on the Schrödinger equation. The factor $mc/\hbar$ is inversely proportional to the wavelength, which, for the resting electron, can be thought of as the vertical W height of the diagram. But our electron in motion has a shorter resonant length. The resting electron's wavefronts are in x, but the fast-moving electron's wavefronts are at an angle θ_v to x. This reduces the wavelength to $\lambda_v = \cos\theta_v \lambda_0$, as seen in the following diagram:



This tells us that

$$\lambda_v = \sqrt{1 - \frac{v^2}{c^2}}\lambda_0.$$

Now, the energy of a wave varies inversely with the wavelength. Hence, the energy E of a fast-moving electron is given, in terms of the rest energy E_0, as

$$E = \frac{E_0}{\sqrt{1 - \frac{v^2}{c^2}}},$$

which is the central equation of special relativity. Notice that, in deriving it, we have needed no reference to the *principle* of relativity, which is now seen to be superfluous.

The Lorentz factor emerges as a consequence of the topological structure of matter. Indeed, the principle of relativity, it turns out, is actively incorrect. In Unity theory, there is one frame of reference that is marked out as fundamental, and that is the substance frame, viz. the frame of the universe itself. Such a formulation resolves many of the paradoxes that have concerned relativists.

Now, the energy formula $E = \gamma E_0$ might seem to suggest, as it did to Einstein and others in early work, that "mass" increases with speed. Einstein himself soon abandoned that idea, and for good reason. We can now cast some light on that decision. Consider a relativistic plane wave $\Psi(x, W, t)$, defined as

$$\Psi(x, W, t) = e^{i(px+mcW-Et)/\hbar}.$$

This is an algebraic formulation of the electron depicted above. Its kinetic energy is pc, its rest energy is mc^2 and its total energy is E. But note that the W component is independent of the t component. As the wavevector tilts towards space, the values of p and E increase, but the value of mc, the W-momentum, cannot. It is bound by resonance to remain fixed. And it is exactly this resonance, requiring a universal rate of change in W across all electron waves, that makes m_e, the mass of the electron, an invariant. The electron mass m_e is simply a measure, in appropriate units, of the circumference of the W dimension. An increase in particle speed does nothing to this quantity.

Mass, as an inner-dimensional rate of change, is invariant under acceleration.

What of the phenomenon of time dilation? Well, with the Lorentz factor γ derived, the behaviour of clocks follows easily. In Unity theory, time itself does not dilate. Moving *clocks* run slow, yes, but time itself marches on. As a particle accelerates, more of its wave speed is taken up with the task of moving through space, which leaves less for travel around the inner dimensions. The wave resonates with the same W-derivative, but W-circuits take longer, by a factor γ. Thus, clocks runs slowly at speed. The relevant formula is

$$\Delta t = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}},$$

where Δt represents the amount of absolute time taken to produce one clock-second.

Given the topological structure of matter dictated by Unity theory, it is equally obvious that physical lengths in space must be affected by acceleration. As a ruler's wavevector tilts forwards into space, that is to say, as it accelerates, the wavefront separations giving the ruler its particular size angle away from their resting orientation in space. Perceived "space" and "time" rotate into one another. Now, this is undoubtedly a complex process, and a full formal analysis, which must consider wavepackets, Riemannian curvature and measurement simultaneity, is beyond the scope of this book. In broad terms, however, Unity dictates exactly what is borne out by experiment: objects contract in the direction of velocity. The scale factor is, of course, γ.

So, what happens when an accelerated observer tries to measure the speed of light? Well, since both length measurement and time measurement are out by the same factor, the overall measurement comes out correct. In other words, despite the fact that the observer's equipment is doing some unexpected things, the speed of light always comes out at c. This has by now been verified by numerous experiments. In the special theory, the phenomenon is assumed as axiomatic; in Unity theory, however, we can *derive* it. From these derivations, the rest of special relativity follows.[2]

This represents another major test passed. We have produced the mathematics of the special theory *without* assuming either of its fundamental tenets, which are 1) the philosophical principle of relativity and 2) the empirical fact that all observers measure the same speed of light. The former is now seen to be surplus to requirements, and indeed incorrect, while the latter is now proved theoretically. Furthermore, we have derived special relativity from the same concepts as we used to derive the Schrödinger equation, which is independent of special relativity in the old paradigm. The Unity model of matter, as pertaining to quantum mechanics, may therefore be considered validated.

3.8 The Dirac Equation

It is fair to call the Dirac equation the jewel in the crown of quantum mechanics. It is the crucial link between quantum mechanics and its child, quantum field theory. Its source and meaning, however, are somewhat opaque. In the old paradigm, its derivation is usually given as a historical tale, recounting Dirac's rejection of the second-order Klein-Gordon equation and his attempt to find a first-order replacement, by "taking the square root". And it was undoubtedly an extraordinary piece of genius that led Dirac to his equation [6]. It still seems like magic. But Dirac's route was rather like that of a mathematical paratrooper jumping behind enemy lines at night. A cracking tale, yes, but not to be recommended for those hoping to visit the country in peacetime. Having parachuted into *terra incognita*, it is impossible to retrace one's steps and so to gain that all-important intuition for what an equation *means*. Even Dirac didn't manage it, as he himself said. It is no insult to his genius to agree.

To complete our derivation of quantum mechanics, we need to produce the Dirac equation in a manner that can be *understood*. This will serve two purposes. Firstly, deriving the Dirac equation from the first principles of Unity theory offers further corroboration of the validity of the Unity paradigm. The Dirac equation itself, of course, needs no such validation. Secondly, with such a derivation in place, we can ascertain the nature of antimatter, a question which has much significance beyond the confines of particle physics. Antimatter was the major prediction of Dirac's work, subsequently borne out fully by experiment, and it sits at the centre of various important questions of cosmology. We will address these in due course.

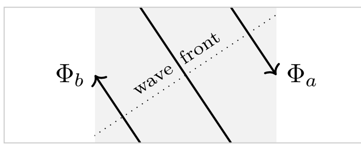
[2] There is considerable further work to be done, both theoretic and experimental, in understanding precisely how the speed of light is measured by fast-moving matter. While Unity's broad generation of special relativistic effects is simple, the formal details are not.

In this derivation, we use a version of the mathematics of Foldy and Wouthuysen [7], who also did something highly impressive: they found their way back, in pure abstract mathematics, from Dirac's *terra incognita* to the familiar ground of the Schrödinger theory. This was no mean feat. In the derivation presented here, we follow their trail in the opposite direction, heading out from the Schrödinger theory, following the trail of the (inverse) Foldy-Wouthuysen transformation, to reach, via a set of physically meaningful steps, the point at which Dirac landed. We work as simply as possible, in one dimension of space and without reference to spin. This is the Dirac equation stripped back as far as it will go. Once the equation is understood in this context, it can subsequently be built back up to full strength.

We begin with a fast-moving plane wave

$$\Phi(x, W, t) = \phi(s, t)\, e^{i(px+mcW-Et)/\hbar},$$

where s is the wavefront dimension in the (x, W) plane. Here, a problem presents itself. Since s contains a W component, this amplitude $\phi(s, t)$ is not observable. Work is needed to render it so. That work involves cancelling the W dependency of the first amplitude with that of another wave travelling in the opposite direction.



The waves depicted above share the same transverse s dimension, which is what allows for subsequent cancellation and observability. This is why, algebraically, we need two waves travelling in opposite directions. These are given by

$$\Phi_a = \phi_a(s, t)\, e^{i(px+mcW-Et)/\hbar}$$
$$\Phi_b = \phi_b(s, t)\, e^{i(px+mcW+Et)/\hbar},$$

where we note the changing sign in the exponent. This is what sends the plane wave in the opposite direction. These two waves share the same eigenvalues for momentum and mass, but have opposite eigenvalues for energy. We can gather these together into a single entity known as a *spinor*, as

$$\Phi = \begin{bmatrix} \phi_a \\ \phi_b \end{bmatrix},$$

where the vector signifies location in *spinor space*, whose basis vectors are $e^{\bullet}_a$ and $e^{\bullet}_b$, the two versions of the exponent. In this notation, the energies can be expressed as

$$i\hbar \frac{\partial}{\partial t} \begin{bmatrix} \phi_a \\ \phi_b \end{bmatrix} = E \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} \phi_a \\ \phi_b \end{bmatrix}.$$

We subsequently notate this matrix diag$(1, -1)$, which encodes the positive and negative energy eigenvalues, as β. Hence, our equation, governing two plane waves travelling in opposite directions, is

$$i\hbar\frac{\partial\Phi}{\partial t} = \beta E\Phi.$$

To reach, and therefore understand, the Dirac equation in the form originally proposed, all we do is rotate the coordinate system of the spinor space (ϕ_a, ϕ_b), mixing the waves together to produce an observable result. Here, we need to pay very careful attention to the mathematical spaces in which we are working. A great deal of confusion in quantum physics stems from a lack of distinction between *physical space*, which represents a physical domain, and *spinor space*, which represents abstract mathematics. The two are closely linked, but different. We should further note that, in Unity theory, "physical space" means *any* physical space, including inner-dimensional spaces. The word "space", on its own, we reserve for (x, y, z). The mathematical link is most easily seen in a simple diagram of each. Note the distinction between the coordinate variables and orthonormal unit vectors of each space. In physical space, we have coordinates (x, W), referring to a basis of unit vectors $\{\hat{x}, \hat{W}\}$. In spinor space, we have coordinates (ϕ_a, ϕ_b), referring to a basis of unit vectors $\{e^{\bullet}_a, e^{\bullet}_b\}$.

Physical space | Spinor space

On the left, we are looking at a local picture of substance, and the arrows represent the movement of waves. On the right, we are looking at a mathematical space, and the dots represent quantities of the phase factors $e^{\bullet}_a$ and $e^{\bullet}_b$. The key point is: in physical space ϕ_a and ϕ_b are 180° apart, whereas in spinor space they are 90° apart. This is a well known, but not in general very well understood, fact of spinor mathematics: a rotation through angle θ in spinor space corresponds to a rotation through angle 2θ in physical space. From the diagrams above, it's obvious why. Positive energy and negative energy are represented, in spinor space, on orthogonal rather than diametrically opposite axes.

We are going to effect a rotation in spinor space, whose purpose is to effect a rotation in physical space. What we want to do is render the ϕ amplitudes, which have components in W, as ψ amplitudes, which have no components in W. In spinor space, a generic rotation is given by

$$\psi_1 = \cos\theta\phi_a - \sin\theta\phi_b$$
$$\psi_2 = \sin\theta\phi_a + \cos\theta\phi_b$$

This can be expressed in matrix terms as

$$\begin{bmatrix}\psi_1\\ \psi_2\end{bmatrix} = \cos\theta \begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}\begin{bmatrix}\phi_a\\ \phi_b\end{bmatrix} + \sin\theta\begin{bmatrix}0 & -1\\ 1 & 0\end{bmatrix}\begin{bmatrix}\phi_a\\ \phi_b\end{bmatrix},$$

or as

$$\Psi = (\cos\theta + \alpha\beta\sin\theta)\Phi,$$

where α and β are

$$\alpha = \begin{bmatrix}0 & 1\\ 1 & 0\end{bmatrix} \text{ and } \beta = \begin{bmatrix}1 & 0\\ 0 & -1\end{bmatrix},$$

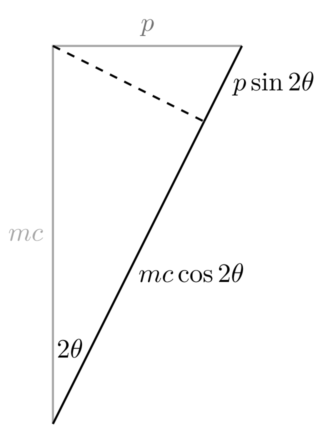
and the identity matrix is left implicit. We note, at this point, various algebraic properties of the transformation which can easily be verified. The matrices α and β are *unitary*, with $\alpha^2 = \beta^2 = 1$, and they *anticommute*, with $\alpha\beta + \beta\alpha$=0. Hence, $\cos\theta + \alpha\beta\sin\theta$ is the reciprocal of $\cos\theta + \beta\alpha\sin\theta$, and the following identity also holds:

$$(\cos\theta + \beta\alpha\sin\theta)^2 = \cos 2\theta + \beta\alpha\sin 2\theta.$$

Now, the formula $\Psi = (\cos\theta + \alpha\beta\sin\theta)\Phi$ becomes the Foldy-Wouthuysen transformation proper when we choose a specific θ in spinor space, or equivalently 2θ in physical space. We want to take the wavefront dimension s of the ϕ amplitudes and rotate it to an x dimension in the ψ amplitudes; that way, it will have no W dependency, and hence will be observable. The wavefront angle is given by the ratio of momenta in x and W, which are p and mc respectively. Hence, we need to define

$$\tan 2\theta = \frac{p}{mc}.$$

The angle θ is the degree of rotation in spinor space, which, since it contains the mathematics, is the space we wish to rotate. But the degree of rotation required is dictated by θ's equivalent in physical space, 2θ. In the variable 2θ, we are simply expressing momentum in the (x, W) plane in an algebraically helpful manner. The physical angle 2θ expresses the departure from rest at $2\theta = 0$ towards the relativistic limit. Representing this angle geometrically, we have the following momenta, in the physical (though not perceptible) (x, W) plane:



The solid line, with grey components, represents the substance-level momentum (in both x and W) of the plane wave. The momentum in the direction of the dashed line is zero. We express these momenta as kinetic and rest energies, multiplying up by c, which gives us a pair of energy equations. All of the energy is contained in the solid dimension, and none in the dashed:

$$E = pc\sin 2\theta + mc^2\cos 2\theta,$$
$$pc\cos 2\theta - mc^2\sin 2\theta = 0.$$

The energy operator is given, then, by

$$i\hbar\frac{\partial}{\partial t} = \beta(pc\sin 2\theta + mc^2\cos 2\theta).$$

But we also need to include the zero component in the transverse direction, so as to be able to effect the relevant cancellation. Since the expression $pc\cos 2\theta - mc^2\sin 2\theta$ is zero, we can insert it freely, multiplied by whatever we want. We choose α. This gives

$$i\hbar\frac{\partial}{\partial t} = \alpha(pc\cos 2\theta - mc^2\sin 2\theta) + \beta(pc\sin 2\theta + mc^2\cos 2\theta).$$

Now for the cunning part, as discovered by Foldy and Wouthuysen. We rearrange the energy components, grouping by sines and cosines, giving

$$i\hbar\frac{\partial}{\partial t} = \cos 2\theta(\alpha pc + \beta mc^2) + \sin 2\theta(\beta pc - \alpha mc^2).$$

Using unitarity and anticommutativity, we can engineer a common factor. Take out a left-factor of $\beta\alpha$ from the right-hand term, and we get

$$\begin{aligned} i\hbar\frac{\partial}{\partial t} &= \cos 2\theta(\alpha pc + \beta mc^2) + \beta\alpha\sin 2\theta(\alpha pc + \beta mc^2) \\ &= (\cos 2\theta + \beta\alpha\sin 2\theta)(\alpha pc + \beta mc^2) \\ &= (\cos\theta + \beta\alpha\sin\theta)^2(\alpha pc + \beta mc^2). \end{aligned}$$

At this point, we distribute the factors of $\cos\theta + \beta\alpha\sin\theta$. We move one rightwards, in which transition it is conjugated by anticommutativity; the α and β matrices duly trade places. We left-multiply by the reciprocal of the other, which produces the same effect. This yields

$$i\hbar\frac{\partial}{\partial t}(\cos\theta + \alpha\beta\sin\theta) = (\alpha pc + \beta mc^2)(\cos\theta + \alpha\beta\sin\theta).$$

Applying this operator equation to Φ then brings out the Foldy-Wouthuysen expression $(\cos\theta + \alpha\beta\sin\theta)\Phi$ on both sides of the equation. Rewriting in terms of Ψ, we find the Dirac equation in one spatial dimension.

$$i\hbar\frac{\partial}{\partial t}\Psi = (\alpha pc + \beta mc^2)\Psi.$$

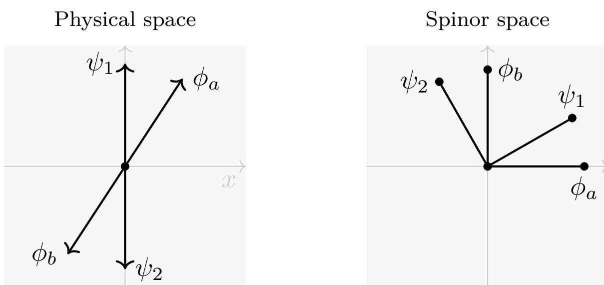
The above is the Dirac equation stripped back to its very simplest form. Extending to three dimensions and two directions of spin is conceptually rather less illuminating, so we won't go into it here, but the process is much the same. The three dimensions of momentum end up associated with three α matrices, which are then gathered together into a vector $\boldsymbol{\alpha}$; spinor space becomes four-dimensional rather than two. This yields the full form of the free Dirac equation:

$$i\hbar\frac{\partial\Psi}{\partial t} = (\boldsymbol{\alpha}\cdot\boldsymbol{p}c + \beta mc^2)\Psi.$$

3.9 Zitterbewegung

We can now understand the Dirac equation fully. The Dirac equation governs configurations of waves with well-defined eigenvalues p and mc of outer- and inner-dimensional momentum, up to a signed eigenvalue of energy E. There is no "going backwards in time", as has sometimes been suggested. Rather, the substance waves that underlie Dirac spinors, i.e. the helices that give them their eigenvalues of kinetic and rest energy pc and mc^2, travel in opposite directions along the same inner wavevector. The effect is like that of an infinite corkscrew: the perceptible hole in the cork (momentum and mass) is the same regardless of which end (energy) one starts from.

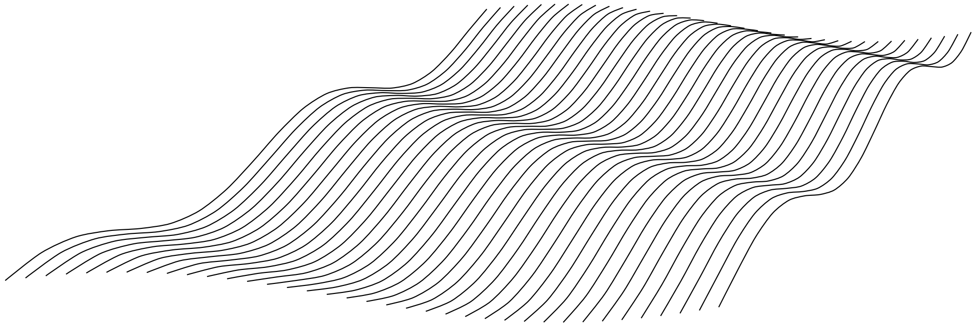
Plane waves are far more intuitively described in the Foldy-Wouthuysen basis, which is where we began this derivation, than they are in the Pauli-Dirac basis, with which we ended it. The former basis is defined parallel and perpendicular to the wavevector, which is, of course, the way to describe a wave. But the Foldy-Wouthuysen basis doesn't govern *observable* amplitudes. It governs oblique amplitudes, which have an inner-dimensional component. The Pauli-Dirac basis, however, while algebraically complicated, is observable, as everything is defined in terms of "waves" travelling in the W direction.



Why "waves", in inverted commas? Well, remember that the word "wave" refers to a physical entity: a configuration of substance. During the above derivation, the physical scenario didn't change. Only our *representation* of it changed. Throughout, the physical waves travelled along the ϕ wavevectors. Those directions were fixed by definition, in eigenvalues of momentum and mass. But rather than viewing this motion, very naturally, as a plane wave, we were forced, to achieve observability, to describe it in terms of quasi-waves "travelling" in W.

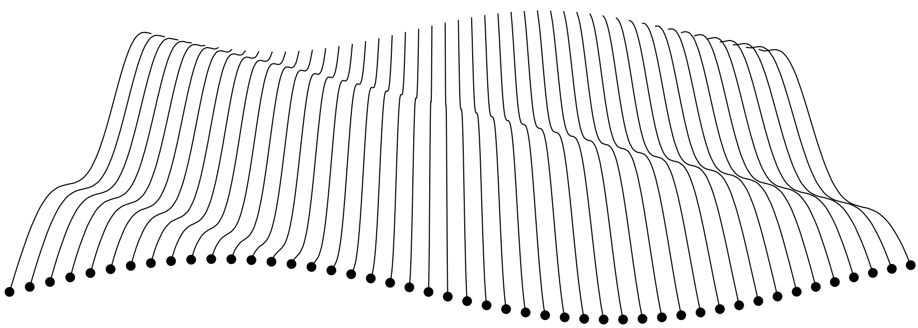
How is such a thing even possible? Only rather artificially. While the original $\phi(s,t)$ amplitudes are steady, like the fixed wings of aeroplanes, the $\psi(x,t)$ amplitudes must undulate, like the flexible wings of manta rays. Because the $\psi(x,t)$ manta rays are effectively going the wrong way, their transverse amplitudes must flutter, so as to send energy out in the correct, oblique direction. This is the effect known as *Zitterbewegung*, or jitter-motion.

In the Foldy-Wouthuysen basis, there is no such thing, because the transverse $\phi(s,t)$ amplitudes contain no energy; in that basis, the wave is the phase factor, the aeroplane-wave's propeller. But in the observable Pauli-Dirac basis, the $\psi(x,t)$ amplitudes contain a portion of the energy themselves. To visualise this, we first depict an electron in the natural Foldy-Wouthuysen representation, with space running from left to right, and W into the page:



The above diagram shows an electron moving rightwards through space at a non-negligible fraction of the speed of light. Fixed-wing aeroplanes fly along the sinusoids, which coincide with the wavevector; the swell height represents (the real part of) Φ. This is the natural Foldy-Wouthuysen representation: the swells, represented in this oblique ϕ manner, contain no transverse momentum; there is no jitter-motion, because the wavevector dimension has all the energy.

But look what happens if we now represent the *same* wave in the Pauli-Dirac basis. To achieve observability, we must place the "wavevectors", in an artificial manner, orthogonally to space:



The apparent "wavevectors" now run directly into the page, which is what permits separability and hence observability. But the transverse amplitudes are no longer still; rather than riding on the phase factors of the swells, they are now forced to enact the wave motion themselves. The spatial sinusoid marked with circles, which contains the momentum of the particle, now *only* travels through space by dint of changes in the transverse amplitude $\psi(x,t)$. This manifests in the mathematics as *Zitterbewegung*, a rapid fluttering motion. This isn't a physical phenomenon as such, but rather represents the impossibility of separating a fast-moving wave cleanly into inner- and outer-dimensional components.

4 Unity and Electromagnetism

Before we can address the cosmological and cosmogonic implications of Unity theory, we must consider the physical nature of *force*. Despite its modern expression in various more abstruse forms, cosmology remains, in large part, a theory of gravity, which, for the last century, has meant general relativity together with its prior Newtonian limit. However, it has become increasingly clear that general relativity, while well verified in a certain domain, doesn't have all the answers. A growing body of evidence has emerged, particularly regarding galactic rotation curves, suggesting strongly that the forces governing the large-scale structure of the cosmos differ from those predicted by general relativity alone [8]. This has caused problems. Lacking any viable alternative to GR, cosmologists have been led to produce a patchwork of ad hoc hypotheses—dark matter, dark energy and inflation the most notable among them—all of which have had to be fine-tuned, so as to provide any agreement with observation [9]. In short, our models for force are creaking.

The real issue has been a lack of understanding of what gravity *is*. To claim any comprehension of the cosmos, we need a clear and simple answer to a clear and simple question: "Why do masses attract?" Numerous answers exist, none satisfactory. The physicist's response is: "Masses follow curved geodesics." But that isn't good enough. Why, in a physical sense, do geodesics bend in the manner they do? Why do they curve to bring matter together, rather than curving to push matter apart? The mathematician steps in, saying: "Consult the field equations." But that isn't good enough either. It shouldn't require quantitative discussion of Riemannian tensor geometry to answer a qualitative question; if you're using a sledgehammer to crack a nut, something has gone wrong. The relativist takes a different tack: "Gravity is a manifestation of length contraction and time dilation." But that merely sweeps the problem under another bit of carpet. Why, after all, do rulers and clocks behave as they do in gravitational fields?

To understand reality scientifically, we must understand force, in a direct physical sense. We need to know *why* things do what they do. But, at this stage of theoretical explanation, we aren't yet ready to tackle the gravitational question "Why do masses attract?" In empirical terms, that ground isn't solid enough. Unlike in quantum physics, where the lack of deep understanding is at least moderately well recognised, the level of uncertainty in cosmology has too often been underplayed. For a long time, we have acted as if we understand gravity and its workings. Let us be clear: we do not know what the laws of gravity are. The fine-tuned and unscientific postulates of dark matter and dark energy are evidence enough of that. What we have, in cosmology, is one good model with a limited domain.

So, before we approach the gravitational question in the second half of this book, we need to do some more preparatory work, not only further to validate Unity theory, but in order to gain the requisite understanding of the nature of physical interaction. In this, we must move beyond quantum mechanics, which describes motion, and towards quantum field theory. In that arena, the level of experimental validation is genuinely high. This means that we can investigate the physical nature of force and interaction, without having to worry about the validity of the mathematics. Then, once we have the requisite understanding, we can venture out into the cosmos. The obvious first stepping stone, as in any pedagogical introduction to quantum field theory, is *electromagnetism*.

4.1 Charge

What is electric charge, then? Well, in Unity theory, it is not enough to say, as is said in the old paradigm, that an electron simply *has* charge. Perceived classical particles get to *have* properties like mass and charge, but the underlying waves do not. In Unity theory, a wave cannot simply carry a number, unless that number is a mathematically describable feature of its physical configuration. This is the brutally stringent test Unity theory subjects itself to: every value a particle *has*, whether it be mass, charge, colour charge, hypercharge, weak isospin or anything else, must have direct, explicable physical meaning. In Unity theory, quantum numbers cannot hide away in abstract realms of mathematics, plotting their spooky influences on matter. No. We must be able to identify some feature, some configuration or change in substance and say: "*That* is the charge."

Consider the electron. At its simplest, a resting electron's structure is that of a single fermionic exchange wave, modelled as a complex-valued helix travelling in the W dimension. Such a resting electron, with zero momentum and no defined position, may be described with the plane wave

$$\Psi(x, W, t) = e^{i(mcW - Et)/\hbar},$$

in which $E = mc^2$. Setting aside the direction of spin, we can see that the eigenvalue m of mass governs the entirety of the wave's mathematical behaviour. Up to helical handedness, a resting electron *is* its leptonic mass m_l. Now, it was long suspected, in classical days, that the electron's mass is electromagnetic, in other words, that its mass and its charge are the same thing. According to Unity theory, this is exactly correct. The hypothesis was only abandoned because it failed in relation to the *proton*, which has the same magnitude of charge but a far greater mass. But it is now obvious, in Unity theory, why this is the case. Mass is a four-dimensional vector, and it has two major components, leptonic and baryonic mass, which describe rates of change in the S^1 and S^3 components of the inner group. An electron has only leptonic mass m_l; a proton has, almost exclusively, baryonic mass m_b.

In Unity theory, electromagnetic charge q is another word/value for leptonic mass m_l. Both describe momentum, or, in scaled units, energy, in the inner W dimension. "Electromagnetic charge" describes the interaction of that W-momentum with a particular type of curvature, soon to be elucidated, known as the electromagnetic field, while "leptonic mass" describes the energy stored within that same W-momentum. The words are different; the entity is the same. The situation is like that of Einstein described as physicist and father: both words describe the same person, the former in relation to his work, the latter in relation to his children.

Let us define the charge operator accordingly. Since leptonic mass and electric charge describe the same thing, there is only one possible definition. The leptonic mass is given as

$$\hat{m}_l c = -i\hbar \frac{\partial}{\partial W}.$$

The charge, then, must be defined by the same quantity, converted from units of mass to units of charge by the factor e/m_e. Leaving out the negative sign, so that the electron has positive mass but negative charge,[1] we must define leptonic charge as

$$\hat{q}c = \frac{e}{m_e} i\hbar \frac{\partial}{\partial W}.$$

Charge is simply a W-derivative. In differing units, the same rate of change with respect to W may be described as a charge q, a mass m, a momentum mc or an energy mc^2. This broadens Einstein's famous conceptual unification of $E = mc^2$ significantly: not only are mass and energy the same concept, but so are charge and momentum. All of the above are ways of describing movement in the inner dimensions. According to Unity theory, not only is the universe precisely one substance, but physics, it turns out, is precisely one concept.

Conservation of charge follows naturally. Conservation of leptonic charge q is conservation of leptonic mass m_l is conservation of leptonic momentum $m_l c$ is conservation of leptonic energy $m_l c^2$. All are true by definition. And *quantisation* of charge, likewise. Since the W dimension has a consistent circumference in vacuum, resonance fixes the W-derivative; the waves underlying electrons, which travel in the negative W direction, are forced to have a particular charge/mass/momentum/energy by the closure of leptonic S^1. Combined with the discrete thickness of the wave of the present, consistent across all matter and radiation, this renders electron mass and charge quantised, as described by the operators already defined.

One other result follows immediately. Reflection in the W direction, that is to say, negation of the W-derivative, corresponds to *charge conjugation*, the operation usually notated $\mathcal{C}$. Hence antimatter, when considered within the wave of the present, is simply what results from a reflection in the leptonic W dimension. A positron resonates around the same closed dimension as an electron, the only difference being its direction of travel. Both share the same eigenvalues, up to a sign.

A corollary of this idea is that, since we define electrons to have positive mass and negative charge, we should think of positrons as having positive charge and negative mass. This doesn't for a moment mean that they are "holes", or anything similar. No such concepts can exist in Unity theory. But neither do we need them. Leptonic mass, at the substance level, is a momentum orthogonal to space, not a "quantity of material". It is a *vector*. A negative mass, then, is simply a mass going in the other direction. Nothing spooky.

[1]This formulation technically gives the proton a negative leptonic mass. In fact, a more consistent definition, were we starting from scratch, would have the mass and charge of the electron both defined as positive, but history dictates that this is not to be.

4.2 Attraction and Repulsion

Why do like charges repel? Why do opposite charges attract? Again, there are many levels on which these questions can be addressed. With regard to Riemannian tensor geometry, they are well answered in Kaluza-Klein theory [10][11][12], which turns out to be a (x, y, z, W) limiting case of Unity theory. The quantitative answer that appears in that theory, which we need address only qualitatively here, is that the Lorentz force law is an expression of the curvature of substance. Now, since according to the axiom of Unity everything is an expression of the curvature of substance, this is somewhat trivial, but it warrants saying nonetheless. In Unity theory, *all* force is an expression of the behaviour of geodesics. Our task is to go a level deeper, and to understand what physical mechanism drives the geodesics to do what they do.

What kind of substance curvature do we get in the vicinity of an electron? Well, we know that the leptonic S^1 dimension, which has precisely the same form in Unity, QED and Kaluza-Klein theory, must be the only non-spatial dimension involved. And, restricted to the leptonic dimension, there is only one possible candidate for electromagnetic curvature: a *shear* in W, that is to say, a rotational displacement of the entire W dimension. Such displacements of substance, like the parallel displacements of opposite sides of a rectangle, produce bosonic curvature.

Now, S^1 is not simply connected, which means that a shear-rotational displacement around the W dimension cannot be undone by any means other than an equivalent shear-rotational displacement in the other direction. This is the essence of the binary nature of the electromagnetic force. Masses always attract, but charges may repel. This is due to the particular curvature involved. A spatial gradient of W-momentum causes a spatial gradient of shear-rotational displacement around W. Charges have torsions of the W dimension associated with them. The charges are first-order waves, small disturbances in substance that carry energy; the torsions are the higher-order effects (macroscopic curvatures) that accumulate in their presence.

It isn't hard to see, in this formulation, why like charges repel and opposite charges attract. The topology of the W dimension dictates that superposing two *like* torsions means doubling the nonlinearity, whereas superposing two *opposite* torsions means cancelling them out. Note that this doesn't involve a cancellation of the waves themselves—first-order linearity superposes perfectly, and hence a combination of waves contains the same total energy regardless of the individual wave directions—but it *does* involve superposition/cancellation of higher-order nonlinearity. Such nonlinearity is energetically costly, as it disrupts coherent solutions of $R_8 = 0$.

4.3 The Four-Potential

Electric W-charge and magnetic W-displacement, two closely related but different phenomena, are best described mathematically with the electromagnetic four-potential A^α. As Feynman pointed out, the four-potential is a more natural way of viewing electromagnetism than the classical fields $\mathbf{E}$ and $\mathbf{B}$ are. In Unity theory, it is clear why. The four-potential A^α describes the state of reality, that is to say, the state of substance itself, whereas the fields $\mathbf{E}$ and $\mathbf{B}$ describe the observable effects of that underlying state as manifested in space. Just as with the Dirac equation, to deal only with observables is, in many ways, to step *away* from the truth, not towards it.

Now, this isn't a treatise on classical electromagnetism. Our business is, in large part, with the photon of QED, whose nature we will address shortly. But to understand the photon, one has to understand what physical information the four-potential encodes, beneath its classical effects.

Light has, for a century and a half, been taught and visualised in the terms in which Maxwell so brilliantly conceived it. Maxwell, of course, spoke the language of the day, that of electric and magnetic fields. But the fields themselves, we remember, are images on the stage, rather than physical things. If we are to understand electromagnetism, and particularly the photon, we would do well to set them aside *entirely*. While the image of a light wave as two orthogonal sinusoidal fluctuations is ubiquitous and of course mathematically correct, it is a far cry from reality. This is what Feynman and others came to realise.

In a light wave, the oscillating electric and magnetic fields are in phase. Hence, the information in either contains the information in both, so long as we specify the dimensions of polarisation. Thus, in mathematical terms, we can describe light of a certain polarisation by its magnetic field alone. And the magnetic field depends only on the magnetic potential, as $\mathbf{B} = \nabla \times \boldsymbol{A}$. In other words, light is essentially a *magnetic* wave. This points to a longstanding misnomer, stemming from the classical days of Maxwell's unification. The elements of the four-potential

$$A^\alpha = \begin{bmatrix} \phi/c \\ \boldsymbol{A} \end{bmatrix}$$

are known as the electric potential ϕ and the magnetic potential $\boldsymbol{A}$. But a light wave is an oscillation in only the magnetic potential. Hence, calling light an "electromagnetic wave" is imprecise and unhelpful in pedagogical terms, since the "electro" part of that expression refers to the electric *field*. The electric field is defined, in terms of the four-potential, by

$$\mathbf{E} = -\nabla\phi - \frac{\partial \boldsymbol{A}}{\partial t},$$

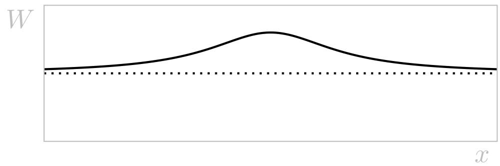
and, in a light wave, the electric field only varies as a result of the variation of the magnetic potential $\boldsymbol{A}$. The $\nabla\phi$ term is zero; there is no electric charge. Hence, in Unity theory, we must apply the words "electric" and "magnetic" carefully.

⦿ Definition: *Electric.* In Unity theory, this adjective refers to the electric potential ϕ, as opposed to the field $\mathbf{E}$. It refers to W-momentum, the flow of energy around the leptonic W dimension.

⦿ Definition: *Magnetic.* In Unity theory, this adjective refers to the magnetic potential $\boldsymbol{A}$, as opposed to the field $\mathbf{B}$. It refers to W-displacement, the rotated position of the substance of the W dimension.

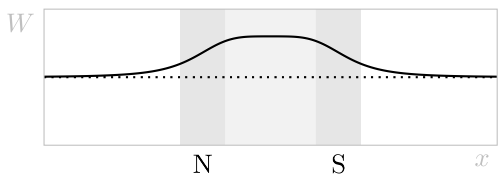
4.4 Magnetism

What is a bar magnet, then? A bar magnet is a configuration of matter in which the overall charge, that is to say, the net linear momentum in W, is zero, but in which higher-order curvature effects do not cancel. In other words, a bar magnet is a stable, localised torsion of the leptonic dimension, as defined by a non-constant magnetic potential $\boldsymbol{A}$. We can represent this as follows. Take a blank (x, W) section of substance, i.e. a portion of a one-dimensional vacuum, and "mark" substance with a line, at $W = 0$. This is mathematically equivalent to the process of choosing a gauge: we break (visually, in this instance) the gauge symmetry of the W dimension by picking out a particular value of it. Physically, then, this value is the zero-displacement level; mathematically, it is $A_x = 0$. We can then represent a bar magnet in terms of its displacement of this line, that is to say, its torsion of the W dimension.



To visualise the physical scenario represented in this image, wrap the first finger and thumb of your right hand around your left forearm, taking hold of a thin section of sleeve, and rotate that thin section of sleeve upwards. The shear-rotation so enacted, as depicted in this still, is the minimal possible disturbance in the magnetic vector potential. This, therefore, is essentially what a magnet looks like.

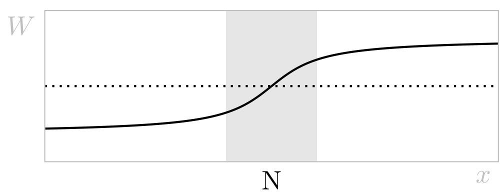
Where are the poles in this? Well, it is nonlinear curvature that creates force. Gauge symmetry dictates that shear-*displacement* in W isn't enough, except insofar as it dictates the presence of curvature around it. Consider the stationary point on the gauge-marker curve, at the point of maximum displacement. At this point, substance is flat, just as flat as it is at infinity. No force is felt. The points of maximal substance curvature are, in fact, at the points of maximal *gradient* in this picture. That is where substance has the greatest shearing torsion, which is what generates force. Calculus tells us that maximal (magnitude of) gradient occurs at the points of inflection. Hence, these are the poles. To make things more obvious, let us pull these poles apart somewhat. Our bar magnet then looks like this:



Note that the N and S poles refer to locations in space, i.e. to the full W extents of the rings above them, not to the lower ends of those rectangles. Gauge symmetry remains intact, despite our *visual* breaking of it, and every point in this picture, both in physical behaviour and spatial location, is identical to every other point vertically above or below it. The lighter area in the centre represents a lower curvature region; this is the middle of the bar magnet, between its poles.

With this image, we can see why no magnetic monopoles have been yet detected, and why no magnetic monopoles will ever be detected. It is as simple as the old expression: what goes up, must come down. According to Continuity, substance has no singularities, no step changes, no discontinuities of any kind. The $W = 0$ line we drew above must remain, in every feasible physical scenario, connected and smooth. Furthermore, far away from any purported magnetic monopole, this line must return to $W = 0$. Hence, shear curvature in one direction must be matched, elsewhere, by shear curvature in the other direction. This argument can be put formally, using divergence, but there is really no need. The fact is exceedingly obvious once you have the correct visual. What goes up, North, must come down, South.

There is a plausible, though invalid, counterargument, which is worth pointing out. It goes like this. Since W is gauge symmetric, there is no reason why all points in space should revert to same $W = 0$ baseline. It should be theoretically possible, therefore, to have the following scenario, which would constitute a monopole:



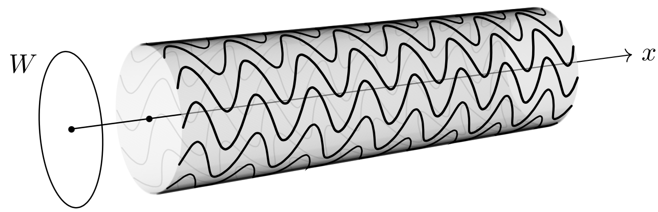
This is valid, so far as it goes. The diagram represents a permanent twist in substance, like one end of a sweet wrapper. However, such a thing is only possible if the universe is infinite and open. In Unity theory, it is not. Around a cosmologically closed spatial dimension, the two opposite ends of the gauge marker must meet up. A failure to do so would violate Continuity. Hence, every single North twist must be matched, somewhere in the universe, by a compensatory South twist. Those poles could, of course, be separated by some distance, but that has nothing to do with the question of monopoles; such a separation is simply a large dipole, i.e. a long bar magnet.

4.5 The Photon

In Unity theory, light is a *magnetic* wave. It is an oscillation in the magnetic potential, which means that it is an oscillating shear displacement of the substance of the W dimension, akin to the motion of a shaking dog. The displacement so defined then moves coherently through space. Viewed at the physical level of potentials, the light wave has, in fact, one dimension of polarisation, W, and can be summarised mathematically, therefore, with a single real-valued magnetic potential function

$$A_x(x, t) = \sin(kx - \omega t),$$

for some wavenumber k and angular speed ω. Such a wave can also be described with a sinusoidally oscillating field $\mathbf{B}$, given by the curl of the potential, and a sinusoidally oscillating field $\mathbf{E}$, given by its time derivative. But those are only subsidiary effects; the physical nature of the wave is as depicted.



A photon, then, is such a wave quantised by the thickness of the wave of the present. As a wave satisfying $\Diamond_c A(x,t) = 0$, light travels across space, moving in the x direction; as a wave satisfying $\Diamond_a A(x,w,t) = 0$, however, it stretches from the back to the front of the wave profile of the present, from which it gets its quantum nature. This is what defines the physical length of the grey cylinder depicted. Viewed solely within the wave of the present, as per Maxwell's equations and $\Diamond_c$, there is no reason for quantisation; viewed from without, however, the thickness δw of the present dictates a fixed length δl for every photon, as defined previously. This length in the outer (w, x) plane is the same as that of an electron wave in (w, W), which is what gives the light wave the same energy operator, up to a complex unit, as the fermionic electron. To accommodate the sinusoids, it must be given as a second derivative:

$$\hat{E}^2_{\text{boson}} = -\hbar^2 \frac{\partial^2}{\partial t^2}.$$

If we apply this to the magnetic potential of our light wave, we get

$$\begin{aligned} \hat{E}^2 A(x,t) &= \hat{E}^2 \sin(kx - \omega t) \\ &= \hbar^2 \omega^2 A(x,t) \end{aligned}$$

which is the Planck-Einstein relation $E = \hbar\omega$.

> The Planck-Einstein relation is an expression of the thickness of the present.

Having ascertained the nature of both bound-state electromagnetic force and light, we can turn to the *radiative* force associated with the photon. This has direct parallels with the graviton force, to be introduced later in this book.

4.6 Photoemission

What happens when an excited electron emits a photon? Well, an excited electron in a potential, such as that around a positively charged hydrogen nucleus, is an electron wave with a resonance in space x as well as in the leptonic W dimension. A ground-state electron has no such resonance, and can be viewed simply as a plane wave, travelling in the negative W direction. But an excited electron also has kinetic energy, due to its oscillation between the walls of its confining potential. This energy, all other things being equal, isn't in a stable form, and must be released. It can only be released as a photon. A change in x-resonance by an electron is a redistribution of charge in space. Momentum in W is conserved, but the spatial *location* of that momentum varies.

Now, by Continuity, the emission of a photon is not a discrete affair. The mathematical particles of QED are models, not realities. The γ photon is a continuous entity, which rises out of the surrounding substance in the manner that everything does, as a swell out of the sea. So, there is no sudden click. Rather, there is a transition period as one electron resonance breaks down and another, lower-energy one is forged. The details of this process are highly nonlinear and beyond the scope of this book. But we can consider them in qualitative terms. A change in x-resonance involves a movement in space, that is to say, a change in the spatial distribution of W-charge/mass/momentum/energy. This change must, to a first approximation, have a vector direction, i.e. take place in a single dimension of space, say x. As we know from classical electromagnetism, such an acceleration of charge generates a time-varying magnetic field. In other words, below the surface, it creates a time-varying magnetic potential. This propagates as a light wave, quantised by the thickness of the present. A *photon* is born.

To visualise this, it is important not to think of a photon as a particle in the manner of Newtonian ball-bearings. Such a view is incorrect, as it gives the impression of an entity travelling with a common velocity vector. A photon has no such thing: it has one speed, but a continuum of velocities. In fact, the word "photon" describes not a single W-shear wave, but a *spherical shell* of W-shear waves.

> An emitted photon is a spherical ripple, expanding from a single location in space.

Let us unpack this idea. The excess energy contained in an excited electron is released in a *continuous* process, not a discrete one. It isn't that the castle gate opens, a solitary photon rider emerges, and then the gate closes behind it. No. Rather, the volume is cranked up, sounds pours out continuously in both time and space, then the volume is turned down to zero again. The word "photon" refers only to the discrete *scalar* amount of classical energy that is released in the process. A photon is a circular ripple spreading out across the surface of a pond. Such an entity has physical existence, yes; it is a thing that can be measured, described and experimented upon, yes. But it isn't even close to the everyday notion of "particle". For one, there is no sense, even setting aside the uncertainty principle, in which it has a physical location in space.

The quantisation of a photon stems from the thickness of the present, not from any dot-like, ball-bearing nature. Photons are quantised because electrons are quantised, both before and after emission.[2] When an electron's excited state decays, a transition

[2] Here, we refer only to real, as opposed to virtual photons. In Unity theory, a "real" photon is one that stretches the full thickness of the present, while a "virtual" photon does not.

to a lower-energy resonance takes place. That transition begins, we must assume, at the w-front of the wave of the present, i.e. at its leading edge, and exists until the rest of the wave has also transitioned. Now, since every electron wave is symmetrical along δw, both before and after emission, the transition region must share the same symmetry. Effectively, the transition region unzips the electron from leading to trailing edge, and the photon is the constant noise of the zip, summed. Symmetry across the w-thickness of the wave of the present is what gives photons their eigenvalues of frequency and emission spectra their characteristic sharpness.

According to Unity theory, a photon is like an expanding spherical bubble, whose soapy film has a finite thickness and contains a finite amount of energy, as defined by the Planck-Einstein relation $E = \hbar\omega$. In that formula, $\hbar$ represents the thickness of the soapy film, which is a manifestation of the w-thickness of the wave of the present, while ω is the angular frequency of the wave, as dictated by the electron resonances before and after. In combination, they give the total classical energy E in the bubble.

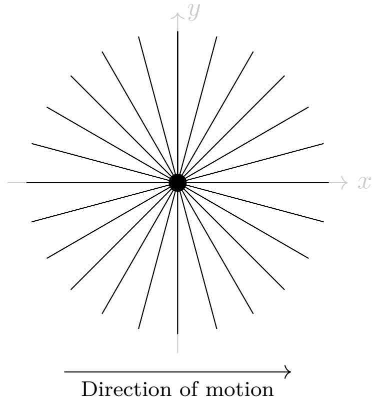
There is a strong visualisation for this spherical emission, due to Thomson. He produced this visualisation in the last days of classical physics in a succinct and powerful explanation as to why radiative electromagnetic forces drop off linearly with distance, while bound-state electromagnetic forces drop off quadratically. This fact is pertinent not only to understanding the nature of quantisation, but also, in its original guise, to upcoming discussions regarding the graviton, so we lay it out explicitly here.

4.7 Thomson's Argument

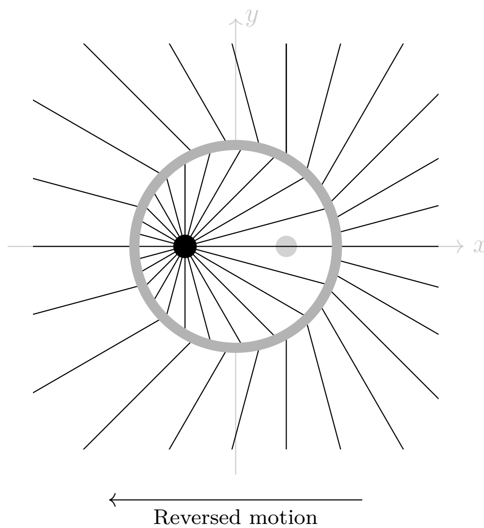
In this section, we work in classical terms, describing fields in space rather than the underlying curvature in substance. Consider an electromagnetic point charge, such as an electron, moving at a constant non-relativistic velocity in an (x, y) plane.[3] Such a charge has an electric field associated with it, which other charged particles feel as an electromagnetic force. As is common in classical electromagnetism, we represent the field with field lines: the closer together the field lines are, the stronger the force felt by charged particles.

Now, an electron moving at a small constant velocity is, according to Newton's laws, essentially identical to one at rest. So, despite the motion, the field lines emerging from such an electron are, at any instant, spherically symmetrical around the electron's location, following the same inertial motion as the electron itself. Such is the speed of propagation of the electric field that an effective symmetry is maintained. This spherical symmetry appears circular in representation, so what we see is an electron, together with its radial field lines, moving slowly through space. The entire system, particle and field, moves as one. Until Maxwell discovered the finite speed of propagation of electromagnetic waves, this was the full conception of electrodynamics.

[3]For clarity, we present this argument electromagnetically. However, the charge in question need not be an electromagnetic charge. It can, in fact, be any kind of charge generating any kind of classical field. In particular, it can be a Newtonian mass generating a Newtonian gravitational field.



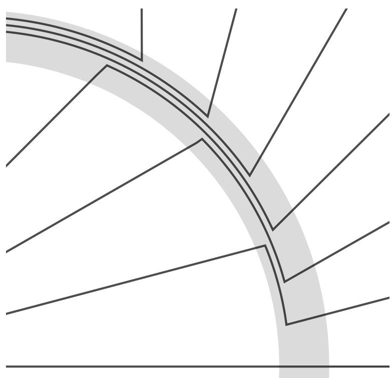
Now, suppose that, at the moment represented above, when the electron is at the origin of our graph, it accelerates leftwards, sharply, over a short period of time δt, reversing its direction of motion. This produces a change in the electric field lines. However, that change can only propagate outwards from the electron at the speed of light. Hence, points in the (x, y) plane that are outside the future light cone of the event cannot yet know about the electron's change of direction. In other words, at small distances from the origin, the field lines are those of the reversed particle, but at large distances, the field lines are those of the particle as it would have been had it not undergone any acceleration. The transition region, then, is a shell of thickness $\delta r = c\,\delta t$, expanding from the historical location of the acceleration, which in this case is the origin.



The grey ring, representing a sphere in space, is the shape of a photon. Indeed, this is as close to a picture of a photon as a simple diagram can offer. Now, a photon is not, in fact, spherically symmetrical—it carries non-zero net momentum—but it is nonetheless *constrained* to such a shell.

This stylised acceleration of a classical point charge is mathematically equivalent to the rapid redistribution of charge that takes place when an electron resonance changes. Rather than a classical ball-bearing accelerating, the entity doing the accelerating is a wave, but the effect is qualitatively the same. A disturbance in the magnetic potential, viz. a torsion of the W dimension, is generated for as long as the resonance is transitioning from one form to the other, and no longer. Hence, in quantum as well as classical emission, a grey photon sphere is emitted as above.

But now, as Thomson explained, consider the *continuity* of the field lines. Since the field lines inside must join up with the field lines outside, they must bunch up within the shell, picking up a component tangential to the grey circle. This effect varies from a minimum zero in the direction of acceleration to a maximum orthogonal to it, hence a photon's directional asymmetry. Pertinent to us is the size of this effect: it increases as the photon gets bigger. Relatively speaking, the field lines within the shell have to bunch up ever more tightly as the photon grows in size, so as to "make their way around" the grey circle to join inner region to outer region.



Since an acceleration of charge in space is effectively one-dimensional, this effect is proportional to the circumference of the photon, which is proportional to its radius. The field itself, following the inverse square law dictated by the three-dimensionality of space, drops off as r^2, independently of this effect. So, locally, the photon still weakens as it grows. However, field strength drops off only *linearly* with r, rather than quadratically. This was known phenomenologically before Thomson's analysis, but it was he who elucidated the argument above. It has major implications in cosmology.

4.8 Quantum Electrodynamics

It is clear, in Unity theory, why quantum electrodynamics, the quantum field theory of the electromagnetic interaction, has a U(1) gauge symmetry. U(1) is the group of infinitesimal rotations of the circular W dimension. The gauge symmetry of QED is the rotational symmetry of the leptonic inner dimension, momentum in which manifests as electric charge and shear displacement in which manifests as magnetic potential. QED emerges naturally from Unity theory, given these simple facts.

A point on notation, which will be relevant later. U(1) and S^1 are the same group, the circular group. The notations are often used interchangeably, and there is nothing mathematically wrong with that; the unitary group U(1) of complex phases is identical to the Lie group S^1 defined by the 1-sphere. But it is worth our making a sharp distinction here, as regards usage, which will be important as we extend our analysis to the other fundamental interactions. While the group of rotations of S^1 is circular, the group of rotations of S^3 isn't spherical. So, we should be careful in notation. In Unity theory, therefore, S^1 and S^3 are taken to refer only to *physical spaces*, never to the rotational symmetries associated with those physical spaces. Hence, we refer to the W dimension as having S^1 topology, which is the underlying fact, and electric and magnetic activity within and of it as having U(1) gauge symmetry as a result.

Now, this book isn't about quantum field theory, nor about electromagnetism, so we won't go into any further detail here regarding QED. The fact that Unity theory, by dint of the U(1) symmetry of the W dimension, contains QED as a limiting case requires no complicated derivation. We have already done it. Essentially, the mathematics of QED lies in its U(1) symmetry. There are certainly questions remaining, most notably regarding renormalisation, which we address in an appendix,[4] but we will set those aside until we have considered the full gamut of the fundamental interactions. That comes next. Having gained some intuition, with reference to electromagnetism, for what a force actually *is*, we can now broaden our gaze.

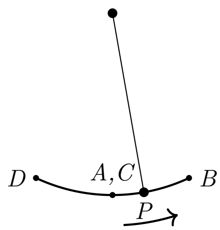
Care will be needed as we do so. The symmetry of the electromagnetic interaction is rather obvious, in the end, which is why we began with it. U(1) is a circle, and everyone knows it's a circle. But the SU(2) and SU(3) symmetries of the weak and strong interactions, while mathematically well validated, are far less well understood. Indeed, the SU(2) symmetry of the weak interaction is hardly understood at all. And gravity? The situation there is even hazier, if such a thing is possible. Gravity hasn't even been described in the language of symmetry. It isn't at all clear, in the old paradigm, what symmetry the gravitational interaction has. Indeed, a physicist working in the old paradigm is hard pressed to say what the phrase "the symmetry of gravity" even means. This has been one of the greatest obstacles to any attempt to unify general relativity with quantum field theory.

So, we must tread carefully as things start to get more complex. The strong and weak interactions are imminent ports of call, but, before we address those, we are going to take an aside, so as to analyse the concept that will allow us to bridge the gap between all four interactions. This is the *action principle*, which has, for centuries now, been recognised as central to physics. It is the action principle that, both in quantum field theoretic and general relativistic domains, determines where particles go when forces act on them. The principle is only partially understood in the old paradigm, and we must update it before we proceed.

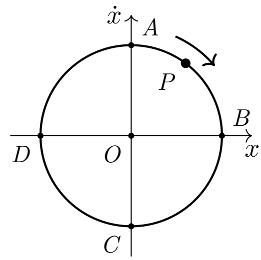
[4]Renormalisation is a technical matter which does find explanation in Unity theory, but it turns out not to be of great significance. As various authors have suggested, it represents a weakness of the modelling process, rather than anything physically important.

5 The Action Principle

The mathematical space which consists of all possible states of a physical system is known as its *phase space*. Now, the phase space can be parametrised in various ways. In classical mechanics, it is often given in variables $(x, \dot{x})$, where x is the position of a classical object. For example, consider a pendulum, as depicted in the picture on the left, swinging to and fro under small oscillations. Its position varies sinusoidally $x = \sin \omega t$, as does its tangential velocity $\dot{x} = \omega \cos \omega t$. The two sinusoids are out of phase, and the point representing the state of the pendulum traces out a circular path, known as a trajectory, in phase space, as shown in the diagram on the right.

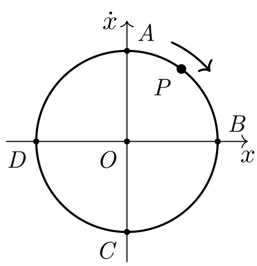


Physical Space

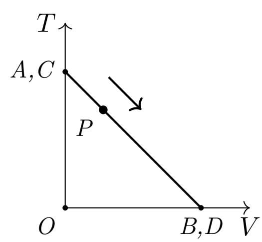


Phase space

We now encode the same information differently. Instead of describing the system in terms of positions and velocities, we first describe it in terms of kinetic and potential energies, T and V. Just like x and $\dot{x}$, these are functions of time. Phase space is then given by a (T, V) plane, and the behaviour of the system is given as a time-parametrised trajectory through that plane. In the case of the pendulum, energy is distributed back and forth between kinetic and potential energies, so the point representing the pendulum oscillates to and fro along a straight line in (T, V) energy space.



Phase space



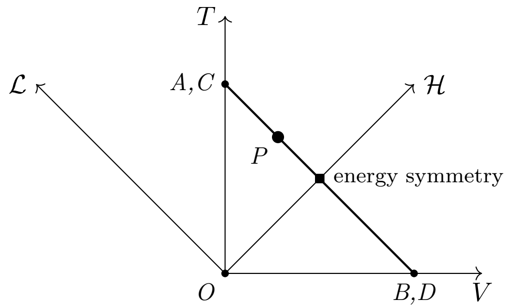
Energy space

5.1 The Lagrangian

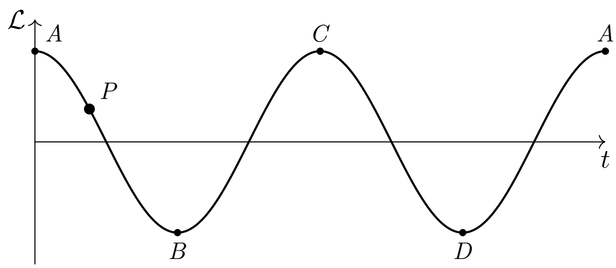
The Lagrangian reformulation then involves a change of coordinates of (T, V) space. We know that the total energy $T + V$ is constant; hence, the most natural set of coordinate axes for energy space is not (T, V), but rather parallel and perpendicular to the line $T + V = E_{\text{total}}$. The variables associated with these axes are known as the Hamiltonian $\mathcal{H}$ and the Lagrangian $\mathcal{L}$. Their algebraic definitions are

$$\mathcal{H} = T + V$$
$$\mathcal{L} = T - V.$$

Representing this on our energy space diagram, we have



The strength of this approach is that, combined with the universal fact of conservation of energy, the Lagrangian contains all of the phase space information. The quantity $\mathcal{L}$ represents the departure from energy equality, i.e. the imbalance in the kinetic and potential energies. The point marked with a square, at which $\mathcal{L} = 0$, represents energy symmetry. Looking at a pendulum, you wouldn't notice occurrence of this point, it being somewhere between the spatial centre and the spatial extreme, but it is, in *energy* terms, the "centre" of the motion. Away from that point, energy either piles up in GPE at the expense of KE, or in KE at the expense of GPE. In the example of the pendulum, the Lagrangian is proportional to $\cos 2\omega t$. Hence, the behaviour of the system is given by the graph below.



The point marked with a square in phase space, viz. energy symmetry, is now the line $\mathcal{L} = 0$, and oscillation around it is given by the cosine. When interpreting such a graph, it is important to remember that A and C represent states of maximum velocity and B and D represent states of maximum gravitational potential; this is a picture of an energy trajectory in energy space, not of a physical trajectory in physical space. This can be seen clearly in the fact that, just as in our derivation of the Dirac equation, the energy sinusoids T, V, and $\mathcal{L}$ oscillate *twice as fast* as the physical position and velocity sinusoids.

5.2 Stationary Action

The *action* is defined to be the time integral of the Lagrangian,

$$S = \int \mathcal{L}\, dt.$$

In other words, the action is the difference between the kinetic and potential energies, summed over time. The *action principle* then states that trajectories through phase space must yield an action that is stationary under small variations of the trajectory. There are two questions to address and understand for subsequent use: 1) Why is the action principle relevant? 2) Why is the action principle true?

The first is straightforward. Consider once again the trajectory of the pendulum through phase space. Conservation of energy tells us that the point P, representing the state of the pendulum, must remain on the line $\mathcal{H} = E_{\text{total}}$. Departures from this line are physically impossible. However, there are various time-parametrised rates at which the point P could proceed *along* this line. All such trajectories are permitted on energetic grounds. We need the action principle because it is the action principle that determines which of these permitted trajectories a particle actually takes.

And now to the nub of the matter: why is the action principle *true*? This is one of the central questions of physics.[1] It was Dirac, that extraordinary theorist, who provided the first real answer to it. We follow his argument here, as presented in his groundbreaking, but also rather abstract, 1933 paper, *The Lagrangian in Quantum Mechanics* [13], with the goal of translating his cryptic algebraic manipulations into the more tangible language of Unity theory. Here goes.

Underlying electrons, and matter more generally, there are fermionic substance waves. These exchange waves are represented by complex-valued functions

$$\Psi(x, W, t) = \psi(x, t) e^{i(mcW - Et)/\hbar},$$

where the amplitude $\psi(x, t)$ is observable and the phase factor $e^{\bullet}$ is not. In such a wave, the amplitude contains the kinetic energy and the phase factor contains the rest energy or mass. Now, for a free electron, there is no transfer of energy between these two types, since the mass-energy is fixed at 0.511 MeV by the need for resonance in the W dimension. But that changes when a *potential* is introduced. In the presence of a potential V, representing background curvature of one description or another, energy is exchanged between the inner and outer dimensions. This isn't the same as annihilation, in which resonance breaks down entirely; this is a smooth and *reversible* change. If the W dimension is enlarged, say, at a particular location, then the waves there have less energy stored in the imperceptible inner dimensions and more stored in the perceptible outer dimensions. To get to this new state, a coherent transfer between inner- and outer-dimensional energies must take place. In other words, the particle must make a coherent journey through energy space.

[1] Particularly, it is crucial to any understanding of the Hilbert action, from which general relativity emerges. In Unity theory, gravity must run on exactly the same principles as everything else.

Leaving aside progress, which isn't relevant here, outer-dimensional energy is precisely kinetic energy, notated T. Inner-dimensional energy, on the other hand, is a combination of rest energy mc^2 and potential energy V, the latter being a departure of the former from baseline. Let us understand this. For example, consider a narrowing of the leptonic inner dimension. This increases the frequency and hence the mass-energy of any electron present. In physics, we regard this not as an increase in mass, but rather as an addition of potential energy on top of the mass. This is a sensible choice, as it leaves the mass as a clearly defined constant. However, underlying this conception, the potential energy and the rest energy are, in fact, the same concept, in the sense that they are rates of change in the same dimension. Potential energy is simply the departure ΔE_{inner} from E_0, the rest energy.

Let as assume we are dealing with coherent matter. This assumption restricts the domain of validity of the action principle. Now, by definition, a particle of coherent matter has a well-defined rest mass. Following the standard formulation, we can therefore set this rest energy as a fixed baseline, and take the potential energy $V = \Delta E_{\text{inner}}$ as the sole measure of inner-dimensional energy, at least for as long as the particle maintains its coherence. Our assumption would be invalid under annihilation, but that's fine; annihilation is beyond the remit of the action principle, which only applies to coherent particles. All of this makes for a simple formulation: in coherent matter, all of the kinetic energy T is contained in the observable amplitude $\psi(x, t)$, and all of the potential energy is contained in the imperceptible phase factor $e^{\bullet}$.

With mass invariant, kinetic energy $T = E_{\text{outer}}$ and potential energy $V = E_{\text{inner}}$.

As a particle travels along a trajectory in phase space, its constituent waves must maintain coherence. If resonance can be achieved/maintained, it is always energetically favourable; that's why musical instruments work. So a particle will seek to maintain coherence in both its inner- and outer-dimensional components. This is a strong criterion: during any acceleration, continued *vector* coherence is required, that is to say, coherence in all dimensions, both inner and outer.

Such continued vector coherence follows automatically for a free particle, because a free particle experiences no changes in energy. But it doesn't follow for a particle in a potential. In the presence of a potential, the inner- and outer-dimensional frequencies change, according to, for example, narrowing of the inner dimensions. In a potential, energy is *transferred* between the inner- and outer-dimensional components of the wave. How can coherence be maintained? Well, a particle begins in a coherent state by definition, so, if subsequent *transfers* between inner and outer are coherent, then both individual components must remain so. Thus, the condition for continued coherence is that, at any given instant, the Lagrangian $\mathcal{L} = T - V$, representing the transfer of energy between inner and outer, is constant through the particle's physical extent in x:

$$\frac{\partial \mathcal{L}}{\partial x} = 0.$$

We can now address the mathematics. We take a fermionic exchange wave, with outputs modelled by ϕ. The magnitude of ϕ isn't relevant to coherence, only the phase is; so, as is usual in quantum mechanics, we can work with $\phi \in \mathrm{U}(1)$ representing the helical phase of our matter wave. Coherence is required in ϕ. Consider then a short period of time δt, over which the Lagrangian may be assumed to be constant. The transfer of phase between inner and outer dimensions during this period is given by

$$\delta\phi = e^{i(T-V)\delta t/\hbar} = e^{i\mathcal{L}\,\delta t/\hbar}.$$

We sum over many such short periods δt, and take the infinitesimal limit. This yields an integral expression for the total transfer of phase

$$\Delta\phi = e^{i\int \mathcal{L}\,dt/\hbar} = e^{iS/\hbar}.$$

This defines the action. S is the total transfer of energy, summed over a period of time, between the inner- and outer-dimensional components of a matter wave. $\Delta\phi$ is then the total transfer of phase (helical rotation) associated with S. Now, as Dirac pointed out, the phases of quantum waves rotate very quickly indeed. Planck's constant $\hbar$ is tiny, so any variation in $\mathcal{L}$ between different parts of a particle must result in phase incoherence. This scenario is energetically outlawed.

But, in a particle, such variation is inbuilt! Irrespective of its historic quantum modelling, a physical particle such as an electron doesn't only exist at a single location in space. Continuity dictates that it cannot do. A physical particle is always spread out to some small extent, however we choose to view it. So, different parts of the particle are forced, *a priori*, to take slightly different trajectories. But those slightly different trajectories, with their slightly different values of the Lagrangian, do not, in general, yield only slightly different values of $\Delta\phi$. Because $\hbar$ is so small, they yield very large discrepancies: tens, hundreds and thousands of helical rotations. And, for a particle that must maintain coherence, that isn't permitted energetically. If one part of a wavepacket experiences even so much as a *half*-turn of phase more than any other part, then the particle is done for.

So, how can a particle maintain coherence in the face of such overwhelming odds? There is only one way. Every particle must travel along a trajectory in phase space for which small variations in the trajectory, such as must always be experienced by the various parts of the particle's wavepacket, do not generate *any* variation in S. In other words, there can be no first-order variation in S around the trajectory, which is only true if the action S is stationary under small variations. This is precisely the content of the action principle.

A particle has two choices: 1) obey the action principle, or 2) fall to pieces. If a particle is a car, then the action principle is a map of the roads. It's not that particles are outlawed from heading off into the wild blue yonder, but just that, as soon as they do, they come to bits. Unstable particles, of course, do exactly that. But, since we give things the name "particle" precisely when they are *not* falling to pieces, the law is a strict one: all particles obey the action principle.

Many educators have written and said things such as: "Particles take all possible paths through phase space, and the phases cancel everywhere except along a trajectory with stationary action." The second part of the statement is mathematically true, and corresponds to the argument given above, but the first part regarding "all possible paths" is somewhat nonsensical, and, as such, not very helpful.

To understand physical reality according to Unity theory, one must dispense with *all* of the metaphysical baggage of the quantum paradigm. Twentieth century quantum physics, in its last-ditch attempts to save the spatial view, was forced to introduce many such elements, and "inherent probability" was perhaps the worst of them. The old paradigm looked at the stage, saw the actors appearing from unseen wings, and, since it is impossible to tell in advance whether an actor will emerge stage-left or stage-right, concluded that the stage direction was "inherently probabilistic". With the benefit of hindsight (and, in Einstein's case, without it), we can see this as poor quality theory.

There is no such thing as inherent probability, either in mathematical theory or physical practice. In fact, there is an eminently real, eminently visualisable, eminently deterministic universe, in which there are no superposed cats, no rolling dice, no logical inconsistencies of any kind. Substance simply does what it does. But it just so happens that this eminently real universe isn't the one we perceive: *backstage*, the material actors obey the careful directions of the action principle, emerging into perception reliably, according to well-laid, although unknowable, plans.

Think of a trajectory through phase space as the cylindrical pipe of a slide at a water park. The old view claims that, when you launch yourself down the chute, you follow all possible paths down it, but the parts of you that ride up the sides of the chute cancel, and hence you remain in the middle. It doesn't make very much sense. What is actually going on is that it is energetically favourable for you to remain in the middle rather than ride up the sides, so you remain in the middle. It is remarkable how much simpler the new paradigm is, yet how hard some folk have fought to avoid its simplicity.[2]

We make the analogy more accurate by considering a particle not as a discrete human being, but as the continuous flow of water down the middle of the chute. That has little wavelets in it, yes, little variations of wavevector, little transfers of energy between kinetic and gravitational potential energies. But the flow of water nevertheless follows a regimented path. A particle such as an electron is much the same. It is a wavepacket, which is a swell in substance consisting of many (continuous) individual parts. It experiences tiny variations. The difference is that the coherence condition is so much more stringent for the electron wavepacket than it is for the water. Hence, while classical water spreads out somewhat, splashing this way and that, the energetic favouring of coherent resonance dictates that an electron, if it is to survive at all, must stick *exceptionally* closely to the lowest line of the chute. These, then, are the tracks we see in spark chambers.

[2]This is the human condition in microcosm: everyone benefits from the truth, but few want it. A line from the *Daodejing* springs to mind, apt both in metaphorical and quantum terms. "The great Dao is very smooth," Laozi wrote, "but people like rough trails."

6 Unity and the Strong Interaction

At the outset of this book, we made a bold and revolutionary claim regarding the nature of reality, namely the axiom of Unity: the universe is one substance. We began with a hypothetical assumption of this axiom, and went logically from there. Subsequently, we have seen the axiom of Unity generate classical mechanics, quantum mechanics, special relativity and the theories of electromagnetism. Given that these results have no theoretic underpinning in the old paradigm, it is reasonable, at this moment in proceedings, to make a conceptual shift. We should move from a purely hypothetical stance, "What would the universe be like if the axiom of Unity were true?", to a firmer position: "The axiom of Unity is true. What does that tell us?"[1]

We need to take this confident step, as, from this point onwards, we begin to see a change in the results of our theoretical derivations. As we build towards gravity and the cosmos, we start to see significant disagreements between Unity and the old paradigm not just regarding the imperceptible *underpinnings* of reality—that has been the case right from the start—but in terms of the perceived reality of the lab. This is an important step, and we take it boldly.

Firstly, in the next two sections concerning the strong and weak interactions, we propose a structure for the proton that is radically different to the incumbent one, in a way that is theoretically testable in the laboratory. Unity theory disagrees with the quark model in a very direct sense. While we concur with the quark model as far as that model has been validated, i.e. with reference to the unstable matter produced in particle colliders, we depart from it in emphatic fashion with reference to the proton, in which domain it has no validation. Given that the universe is essentially made of protons, this constitutes very significant disagreement. Secondly, in the sections following, on gravity and cosmology, Unity theory goes even further, disagreeing with various hypotheses—dark matter, dark energy, inflation, and, yes, even the Big Bang itself—that are currently taken as halfway to gospel truth. We will address those starker disagreements at the appropriate moment.

Given the scale of Unity theory's departure from the current scientific worldview, it would be quite absurd to expect anyone to work to understand it, in its *disagreements* with the familiar, were the theory not already strongly validated by its *agreements* with the familiar. This is why we have spent time and will continue to spend time addressing standard results in classical and quantum physics, before and while we forge ahead into new ground. Quantum mechanics, with its extraordinarily high levels of mathematical certainty, constitutes the launching point of Unity theory, while nuclear physics and cosmology, with their necessarily lower levels of mathematical certainty, constitute its *terra nova*. In this section, we begin the transition from evidence to end results.

[1] Naturally, with this confidence, we should retain a willingness to be corrected. However, that willingness should not detract from the courage of our convictions. Here, the appropriate level of confidence in the axiom of Unity is that of someone answering the question "What day is it?" The answer isn't "Tuesday, to 99% confidence". The answer is a firm "Tuesday", with an unspoken willingness to be corrected by further data.

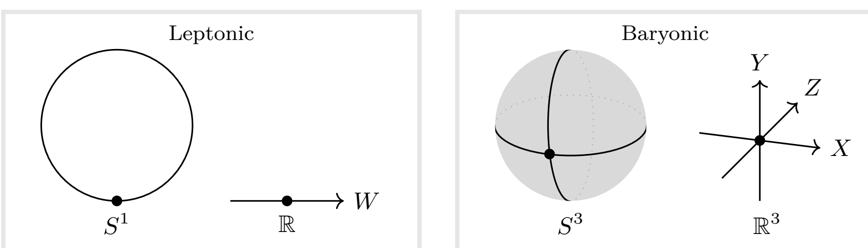
6.1 The Baryonic Inner Dimensions

The profound strength of the axiom of Unity is that we need not, and indeed cannot, introduce new theoretic elements to describe the baryonic S^3 component of the inner dimensions, as compared to those we used to describe the leptonic S^1 component. What theory we use to model (X, Y, Z) inner space must be the same as we used to model the leptonic W dimension. As before, everything must emerge from the substance equation. In Unity theory, local geometry is the same everywhere and in every direction. So, what generates the marked observed differences between the behaviours of leptons and baryons? It can only be *topology*.

The leptonic dimension is circular; the baryonic dimensions are spherical. The relevant topological spaces are related, yet they exhibit significant differences. In common, both S^1 and S^3 have circumferences that are circular: the great circles of S^3 are copies of S^1. Hence, at the broadest level, the same types of wave solutions exist in X as do in W, namely resonant fermionic exchange waves. Both components host coherent, massive particles. But that's where the similarity ends. The key difference is topological: S^3 is simply connected, while S^1 is not. This is a crucial fact in Unity theory.

⦿ Definition: *Simply connected.* A topological space is simply connected if and only if every loop in that space can be reduced continuously to a point.

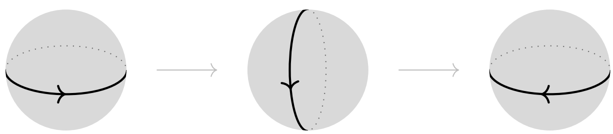
To see this, it helps to visualise S^3 as S^2, the surface of a globe. There is, in fact, no significant downside to this analogy, and, as a result, it is recommended pedagogically in this section and throughout Unity theory. Baryonic inner space can be held in mind as a hybrid of S^2, which contains all of its topological features, and $\mathbb{R}^3$, which contains its local geometry. There is no behaviour of S^3 that cannot be clearly seen in either the topological or geometric view, both of which are readily visualisable. In the diagrams below, the topological Lie groups are on the left of each pair, and their tangent spaces, the relevant geometric Lie algebras, are on the right.



Self-evidently, S^1 is not simply connected. It is the very essence of a circle that it has a hole in the middle. But S^2 and S^3 are. S^2 has a certain type of hole in the middle—the air at the centre of a balloon—but that type of hole doesn't stop loops on S^2, which consists only of the *surface* of the balloon, from shrinking down to a point. There is no lasso of rope on the surface of the Earth that cannot be tightened to nothing.

And the same topological fact holds in all higher-dimensional spheres, including S^3. In the baryonic inner dimensions, every great circle is topologically flexible. The guise in which this fact is most pertinent is that a great circle on S^2 or S^3 can be *reversed*. This isn't possible in S^1, which is why electromagnetic charge is a permanent feature of a leptonic wave. An electron moves in the negative W direction, and no amount of continuous deformation, no amount of bending by external potentials, no amount of force can turn that negative charge into positive charge. Resonant leptonic mass/charge is topologically indestructible. But the same isn't true of baryonic mass/charge. A wave travelling around the baryonic X great circle can be continuously deformed into a wave travelling *in the opposite direction around the very same circle.*

We can visualise this with reference to S^2. Consider the equator as a great circle, and mark an arrow on it pointing east. Now, fix two diametrically opposite points on the equator, front and back on the diagram below, and rotate one side of the great circle up and over the North Pole. Complete 180° of rotation and *voilà*, the great circle is back on the equator, with its arrow pointing west. Exactly the same possibility exists in baryonic S^3.



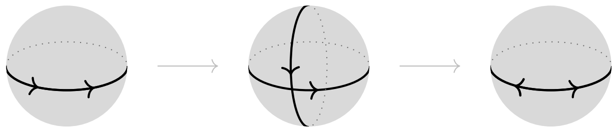
Theorem. *Charge theorem.* Continuous transformations exist between particles of positive and negative charge q_j, as defined by

$$\hat{q}_j \propto \frac{\partial}{\partial X_j},$$

if and only if X_j is a simply connected dimension.

This theorem is the difference between leptons and baryons. An electron travelling in the W dimension has charge, and that charge is permanent. But, if we endeavour to construct an "X-electron", exactly analogous to a familiar W-electron, we come up against a problem. An X-electron, circling the inner X dimension, has no topological safeguard to maintain its path through inner space. There is a continuous, hence permitted, transformation that turns it into a negatively X-charged version of itself. Now, that wouldn't be a problem, were the whole wave transformed. But waves have no God-given right to hold together. So, there also exists a transformation in which, say, half of the X-electron wave remains positively charged and the other half becomes negatively charged. This is a possibility that doesn't exist for a regular W-electron.

Consider a hypothetical X-electron as two superposed half waves, both negatively X-charged. Then, consider instead a superposition in which the first half has been transformed continuously into a particle of opposite X-charge. Essentially, we can view this as taking a thick equator, slicing it into two thin equators, and then rotating one of them over the poles. Energetically, what is going on? Well, as we know from electromagnetism, the superposition of opposite charges is energetically favourable as compared to the superposition of like charges. If possible, nature likes not to keep things twisted. Hence, the X-electron must seek the $+-$ state.



Now, the same energetic wish for balance exists in a regular W-electron, but there it makes no difference, as the transformation is topologically impossible. But in S^3 the transformation is continuously permitted and energetically favoured; so, by hook or by crook, it will happen. This is the reason for *confinement*: the fact that there are no isolated quarks. It is impossible to maintain X-charge in isolation, as transformation of half of that X-charge into its opposite is always possible and always favoured. Hence, the only stable or metastable configurations of waves travelling around the baryonic inner dimensions are those that either have no net charge in any single inner space dimension or else occupy all three dimensions of inner space symmetrically. The former type of particle is known as a *meson*, the latter as a *baryon*.

6.2 Colour

The three dimensions of inner space (X, Y, Z) correspond to the three colour charges *rgb* of quantum chromodynamics. The colour space which is the central object of QCD is a mathematical description of the three-dimensionality of the baryonic inner space of Unity theory. And, just as leptonic charge describes the same momentum/energy as leptonic mass, baryonic charge describes the same momentum/energy as baryonic mass. In other words, the three dimensions of colour charge are, in appropriate units, the three dimensions of the baryonic mass vector. Colour charges are then analogous to electromagnetic charges, just as baryonic mass m_b is analogous to leptonic mass m_l.

However, we cannot give a value of elementary colour charge that is as well defined as the elementary electric charge e. This is due to the simple connectedness of S^3: colour charge cannot be isolated. So, we are better off not attempting to define colour charge in the linear language of quantum mechanics. Such a definition could be made, but it would be of limited use, since baryonic inner space is beyond the modelling capacity of quantum mechanics; non-abelian quantum field theory is required. In Unity theory, we will simply make the link between baryonic mass and colour charge, observing that they are different names for the same X-energy.

⦿ Definition: *Baryonic mass.* Energy in the S^3 component of the inner dimensions, as that energy pertains to the electromagnetic, weak and gravitational interactions. Equivalently, momentum in inner space, as that momentum pertains to geodesics in the non-baryonic components of the Unity group.

⦿ Definition: *Baryonic charge.* Also known as colour charge. Energy in the S^3 component of the inner dimensions, as that energy pertains to the strong interaction. Equivalently, momentum in inner space, as that momentum pertains to geodesics in the baryonic component of the Unity group.

With the relevant concepts defined, we can turn to the strong interaction itself. The waves that participate in the strong interaction are fermionic exchange waves, essentially identical, *mutatis mutandis*, to electrons and gravitational waves. The only qualitative differences between these types are those of dimensionality: the direction and extent of polarisation and the inner dimensions in which the waves resonate. The latter attribute is the most fundamental, discriminating as it does between families of particles at the broadest level. While a leptonic electron moves in $\hat{W}$, a baryonic proton moves in $\hat{X}$.

At this point in the work, as the variety of different types of wave begins to proliferate, we introduce a shorthand: *configuration notation.* With $e^- : \hat{W} \,\big|\, xy$ we signify the wave configuration underlying an electron, i.e. an exchange wave with unit wavevector $\hat{W}$ and plane of polarisation (x, y).

e^-	:	$\hat{W}$	$\big|$	xy
Particle		Wavevector		Polarisation

So, a cross-polarised gravitational exchange wave travelling in x is represented as $h_\times : \hat{x} \,\big|\, yz$, and a quark with red colour charge is represented $q_r : \hat{X} \,\big|\, xy$. We then notate shear waves, such as light, with a single dimension of polarisation, signifying shear displacement around a closed circle.

γ	:	$\hat{x}$	$\big|$	W
Particle		Wavevector		Polarisation

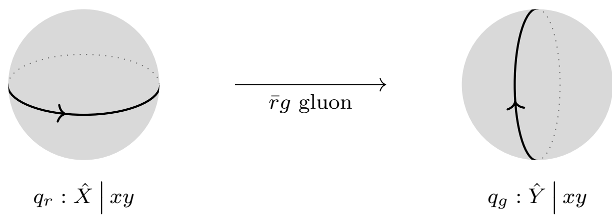
All of the above may be relative to the present or substance, depending on context. When we want to work in $\diamondsuit_a$ explicitly, we can notate the transformed dimensions, angled into w by angle θ_p, with a prime. Hence, relative to substance, a resting electron is $e^- : \hat{W}' \,\big|\, xy$, which technically means $e^- : \cos\theta_p \hat{W} + \sin\theta_p \hat{w} \,\big|\, xy$.

The strong interaction describes rotations within inner space. In other words, it describes transformations such as the one turning a wave resonating in X into a wave resonating in Y. In configuration notation, such a transformation, which is permitted only by the simple connectedness of inner space, may be expressed as

$$q_r : \hat{X} \,\big|\, xy \longrightarrow q_g : \hat{Y} \,\big|\, xy.$$

The above turns red-charged energy into green-charged energy. As a transformation, specifically a rotation, it is, therefore, a *gluon* of the type $\bar{r}g$, as described in QCD. In the language of quantum field theory, such a particle annihilates a red quark, with

$\bar{r}$, and creates a green quark in its stead, with g. We should note, however, that this story, while accurate on one level of mathematics, is a poor account of what is actually happening, in a physical sense. In Unity theory, there is no annihilation or creation, because, according to the principle of Continuity, such things are impossible, at least at a fundamental level. In Unity theory, "gluon" is a name for a particular type of curvature of the inner space dimensions, such as bends a geodesic from a great circle in X into a great circle in Y. This has the effect, quantised in our highly limited perception, of "annihilating" the former and "creating" the latter.



Now, fermionic exchange waves such as the quark-like $q_r : \hat{X} \,\big|\, xy$ must be described by complex-valued functions, exactly as in the quantum mechanics of electrons. Since space is orthogonal to inner space, we can and must assume a fixed plane of polarisation under such a rotation: the strong interaction describes rotations in inner space *alone*. Mathematically, then, the transformation that takes $q_r : \hat{X} \,\big|\, xy$ to $q_g : \hat{Y} \,\big|\, xy$, which in physical terms rotates one axis of the baryonic 3-sphere onto another, is a rotation of a complex-valued, three-dimensional Hilbert space.

Before analysing the full quantum field theoretic connotations of this fact, we should consider an important distinction with quantum electrodynamics. It is all too easy, coming from the old paradigm, to be led, by the historical overuse of the expression "gauge symmetry", into thinking that "gauge" is a word with a clear definition. It is not. Like all tools, both physical and mental, gauge symmetry is useful, but nevertheless limited in its applicability. It doesn't mean the same thing everywhere. The much-touted symmetries U(1), SU(2) and SU(3) of the Standard Model do have commonality, yes, but they also have significant differences, *beyond those* of their group structures. The leptonic W dimension produces a U(1) gauge symmetry because the rotations involved are real-valued: locations on the W circle are transported to other locations on the circle. U(1) describes the symmetry of the *outputs* of the photon wave. But a more complicated description is required in the S^3 baryonic dimensions. There, the rotations involved are not displacements of substance, rather they are transfers of *energy* from dimension to dimension. Enact an electromagnetic rotation, and the W dimension picks up a magnetic torsion; enact a strong rotation, and energy in the X dimension is rotated, by the nonlinear bending of geodesics, into the Y dimension. Such rotations exist on different conceptual levels; in other words, the expression "gauge symmetry" means *different* things for the photon and the gluon.[2]

[2]By the time we consider the weak interaction, the notion of *gauge* symmetry has broken down altogether. There is weak symmetry, yes, but there is nothing "gauge" about it.

With this point clarified, we can now consider the (gauge) symmetry of the strong interaction. It emerges easily. The relevant set of symmetry operations is that which *rotates* between different *exchange waves* within inner space (X, Y, Z). Mathematically, then, the relevant symmetry group is the set of *unitary* *complex-valued* 3×3 matrices. This is the special unitary group SU(3), which is the symmetry group of the strong sector of the Standard Model.

The above is a derivation that doesn't exist in quantum field theory, which assumes the phenomenological symmetries of the Standard Model as its axiomatic foundation. As such, it represents another test passed by the paradigm built on the axiom of Unity. Now, to some extent this is a test passed by design, since the three-dimensionality of colour space was one of the ingredients that guided us towards proposing baryonic S^3 to begin with. A critic might say that Unity's derivation of SU(3) structure is ad hoc. However, that would miss a broader point. Even without the evidence of QCD, the *overall* symmetry of Unity theory dictates the three-dimensionality of inner space. The (x, y, z) and (X, Y, Z) components must match, firstly for aesthetic reasons, but also for many practical ones, a number of which we have yet to elucidate.

So, we now have Unity theory generating not only quantum mechanics and special relativity, but both QED and QCD, the quantum field theories of the electron and the proton, as limiting cases. Now, the experimental corroboration of QCD may not be quite as overwhelming as that of QED, but it nonetheless extremely powerful: the symmetry structure of the Standard Model is essentially beyond doubt. And all of that experimental corroboration, in both the leptonic and baryonic domains, can and should now be taken as empirical validation of Unity theory. The weight of evidence is now a long way beyond the point at which it would be reasonable to doubt the essential truth of the new paradigm.

6.3 The Pion

To address the nature of quarks and the quark model, we begin by proposing a structure for the neutral pion π^0, which is the lightest and simplest particle resonating in the baryonic inner dimensions. The pion is the nearest thing to an "X-electron", as far as such a particle is permitted by the topology of inner space. We propose, therefore, that a neutral pion is built of waves of the type

$$\Psi(x, X, t) = \psi(x, t) e^{imc(X - ct)/\hbar}.$$

We can dispense with the amplitude, as, for present purposes, we are only interested in mass structure, not kinematics. As we have seen in our work on quantum mechanics, the amplitude $\psi(x, t)$ only determines the spatial behaviour of the massive classical particle; it is the phase factor $e^{\bullet}$ that generates the particle itself. So, let us work with a neutral, quark-like wave, of zero momentum and undefined position:

$$\Psi(X, t) = e^{imc(X - ct)/\hbar}.$$

According to the fine-structure hypothesis, the size $|X|$ is smaller than $|W|$ by a factor of α, the fine-structure constant. Hence, the frequency of a wave resonating in X must be $\alpha^{-1} = 137$ times that of a wave resonating in W. So, in order to achieve resonance, hence observability, our wave must have a mass given by $m = m_e/\alpha$. We define this as the *first-order mass unit*, equivalent to an energy of

$$\frac{m_e c^2}{\alpha} = 70 \text{ MeV}.$$

But, in seeking the structure of the "X-electron", we must take one more thing into account. The charge theorem tells us that a *single* wave of this description is unstable: it is energetically favourable for the wave to split apart immediately, so as to seek a superposition of opposite charges. Hence, the only metastable version of this wave is one in which this superposition of opposite charges has already been achieved. This is a standing wave around a great circle in S^3, which may survive for a while, since there is no immediately attainable lower-energy state available to it. Such a wave looks like

$$\Psi(X,t) = e^{i\mu(X-ct)} + e^{i\mu(-X-ct)},$$

where

$$\mu = \frac{m_e c}{\alpha\hbar}.$$

This pion wave simplifies to

$$\Psi(X,t) = 2\cos(\mu X)e^{-i\mu ct}.$$

What is this wave's mass? According to the quantum-mechanical energy operator, only 70 MeV. But it isn't the quantum-mechanical energy operator that gives the energy of such a superposition. The energy operator only applies to individual quantum waves: once it has enacted its translation, via Planck's constant, into classical terms, energies add *classically*.[3] Horses for courses! Hence, to a linear approximation, the rest energy in the superposition is equal to the sum of the rest energies of the individual components. This is given by

$$m_\pi = \frac{2m_e c^2}{\alpha} = 140 \text{ MeV}.$$

The observed mass-energy of the π^0 is around 135 MeV [14]. This is as dictated by Unity, not merely in proximity but in the fact that $140 > 135$. The superposition is not quite linear, and the pion has a small mass defect of around 3.6%, which comes, we may assume, from the expansion of the inner baryonic dimensions at the expense of the leptonic.[4] It is energetically favourable for each wave to expand $|X|$ slightly, and the relaxation enacted by each wave is felt by both. Since the pion is only metastable, the total energy should be a little less than 140 MeV. This is exactly what is observed.

[3]The word "energy" is not tied to any one mathematical descriptor. What links effectively with it in one domain—for example, the quantum-mechanical time derivative—fails in another.

[4]This nonlinearity, involving higher-order exchange, is modelling in the theory of the Higgs field. The fields of quantum physics, it seems, are Riemannian solutions to $R_8 = 0$, one dimension at a time.

Particle mass, both in qualitative essence and quantitative value, constitutes one of the most significant tests of Unity theory. This is particularly true as the old paradigm offers no such explanation, not even in the broadest terms. Feynman was characteristically honest about the situation [15]:

> "Throughout this entire story there remains one especially unsatisfactory feature: the observed masses of the particles, *m*. There is no theory that adequately explains these numbers. We use the numbers in all our theories, but we don't understand them—what they are, or where they come from."

In fact, the situation in the old paradigm is even worse that that. The quark model, which has a neutral pion as $u\bar{u}$ or $d\bar{d}$, is mute on the subject of particle mass, mainly because, if it plucked up the courage to say something firm rather than dabbling in vagaries, it would be immediately recognised as phoney. According to the quark model, the mass of the pion should be of the order of 10 MeV. This is catastrophically wrong. And don't be fooled by the power of the incumbent; just because the quark model has exempted *itself* from making sensible predictions with regard to particle mass does not mean that the quark model *is* exempt from making sensible predictions with regard to particle mass. The up/down quark model passes some self-administered tests, yes, but it fails a number of others that are more fundamental.

In particular, consider the usual ascription of hadronic mass to "quantum chromodynamics binding energy". This is theoretic detritus, and we must expunge it before we can rebuild. As many confused students have noted, before being swept along by the tide of dogma, binding energy *goes in the opposite direction*: it explains why particles have *less* mass than they might be theorised to have, not *more*. If it seems extraordinary that such an elementary error can have gone uncorrected for so long, remember what Einstein said: "Unthinking respect for authority is the greatest enemy of truth."

Let us take a moment to consider the current mess. The quark model, such as has been taught to countless students, states that first-generation hadrons such as the pion and the proton are built of up and down quarks. These are taken to have masses in the region of 5 MeV. Two such particles make up the pion, which has mass 135 MeV, and three make up the proton, which has mass 938 MeV. In each case, the observed value of the mass is far higher than the combined masses of the constituent particles. How does the old paradigm cope? The standard dogma goes something like this:

> *The remaining mass, beyond that of the valence quarks, is made up of the kinetic and rest energies of a sea of virtual quarks and gluons, which pop in and out of existence within the proton.*

The words in the above statement have meanings, yes, but that doesn't mean that the statement itself contains any meaning. Gluons are massless in QCD, which means any energy they have can only be kinetic, and kinetic energy contributes to *instability*, not stability. If gluons were massive, fine. But they are not. Likewise the "virtual quarks". If those quarks have mass, then by what right can anyone claim that the proton is "made up of three quarks"?

To describe the up/down quark model as nonsense is not to insult the many people who have used it. The discovery of iron didn't make fools of prior users of bronze. Even the most profound genius uses the tools of the day. The up/down quark model was a tool of the twentieth century, and people tried, with much perseverance, to make as much sense of it as possible. And that's fine. The important thing, however, and the reason for emphasising the nonsensical nature of the model in such strident tones, is that neither the historical acceptance of the existence of up/down quarks nor the millions of hours spent analysing and describing them imply that pions and protons are, in any physical sense, made of up and down quarks.

A pion is, in fact, made of two superposed fermionic exchange waves of positive and negative X-charge, configured as a spinless standing wave. It is reasonable to say, therefore, that a pion consists of a *red quark* and an *antired quark*, if we take the word quark to mean "wave resonating in X". But the words "up" and "down" are to be deprecated. There is, up to direction of travel, only one kind of quark in a pion, and those two words "up" and "down" offer no useful distinction other than with regard to electromagnetic charge, which, as we have established, is orthogonal to and thus independent of baryonic mass.

Based on the pion structure elucidated above, we propose, as a replacement for the up and down quarks, the name *unity quark*, notated u, as the name for the lightest wave in inner space, viz. the 70 MeV resonance. In this language, the pion structure given above is $u\bar{u}$. Quite deliberately, we make no attempt to distinguish the unity/up notations here, as the former should trample and destroy the latter. In broad terms, the particles are identical; the only differences are in mass and charge, and in neither regard is the up quark correct.

⦿ Definition: *Unity quark, u.* Energy resonating in a single dimension of inner space, either stable or metastable, with a single local direction of wave travel. Conceptually, a unity quark is an up/down quark of variable electromagnetic charge. The minimal energy of a unity quark is 70 MeV.

In configuration notation, a unity quark is $u : \hat{X} \,\big|\, xy$. Note that the polarisation, which for fermionic exchange waves involves expansion and contraction, must, as with the electron, be in the outer dimensions. For exchange waves to be polarised in the inner dimensions, nonlinear effects must be involved, due to the closed topologies. Such waves exist, but the energies involved are much higher and the lifetimes much shorter. We will address such higher-generational waves in due course.

Having defined the unity quark, we should exercise due caution. We cannot assume, by dint of our having a word for something, that everything referred to by that word shares every one of its properties. For the electron, that is close to true: the electron has invariant mass/charge, and any changes to an electron wave can appropriately be described as "excited states of an electron". But the same isn't true in inner space S^3. With three dimensions to play with, there is no reason why standing waves in single inner space dimensions (neutral pions) should be constructed identically to non-standing waves occupying all three inner space dimensions (protons).[5] Let us be clear, therefore: even as defined above, the expression "unity quark" refers to a *family* of configurations of substance, not to some specific and repeated entity.

6.4 Electric Charge

We can now approach the proton, free of the baggage of the up/down model. Firstly, the proton's electric charge. In Unity theory, a proton must have the same W-momentum as an electron, in the opposite direction. By definition of baryonic mass, this momentum is in a non-resonant dimension. If the proton resonates in X, then it cannot resonate in W. In other words, the proton cannot fill the W dimension, but must be located somewhere within it. With regard to charge, this sets the proton apart from the electron, which must necessarily have full gauge symmetry in W.

How can the proton be located *within* the inner W dimension, as opposed to filling it, as the electron does? This is possible because X is 137 times smaller than W. Resonance in the tiny X dimensions means that the diameter of the proton is significantly smaller than the circumference of the W dimension. Now, the size of the leptonic W dimension is given by half the reduced Compton wavelength of the electron, since the electron's exchange wave is spin-2 at substance level. So,

$$|W| = \frac{1}{2}\lambda_e = \frac{h}{2m_e c} = 1.2 \times 10^{-12} \text{ m}.$$

The circumference of the baryonic dimensions, then, is given by

$$|X| = \alpha|W| = \frac{\alpha h}{2m_e c} = 1.8 \times 10^{-14} \text{ m}.$$

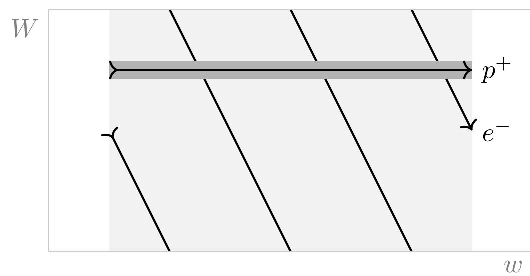
The above is in line with the observed charge radius of the proton, which is generally taken as around 0.85×10^{-15} m. We note that the proton is a continuous wavepacket, not a hard-edged ball-bearing, and that it doesn't have a strictly defined radius, other than in the same average sense in which the atmosphere of the Earth has one. Nevertheless, this size, of the order of 1 fm, is a useful guide. It tells us that, in spatial extent as well as in wavelength, the proton is much smaller than the circumference of the W dimension. This is a significant fact.

> To the proton, the leptonic W dimension is an *outer* dimension, with topology $\mathbb{R}$.

Even relative to the wave of the present, the proton exists against a space-like backdrop of *four* outer dimensions. So, between the W-cline and the X-cline, at a scale of e.g. 100 fm, while the electron is a *wave* filling the entire W dimension, the proton is a *particle* located somewhere within the W dimension. At scales between the clines, the electron and proton sit on opposite sides of the wave-particle divide.

[5] An electron is like a glass of water: broadly the same however it is made. A quark, on the other hand, is like a cup of coffee: certainly worthy of a name, but much more variable.

This is depicted in the diagram below, which shows the (w, W) structure of a hydrogen atom. The relevant feature is the asymmetrical extent of the electron and proton wavepackets, which are shown (not to scale) as pale and darker grey rectangles. The electron wave occupies the whole of the W dimension, resonating in it; the proton, on the other hand, moves *within* the W dimension, as a classical particle:



This is an important concept in Unity theory, with multiple ramifications. Here, it dictates that the charges of electrons and protons should be modelled differently. Within the leptonic dimension, the proton is a classical particle, so the proton's baryonic mass is, at that scale, already a "quantity of stuff", as per Newton's theory. So, the proton's electric charge should be viewed as a *classical* momentum in W. Given that almost all of the mass of a proton is baryonic, this means that v is some $\frac{c}{1836}$, a relatively small value which we can neglect kinematically in most scenarios, summarising the proton charge as a classical q. In the diagram above, this very small value of W-speed and our neglecting of it are depicted in the fact that the resting proton is shown progressing rightwards, with negligible W component.

This formulation presents us with a question. How come *proton* charge is quantised? Now, the answer to this question requires, to some extent, a full analysis of the proton's structure, which we are to elucidate shortly. However, there is a broader point worth mentioning before we do so. The quantisation of proton charge comes, essentially, from the quantisation of electron charge. Since electrons resonate in W, their W-momentum is fixed. Since protons do not resonate in W, however, their W-momentum is flexible. A proton can, therefore, take values from a continuum of charge. Now, this might seem curious. "Surely", a twentieth century physicist might say, "it is verified beyond doubt that protons have unit charge." But not so.[6] Protons are only ever *observed* by their interaction with electrons; no one has ever seen, nor could anyone ever see a proton per se. And the lowest energy configuration of a proton in the company of an electron is, as elsewhere in this theory, one in which the electromagnetic charges balance exactly. Hence, given that protons are flexible in that regard, all observed protons have charge $+e$. This point is of significance not just in regard to the proton. Charge itself is not quantised; only electrons are.

[6]The issue, as ever, is one of *definition*. In Unity theory, the word "proton" is necessarily broader than in current usage. Since a proton, a neutral proton and an antiproton are all essentially the same particle, albeit travelling in different directions, it makes sense to call them all by the same name.

6.5 The Proton

A crucial trait shared by protons and electrons is *stability*. It is this stability that makes our material lives possible. While the evanescent ghosts that emerge from high-energy collisions may be of considerable scientific interest, they are irrelevant in practical, everyday terms. The material universe is, to a very good approximation, protons and electrons.[7] Nothing else lasts.

Consider the source of this stability. The electron is stable because, since its charge is topologically indestructible, there is no lower-energy configuration into which it can fall. But the same isn't true of the proton. Lower-energy configurations, such as the pion, exist, and, what's more, there exists topological flexibility, due to the simple-connectedness of inner space, with which to reach them. So, how does the proton maintain its stability? It must do so *actively*, occupying all three dimensions of inner space and maintaining its own potential well. While the electron has an automatic, passive type of stability, that of a baby lying on the floor, a proton has active stability, that of an adult standing on its feet. An electron would fall if it could; a proton could, but doesn't.

This is a key distinction. The proton's stability comes from the nonlinear curvature created by its energy, the same nonlinear curvature that gave us a 3.6% mass defect for the pion. In the case of the pion, 3.6% wasn't enough to withstand the random undulations of substance. (Remember that space itself is the surface of an ocean.) Hence, the free proton, which has never been observed to decay, must have a much greater mass defect. Indeed, to achieve maximal stability, it requires a locally *maximal* mass defect. What kind of wave structure attains such a maximum? Well, a particle such as the proton has a single eigenvalue of mass, which means that its constituent waves must all have the same frequency, fixed by the size of inner space. Hence, the only flexibility is in the *number of colocated waves* of the same frequency.

Conjecture. *Proton structure.* The wave structure of the proton is dictated by the following requirements, to be attained at a single location in (x, y, z, W) space-plus:

1. Minimal frequency.
2. Maximal wave dimensionality.

The former ensures that the particle is not in an excited state, while the latter prevents disintegration, viz. spatial escape of constituent waves. Together, these ensure that we have a stable, ground-state particle with a well-defined mass eigenvalue, whose chances of avoiding decay are as high as they can possibly be.

We can now derive the structure of the proton, and with it a first-order approximation of the observed proton mass $m_p = 938$ MeV$/c^2$ [14]. What theoretical value should we expect? Well, first off, the mass defect must be significantly larger, in percentage terms, than the pion value 3.6%. Given the stability of the proton, 10% would seem

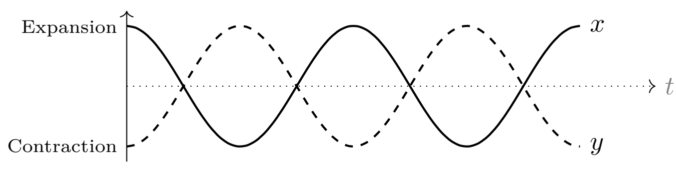
[7] The neutron gets an overhaul in Unity theory. We dispense with the *udd* structure, and view the neutron as a proton tightly bound to a bosonic particle related to the electron.

a reasonable lower bound, to 1sf. At the other end of things, scaling 3.6% linearly by the ratio m_p/m_π would suggest an upper bound, which will not be achieved, of around 25%. Again to 1sf, an upper bound of 20% seems reasonable. So, we should see a proton mass defect in the range $10-20\%$.[8] Hence, our first-order approximation should give a theoretical value for the proton mass a good deal higher than the observed value 938 MeV, somewhere in the region $1040-1170$ MeV.

To the structure itself. The first ingredient is *minimal frequency*. What is the lowest resonant frequency available to the proton? Well, at first glance, the answer is that of the pion, corresponding to an energy of 70 MeV, since both pion and proton resonate in the same inner space. But, in fact, this lowest frequency is not available to a proton. A single dimension of inner space, such as is occupied by the pion waves, is a great circle in S^3. In the absence of other waves, this circle acts like S^1, at least until the particle decays. But a proton, to achieve maximality, must occupy all three dimensions of inner space, not just one. And two great circles in S^3, e.g. X and Y, do not intersect only once, but *twice*, at two antipodal points. The same applies in S^2, with the Greenwich and equatorial great circles meeting in the Gulf of Guinea and the mid-Pacific. Hence, the resonant length of the proton is halved, compared to 70 MeV. This doubles the ground-state frequency of the proton compared to that of the pion.

Next, given this minimal frequency, we seek a structure of maximal dimensionality. We require as much classical energy as possible in a single location in (x, y, z, W) space-plus. This is achieved in two ways: we maximise 1) the dimensionality of the proton's *polarisation* space, and 2) the dimensionality of the proton's *wavevector* space. Mathematically, these two are the (x, y, z, W) output space and the (X, Y, Z, w) input space of the proton wavefunction Ψ_p. Maximality requires that each is four-dimensional.

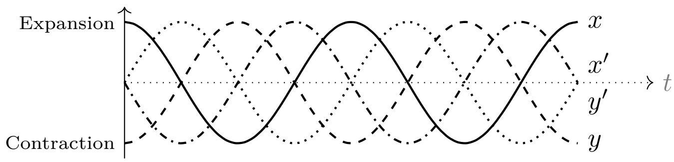
Firstly, polarisation dimensionality. A single quark wave is $u : \hat{X} \,\big|\, xy$, exchanging expansion and contraction in the x and y directions of space. Now, pictorially, we will run out of dimensions with which to represent proton waves, at least in any direct sense, but we can nevertheless gain a good visual using graphical methods. The following graph represents a plus-polarised Ψ_+ fermionic exchange wave, with two in-phase sinusoids encoding the sizes of line elements in the relevant polarisation dimensions.



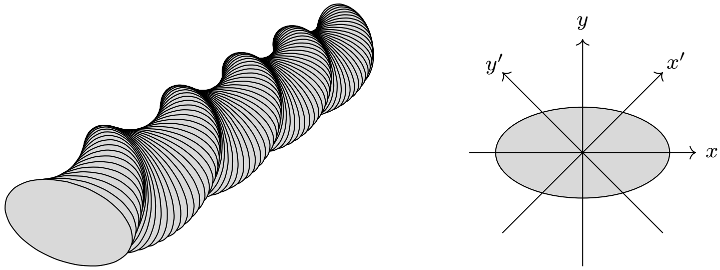
Note that the single vertical dimension of the graph above represents expansion and contraction in the *two* dimensions of a plane. The solid and dashed sinusoids are the (x, y) aspects of a planar trade. Now, to represent a *helical* electron or unity quark

[8] This calculation is deliberately back-of-an-envelope, so that, as far as possible, we don't fall prey to fine-tuning: the nonlinear curvature of the baryonic dimensions is well beyond the scope of this book, which deals only in first-order approximations, and we already know the result we are looking for. So, it's best to keep things broad.

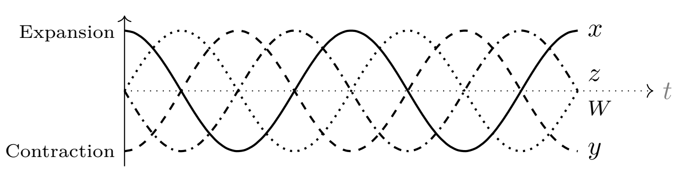
wave on such a graph, we must also include $\Psi_\times$, out of phase, exchanging expansion and contraction between the $x+y$ and $-x+y$ directions, offset by 45° in the (x, y) plane of polarisation. Calling these oblique dimensions x' and y', our graph is as follows:



The above represents a helical exchange wave such as the electron $e^- : \hat{W} \,\big|\, xy$ or the unity quark $u : \hat{X} \,\big|\, xy$. At every point, the substance equation $R_8 = 0$ is satisfied, in the vertical symmetry of the graph. The presence of both Ψ_+ and $\Psi_\times$, out of phase, ensures helical rotation. Below, we show the same wave directly:



But now consider the extra plane of polarisation available to proton waves. By dint of their small extent, protons, unlike electrons, occupy a precise location *within* W. With such freedom in polarisation, a new solution to $R_8 = 0$ presents itself, a solution that doesn't exist for electrons or gravitational waves. Take the helical solution above, which is analogous to a circularly polarised gravitational wave, and replace the x' and y' dimensions with z and W. We no longer have helical rotation restricted to a plane (x, y). Rather, we have twinned helical rotations in the four-dimensional polarisation space (x, y, z, W). We designate this waveform a *four-helix*, in contradistinction to the two-helices of the electron and the pion. It isn't possible to depict such a thing directly, but our previous graph remains effective. Note that the single vertical dimension now represents expansion and contraction in the *four* dimensions (x, y, z, W).



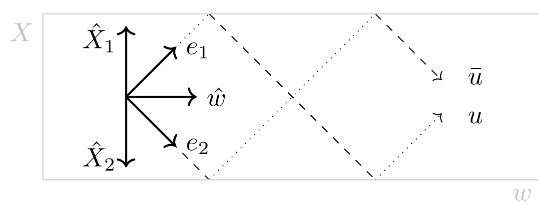
Such waves have remarkable properties. They are symmetrical, it seems, in just about every way in which it is possible for a wave to be so. They consist of a dimensionally intertwined pair of helices, with four symmetrical outer dimensions trading expansion and contraction; yet, despite the presence of two different planes of polarisation, the phases ensure that all exchanges are first-order: no planar expansion of substance is involved. Hence, in mathematical terms, all is well; the original gravitational wave solution to $R_8 = 0$, the two-helix, goes over into the four-helix case.

With the output space of the proton established as (x, y, z, W), we can proceed to analysing the input space. The four-helix has maximal *polarisation* dimensionality; we must now maximise *wavevector* dimensionality. How many orthogonal four-helices can be squeezed into a single location in space-plus? The answer that springs readily to mind turns out, in fact, not to be the correct one. Three seems obvious. After all, there are three dimensions of inner space (X, Y, Z). So, one might naturally think, we can superpose three orthogonal four-helices, one for each colour charge, given by $u_r : \hat{X} \,\big|\, xyzW$, $u_g : \hat{Y} \,\big|\, xyzW$ and $u_b : \hat{Z} \,\big|\, xyzW$. But this logic ignores one crucial fact: the progress of the wave of the present. There aren't only three wavevector dimensions available to the proton, there are *four*. Proton waves are polarised in (x, y, z, W), which leaves the remaining four dimensions (X, Y, Z, w) available for wavevectors. How does this fit in with the requirement of resonance in inner space? Easily, it turns out.

Consider the group $S^3 \times \mathbb{R}$, whose tangent space $\mathbb{R}^4$ is spanned by the orthonormal basis $\{\hat{X}, \hat{Y}, \hat{Z}, \hat{w}\}$. This space can equally be described as spanned by the rotated orthonormal basis $\{e_1, e_2, e_3, e_4\}$, where $e_j = \frac{1}{2}\hat{w} + \frac{\sqrt{3}}{2}\hat{X}_j$. The four $\hat{X}_j$ vectors are then a set of four symmetrical unit vectors in inner space S^3, arranged as the vertices of a tetrahedron. To reach this basis, we simply take the original hypercubic coordinate frame and place its longest diagonal in the direction of progress.

The above can be tricky to visualise, so let us build up a clear conception by lower-dimensional analogy. Reduce inner space to one circular dimension, and consider a cylindrical, two-dimensional space (X, w), with topology $S^1 \times \mathbb{R}$. This is spanned by the orthonormal basis $\{\hat{X}, \hat{w}\}$, where X is a single dimension of inner space, and w is the direction of progress, as usual. Now, in a single inner dimension, a *pair* of waves may coprogress in w and resonate symmetrically in X, so long as they take up the square configuration shown below,[9] with wavevectors $\{e_1, e_2\}$ given algebraically as

$$e_j = \tfrac{1}{\sqrt{2}}\hat{w} + \tfrac{1}{\sqrt{2}}\hat{X}_j, \text{ for } j = 1, 2.$$



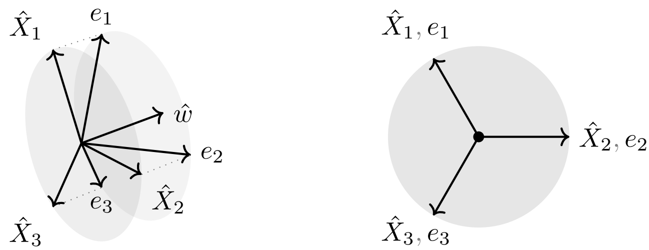
The angle of progress in such a configuration is clearly 45°. In formulaic terms, such as we may carry over into higher dimensions, this may be calculated from the ratio of progress to wave speed, given by the w component of the e_j vectors:

$$\sin\theta_p = \frac{b}{a} = \frac{1}{\sqrt{2}}.$$

[9]This is the wave configuration of the neutral pion, as discussed previously.

Now, raise the dimension by one. Consider the space (X, Y, w), with topology $S^2 \times \mathbb{R}$. We can think of this as another cylindrical space, but with a two-dimensional disc now playing the role of the inner dimensions. This space is spanned by the orthonormal basis $\{\hat{X}, \hat{Y}, \hat{w}\}$. With two dimensions of inner space to play with, a *trio* of waves may coprogress in w and resonate symmetrically in S^2, so long as they take up the cubic configuration shown below, with wavevectors $\{e_1, e_2, e_3\}$ given algebraically as

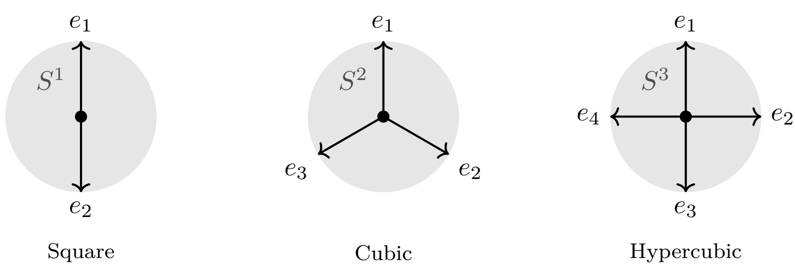
$$e_j = \frac{1}{\sqrt{3}}\hat{w} + \frac{\sqrt{2}}{\sqrt{3}}\hat{X}_j, \text{ for } j = 1, 2, 3.$$



The wavevectors $\{e_1, e_2, e_3\}$ now lie along the edges of a cube, whose space diagonal is w, the direction of progress. The angle of progress, with three orthogonal wavevectors coprogressing, is now less obvious in visual terms, but it is straightforward to calculate using the same routine as in the two-dimensional case. It is 35.3°, as given by

$$\sin\theta_p = \frac{b}{a} = \frac{1}{\sqrt{3}}.$$

Back to the full picture. We can no longer depict the wavevectors directly; there aren't enough spatial dimensions to play with. However, we can see what is going on by taking a view along the dimension of progress. In each case the grey disc represents the transverse space of the inner dimensions, while the dimension of progress is unseen as a vector running into the page. On the left, only one transverse dimension is used; in the middle, two; on the right, three.



In the right-hand picture, the four wavevectors $\{e_1, e_2, e_3, e_4\}$ now lie along the edges of a four-dimensional hypercube, whose longest diagonal, as with the previous cases, runs in w, the dimension of progress. Following the same procedure as before, the angle of progress is now given by

$$\sin\theta_p = \frac{b}{a} = \frac{1}{\sqrt{4}} = \frac{1}{2}.$$

With S^3 as the transverse resonant space, the angle of progress is $\theta_p = 30°$. This is an elementary but nevertheless far-reaching result, with implications in many areas of physics.[10] We observe that the maximal solution of four orthogonal proton wavevectors is indeed available, but only if the present progresses at a specific speed.

For maximal proton stability, the wave of the present must progress at $\theta_p = 30°$.

We are presented with a number of results simultaneously. Firstly, this theoretical derivation of the angle of progress θ_p allows us to explain why the present has a consistent wave speed. Indeed, it explains why the wave of the present exists in the first place. The speed of progress, notated b in Unity theory, is dictated by the structure of the proton. A proton cannot be truly static, because, to achieve maximality, it must fill all eight dimensions of substance, four in polarisation space and four in wavevector space. To maintain resonant coherence, then, it *must* progress in w. The progress of the present, it seems, arrived with the proton, which yet remains its engine. This explanation removes a major obstacle to Unity's viability. Stepping beyond the old paradigm, we have modelled the present as a physical object. But such a step generates questions in the new paradigm that don't exist in the old. Why is the present a wave? Why do all parts of the present coprogress? On the stage of space, these are non-questions, but, in the Unity model, with the present contained *physically* within the universe, explanation is required. In large part, the maximal structure of the proton is that explanation.

The second result that emerges is a theoretical calculation of a and b, the universal speeds of propagation and progress. These are given by $b = a \sin\theta_p$ and $c = a\cos\theta_p$, as calculated from the observed speed of light and our first-order value for θ_p. To three significant figures, we get

$$\begin{aligned} a &= 3.46 \times 10^9 \text{ ms}^{-1}, \\ b &= 1.73 \times 10^9 \text{ ms}^{-1}, \\ c &= 3.00 \times 10^9 \text{ ms}^{-1}. \end{aligned}$$

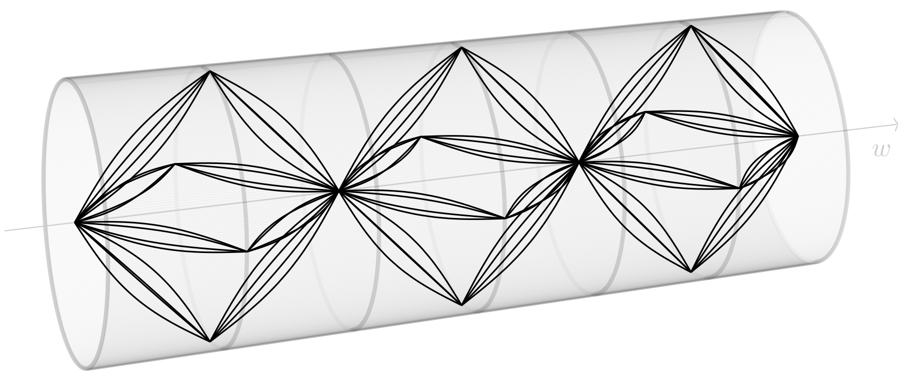
So, it turns out that the speed limit a of the universe is somewhat higher than the speed limit c of the cosmos, but nevertheless comparable to it. The surprising element of the above, at least initially, is the value of b; the perceived cosmos is progressing in w at more than half the observed speed of light. In the old paradigm, this is certainly unexpected. However, despite its somewhat outlandish feel, this rapid speed of progress is entirely in line with the evidence of experiment. To a very close approximation, everything in the wave of the present is moving at this same speed; hence, b is the imperceptible speed of a smooth ride in a train carriage.[11] The value of that speed, however large, is quite independent of perceptibility.

[10] Theorists of the weak interaction will recognise the weak mixing angle θ_W, whose measured value is around 29°. This is, of course, no coincidence.

[11] Given this large speed, there are relativistic effects in the direction of progress that we will have to account for at later stages of modelling, in reference to the higher generations of matter. However, since these effects are shared by all protons and electrons, we can ignore them for now.

The third result that emerges is *proton mass*, whose theoretical value, which should be in the range 1040 – 1170 MeV, may be considered an empirical test of the above conjectures. Indeed, even given the broad nature of a first-order approximation, it is a stringent test, as there is no scope for tuning, except in factors of two, in the arguments above. The fine-structure hypothesis is verified elsewhere in Unity theory, with regard to force strength and pion mass, and the 4×4 dimensionality of the proton is determined precisely by the axioms of Unity theory, in combination with the empirical evidence of QCD. It is hard to see how the arguments given above could be altered. In Unity theory, there is only one possible structure for the proton.

Furthermore, this structure avails itself of very high levels of symmetry. It has four orthogonal wavevectors spanning the space (X, Y, Z, w), symmetrically distributed around the w axis. Each of those waves has exactly the same relationship with the baryonic inner space dimensions as the others, and hence they all have the same resonant frequency, twice that of the pion. Each wave is a four-helix with four orthogonal dimensions of polarisation, spanning the space (x, y, z, W). There is no way to squeeze any more energy into the same location, short of raising the frequency above the ground state, and the wave occupies every possible dimension. A resting proton looks as follows (with some artistic license taken):



And the structure above yields a value for the proton mass which brooks almost no tuning. To evaluate it, all we need do is scale the first-order mass unit, as derived with reference to the pion, up by the requisite amount. Quantifying the arguments given above, we have, compared to a half-pion wave at 70 MeV, a) a factor of two dictated by the need for antipodal resonance, b) a factor of two for the doubling of polarisation dimensionality, and c) a factor of four for the foursome of wavevectors. This yields

$$m_p = 16 \times \frac{m_e}{\alpha} = 1120 \text{ MeV}/c^2,$$

which is exactly as expected for a first-order, linear approximation. There is no such derivation in twentieth century physics. It is appropriate to read this result, therefore, as a direct falsification of both the up/down quark model as it pertains to the proton, and, more importantly, of the spatial paradigm itself.

6.6 The Neutron

In discarding the up/down quark structure of the proton, we are bound, in the same breath, to reconsider the structure of the neutron. The neutron, it turns out, has also been misunderstood. As we will see, according to Unity theory, Rutherford, along with most early nuclear physicists, had a picture of the neutron far closer to reality than the one proposed in the Standard Model [16]. As previously discussed with regard to QCD binding energy, this is a relief, as the Standard Model, while reliable elsewhere, makes poor predictions and very little sense concerning stable nuclei.[12]

It has long been established, beginning with Heisenberg's theory of isospin, that protons and neutrons act almost identically in the nucleus [17]. This equivalence is a highly revealing fact, whose importance has historically been somewhat downplayed. It has been downplayed because it points, very clearly, to the falsehood of the up/down quark model, which folk have been loath to admit. Both our analysis of the proton in the last section and nucleonic equivalence rule out up/down structure, and, what's more, they do so *independently*. Even supposing the analysis of the last section were wrong, if the up and down quarks sit at the heart of strong interaction behaviour, then why should *uud* behave exactly like *udd*? Fine-tuned arguments notwithstanding, it shouldn't. There is, in the end, only one simple explanation for the fact that protons and neutrons behave like the same particle. Obviously, they *are* the same particle.

One of the problems with the old paradigm is that patent truths such as this one, have, in many places, been swept under the carpet to accommodate theories, such as the quark model, that disagree with them. But if we are thinking simply, without the baggage of a century weighing on our minds, it is clear, as Rutherford et al. suspected, that the proton and the neutron are essentially the same particle, and that the neutron consists of a positively charged proton with a particle of negative charge tightly bound to it. This was, of course, the content of the *nuclear electrons hypothesis* that held sway in the first years of nuclear physics.

Now, that hypothesis was discarded, and for good reason. It was plainly wrong. There are a number of theoretic reasons, which we will consider shortly, why the neutron cannot consist of an electron tightly bound to a proton. But the pendulum swung too far. It turns out that, according to Unity theory, the neutron *does* consist of a negatively charged particle bound tightly to a positively charged proton. It's just that the relevant negatively charged particle isn't the electron; rather, it is something similar to one. In Unity theory, a particle like the electron doesn't get to keep its identity everywhere it goes. If one reads the expression "nuclear electron" as "the *version* of the electron found in the nucleus", then Rutherford was exactly correct.

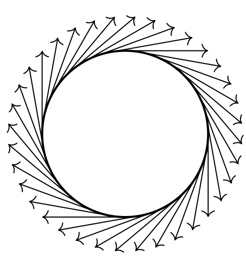
[12]We should note, to avoid alarming the many physicists who have used QCD: here, as in regard to the proton, dispensing with the up/down quark model does not invalidate the theory of colour, nor does it invalidate work on higher-generational matter. Unity theory contains and generates QCD as the quantum field theory of the baryonic component of the inner dimensions. But, while QCD is well verified with regard to the unstable output of a collider, but it has no verification whatsoever within the humble nucleon. It has been over-applied to entities—the proton and the neutron—that simply aren't within its empirical domain of validity. This is the problem we seek to rectify.

The logic is straightforward. Essentially, the historic arguments against the nuclear electrons hypothesis all boiled down to *spin*.[13] For a number of different experimental reasons, it became evident that neutrons couldn't be modelled as containing electrons, because, empirically, the negatively charged part of a neutron doesn't contribute spin. To a world that knew only protons and electrons, both of which are spin-$\frac{1}{2}$ fermions, that settled things. In Unity theory, however, we have another card to play. What if the electron-like wave that binds to the proton to make a neutron is a bosonic *shear* wave? If there is such a wave, resonating in W, perhaps it is the old "nuclear electron"?

What solutions are possible? Consider polarisation. Any charged, electron-like particle must have a wavevector in $\hat{W}$, which rules out the possibility that its shear polarisation could also be in W. And such a wave cannot be polarised in the outer dimensions, as shear solutions to $R_8 = 0$ only exist around closed inner dimensions. Hence, this hypothetical cousin to the electron has to be polarised in the inner space dimensions. We will call it, therefore, the β_X particle.[14] If it is to exist, it must have the configuration $\beta_X : \hat{W} \,\big|\, X$. *Can* it exist? Yes. The solution is a little harder to visualise than the magnetic shear of $\gamma : \hat{x} \,\big|\, W$, but it is no less mathematically valid. The argument rests on a simple topological fact: S^3 is *parallelisable*.

The relevant mathematics was given by Hopf [18], almost contemporaneously, in fact, to the discovery of the neutron. The *Hopf fibration*, which is rightly revered by topologists, is a decomposition of S^3 into a set of S^1 fibres over a central S^2 base space. It allows for the existence of a continuous vector field on S^3. Each vector of such a field generates rotation around a great circle, and every such great circle is locally parallel to those neighbouring it. Globally, the fibre-bundle topology is nontrivial, as S^3 isn't a product space of S^2 and S^1, but that isn't relevant to existence of our β_X solution, which requires only locally parallel flow.

Let us visualise the construction. Consider first the magnetic shear of a photon $\gamma : \hat{x} \,\big|\, W$. Implicitly, we have used the (trivial) parallelisability of S^1 in fashioning such a solution to $R_8 = 0$. A vector field is defined around the leptonic W dimension, and substance then oscillates sinusoidally in and against the direction of this vector field, shearing continuously against neighbouring points in space.

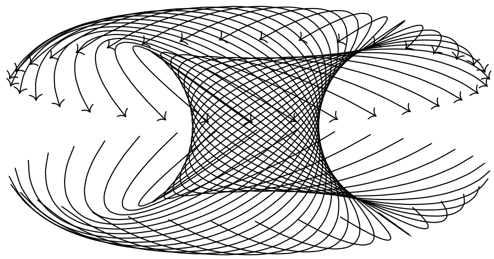


Consider the equivalent construction in S^3. We won't attempt to represent this vector field in full here, but will give a similar construction, in Villarceau circles, on

[13] The word "spin" has a number of meanings in physics. Here, we refer to *transformation* properties: a particle is spin-0, spin-$\frac{1}{2}$, spin-1, or spin-2 depending on its rotational symmetry in space.

[14] Here, as elsewhere, the X in β_X is taken to represent all three inner space dimensions.

the parallelisable Clifford torus $S^1 \times S^1$, which has the relevant topological features. In the following, each arrow forms a Villarceau circle, representing a great circle of S^3. The entire torus may rotate along the directions indicated by the vector field, without incurring any fermionic expansion or contraction.



In Unity theory, we designate such a locally parallel displacement of substance in S^3 as a *Hopf shear*. A Hopf shear is analogous, in S^3, to the photonic shear in S^1: it is a bosonic shearing of substance in the direction of the great circle fibres defined by the Hopf fibration. *A priori*, since they are smooth and involve no expansion or contraction, such displacements must satisfy the substance equation $R_8 = 0$. Mathematically speaking, therefore, the proposed configuration $\beta_X : \hat{W} \,\big|\, X$ must exist. And Murphy's law applies: if a resonance can happen, then it *will* happen. Since it offers such a coherent, low-energy resonance in W, the β_X is bound to exist physically.

What are its properties? Well, firstly, being a shear wave, it is described by a real-valued sinusoid, and is a boson. Secondly, given its lack of polarisation in space, it must be spin-0, since it is unaffected by spatial rotation. These two facts resolve most of the objections to the nuclear electrons hypothesis without further ado. Firstly, the spin issues are sorted: any number of these *beta bosons*, as we may now call them, can bind to nucleons without incurring any alteration to nucleonic spin. Secondly, the quantum-mechanical Klein paradox now doesn't apply, as it only describes complex-valued fermions. Thirdly, the argument from the quantum-mechanical uncertainty principle is also irrelevant, because a beta boson, with its polarisation in X, may interact with a *strong* potential.[15]

The only remaining objection is that of *mass*, which nailed the lid on the coffin of the historical nuclear electrons hypothesis. QCD binding nonsense notwithstanding, an electron cannot be the difference between a proton and a neutron, because $m_n - m_p > m_e$. The electron is too light. But does the same apply to the β_X particle? No. Firstly, a parallelised, sinusoidal oscillation, unlike a fermionic exchange, has a signed direction; hence, the beta boson cannot avail itself of the half-turn (per cycle around leptonic S^1) that is available to the fermionic electron. Its frequency, therefore, must be *double* the electron's. Secondly, as the β_X displaces not just a spatial plane but all of inner space, it has three dimensions of polarisation as opposed to two.

[15] The beta boson, it seems, doesn't fit neatly into either of the categories *lepton* or *hadron*. As is often the case with entities that don't succumb to simple classification within current models, this has surely contributed to its mainstream nonexistence.

Taken together, the above facts yield a theoretical beta boson mass somewhere in the region of $m_\beta \approx 3m_e$.[16] Using the observed proton mass $m_p = 938.27$ MeV/c^2, this gives a theoretical neutron mass of

$$m_n = m_p + 3m_e = 939.81 \text{ MeV}/c^2,$$

compared to the observed value of $m_n = 939.57$ MeV/c^2 [14]. We now have a mass difference $m_n - m_p < m_\beta \approx 3m_e$, and the last objection is resolved. A mass defect of around 16% exists in the additional beta boson, which is in line with the significant, but not eternal, stability of the free neutron.

Another question presents itself, given that the leptonic mass of the β_X particle is greater than that of the electron. Since leptonic mass is electromagnetic charge, shouldn't the beta particle have a *charge* that is greater than that of the electron? Yes indeed. The charge of the β_X boson, we must presume, is, in fact, larger than that of the electron, by the ratio $m_\beta : m_e$. It is highly unlikely that this charge is integral. This might, at first glance, seem like a problem. But it isn't so.

Since the β_X particle, in separation from the proton, has the electron resonance available to it, it must decay immediately. Hence, both theoretically and empirically, β_X particles could never be seen in isolation. They only ever appear as the fast-moving electrons emitted in beta decay, already known as beta particles. By then, the waves are electrons proper. But this means that the apparently anomalous $-3e$ charge of a β_X particle is of no experimental consequence. Since a β_X is only found in the presence of a proton, and since an unobserved proton has flexible charge, the lowest-energy configuration for a proton and a β_X particle of charge $-3e$ is for the proton to pick up a charge of $+3e$. In electron capture, say, a beta boson is created as a high-energy electron impinges on a proton. As they approach, the charge distribution is $\pm e$. But the beta resonance is then only available if the incoming electron picks up an increased negative W-momentum. If there is enough energy available, the proton obliges, picking up the requisite positive charge.

And what happens to this charge in beta decay? Well, according to Unity theory, when a β_X particle of charge around $-3e$, bound to a overcharged proton of charge $+3e$, escapes, it decays immediately. In the process, the β_X particle repolarises to become an electron, reducing its W-momentum to $-e$. But, by conservation of W-momentum, viz. by conservation of charge, the proton must also shed positive W-momentum, reducing to its usual free $+e$. Hence, while intellectually piquant, these unexpected charges are entirely in line with experimental evidence.

There seems little doubt, given the simplicity of the hypothesis, that the proton-beta structure of the neutron is markedly superior to that offered in the Standard Model. Hence, in Unity theory, we deprecate the up and down quarks entirely, recasting the proton and neutron as one and the same. The beta decay of a neutron is then the simplest thing: a beta boson unstably bound to a proton escapes, and decays to an electron in the process. The fabled quarks, it turns out, aren't involved at all.

[16] It isn't clear exactly how the dimensionality scales here. It it is no major concern, however, since m_β isn't observable. What matters is that m_β is comparable to, but significantly higher than, m_e.

7 Unity and the Weak Interaction

What physical processes underpin the weak interaction? In posing and attempting to answer such a question, our aim is not merely to gain an understanding of the weak interaction. In physical terms, weak processes are of minor importance; indeed, so-called "weakless universes" have been proposed, in which the cosmos gets along perfectly well with no weak interaction at all [19]. Our purpose, as ever, is to develop an understanding of Unity as a theory, and, in doing so, to establish beyond doubt the truth or falsehood of the axiom of Unity itself.

So, the theory of the weak interaction is another means to an end. But it is a significant one. Often, the little details are most revealing, and this case is no exception. While the weak interaction may have little to do with the perceptible everyday, by that very fact it is gold dust for us, because it is precisely the *imperceptible* foundations of reality that are on the table here. In terms of Unity theory's verification/falsification, we are interested in the most opaque, yet still empirically well verified, aspects of physical theory. And it turns out that the physics of the weak interaction, both in theory and experiment, is a key ingredient in establishing, in a very direct sense, the theory of the wave of the present, beyond reasonable doubt.

In order to ascertain, within Unity theory, the physical nature of the weak interaction, the two most significant theoretic elements are *particle structure*, especially of the electron, proton and photon, as already laid out in previous sections of this book, and the *electroweak theory* of Weinberg, which describes the mixing of the photon and the Z boson [20]. As we shall see, Weinberg's theory, which is now well validated in the context of the Standard Model, is in direct agreement with Unity theory. And, moreover, Unity theory provides a theoretical basis for its most fundamental and mysterious mathematical element, the weak mixing angle θ_W. In the Standard Model, θ_W must be measured empirically, at around 29° [21], and no reason can be given for either its existence or its value. The "mixing of the vector boson plane", which is the name given to the rotation of axes that produces the photon and the Z^0, is left as a purely abstract phenomenon. Within the spatial paradigm, there is no clue as to why nature should have chosen such a strange departure from symmetry. In particular, the fact that θ_W is so close to 30°, which is exceedingly suggestive, is left unaddressed.

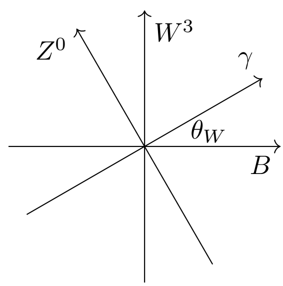
But these facts appear by themselves in Unity theory, in precise agreement with experiment. It would perhaps have seemed surprising to a physicist of the twentieth century, steeped in the ways of relativity, that empirical validation of the present as a physical entity in motion could ever be obtained qualitatively, let alone quantitatively. But this is the power of particle physics. The countless hours probing particles at ever greater degrees of theoretic abstraction have not been spent in vain. While θ_W is a value that can only be measured at second or third hand, via precision measurements of subsidiary quantum field theoretic predictions, it *can* nevertheless be measured. And it has been so, again and again. Uncertainty remains as to the decimal places, but the overarching fact, that $\theta_W \approx 30°$, is now beyond doubt.

The weak mixing angle represents an element of reality. What is that element? It is this question which the old paradigm is incapable of answering. This is not due to failure of intelligence or imagination. It is more fundamental than that. The answer to the question "What element of reality does the weak mixing angle correspond to?" simply doesn't exist in the old paradigm. Why not? Because the weak mixing angle isn't an angle between this element of space and that element of space, as classical mechanics might have supposed. It isn't an angle between this element of space and that element of the inner dimensions, as QED might have supposed. It isn't even an angle between this element of the inner dimensions and that element of the inner dimensions, as QCD might have supposed. No. It is an angle outside space, outside the inner dimensions, *outside the present altogether*. Little wonder the weak interaction has been shrouded in mystery: the weak mixing angle describes the relationship between the cosmos and the universe through which it progresses.

7.1 Electroweak Unification

Weinberg proposed, and it has now become accepted as part of the Standard Model, that the photon γ and the Z^0 boson are produced from the underlying B and W^3 bosons by the "mixing of the vector boson plane", described mathematically by the following redefinition of coordinate axes:

$$\begin{aligned}\gamma &= \sin\theta_W W^3 + \cos\theta_W B,\\ Z^0 &= \cos\theta_W W^3 - \sin\theta_W B.\end{aligned}$$



Before we analyse this rotation within the Unity model, we should remind ourselves what the mathematical symbols γ, Z^0, B, W^3 actually mean, in a physical sense. While the symbol γ may, in certain ways, be thought of as "a photon", and B similarly as a light-like wave, the mixing of the vector boson plane does not represent rotation of light waves. Note that B, W^3, γ, and Z^0 are mathematical symbols encoding functional value, they aren't names for waves. At the substance level, the term "photon" is a name for a *coherent state of* the γ function. In the ocean, the difference is between the ideas "swell" and "the height of a swell". The former refers to an entity, the latter to a mathematical characteristic of that entity. We might describe such things with the same symbol, yes, because value is what we use to describe entities, but we should keep in mind that the symbol γ is really a function $\gamma(x,t)$ representing "the amount of shear-rotational displacement at a particular place and time". It is not *yet* a photon.

This distinction, which is important for correct understanding, can be elucidated by considering the statement $\gamma = 0$. This is a valid statement of mathematical physics, meaning "the magnetic potential is flat". In Unity theory, to say $\gamma = 0$ is to state that there is no displacement of substance in W. It is not a statement about a photon, just as the statement "There are no sheep in this field" isn't a statement about a sheep; it is a statement regarding the *absence* of sheep. And the function γ is the same. It describes the presence, absence and nature of shear-rotational disturbances of the leptonic W dimension, some of which, if they are coherent enough, end up classified as "photons". So, when we consider the coordinate axis change from (B, W^3) to (γ, Z^0), we are talking of a reclassification of functional description, not a physical change in direction. All that happens, during the "mixing of the vector boson plane", is that the manner in which we *describe* whatever waves are present changes. And that description is in terms of local value, not global motion. The function γ stays where it is, changing in output; photons, on the other hand, are things that move.[1]

Now, orthogonality of output does give the impression of a change in direction of travel. The γ and Z^0 fields describe orthogonal directions of polarisation in the as-yet abstract "vector boson plane", and transverse waves that partake of such orthogonal polarisations do move in orthogonal directions. Hence, it is reasonable, on one level, to think of waves in the γ and Z^0 fields as travelling perpendicularly. However, this is not an image that can be applied blindly, as the terms γ and Z^0 are also used extensively to refer to the observable particles that emerge from the underlying fields. The distinction matters because the mixing of the vector boson plane is, in fact, a rotation of *polarisations*, not, as might be assumed, a rotation of waves or particles.

> The coordinate axes of the vector boson plane (γ, Z^0) should be thought of as local *polarisation* dimensions, not as global *wavevector* dimensions.

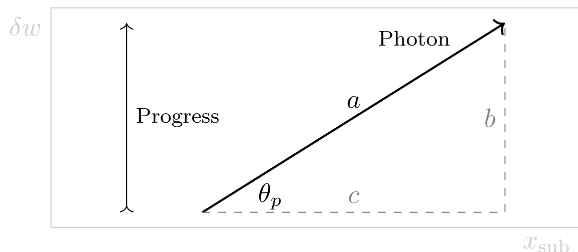
Let us unpack this further. The same wave, travelling along the same wavevector, can be expressed with regard to different polarisation axes. The most natural polarisation axes are those perpendicular and parallel to the wavevector, that is to say, the transverse and longitudinal directions. In this view, a light-like plane wave is all transverse, with no longitudinal component. But, even for a light-like plane wave, transverse/longitudinal isn't the only possible description; there are infinitely many. For a simple plane wave, however, the other possibilities are decidedly inferior, and, usually, we would never bother with them. It isn't helpful, in general, to describe a coherent wave in any other manner than in the directions of its coherence.

But things aren't quite as simple as all that. Think back to the Foldy-Wouthuysen and Pauli-Dirac bases. Relativistic matter is most naturally described in the Foldy-Wouthuysen basis, whose axes are parallel and perpendicular to the wavefront and wavevector. But those axes are mixed inner/outer, hence they don't produce an observable theory. The Pauli-Dirac basis, on the other hand, has axes parallel and perpendicular to the inner and outer dimensions. This is less natural from the point of view of the wave, but more natural from the point of view of the matter-based observer in the lab. Hence, depending on context, we need both bases.

[1] The distinction is between the field known as γ and the quantised wave known as "a photon".

The process is somewhat analogous here. The $\{\gamma, Z^0\}$ basis has axes parallel and perpendicular to the physical waves. We know this, because γ is the observable wave known as light, and it is empirically transverse. It is independent of Z^0, i.e. it has no longitudinal polarisation. The $\{B, W^3\}$ basis, therefore, must have axes that are *not* parallel and perpendicular to light.

Consider a light wave. By this we don't mean the real-valued function γ, we mean a physical light wave travelling through substance. Such a wave is stable within the wave of the present. It coprogresses at b. Hence, while it travels at the speed of light c through space, according to the wave equation $\diamondsuit_c \Psi = 0$, it must travel at $a = \sqrt{b^2 + c^2}$ through substance, obeying the broader wave equation $\diamondsuit_a \Psi = 0$, such as includes the outer w dimension of progress. The relevant diagram, in one dimension of space, is as follows.

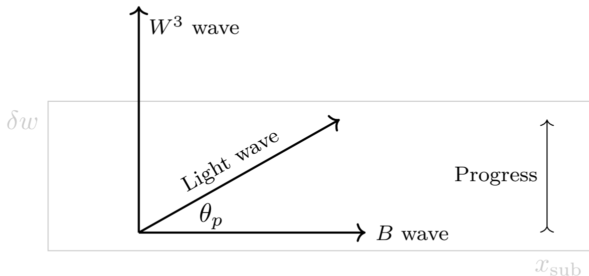


With the wave of the present seen as an ocean swell moving up the page, this picture is a bird's-eye view. The vertical δw dimension is the thickness of the wave of the present, i.e. the front-to-back extent of the swell, and x_{sub} is the dimension, running perpendicular to w, that comes to be experienced as space x. A photon can be thought of as akin to a surfer moving along the wave of the present, yet all the while remaining within it.

It becomes clear, in this visualisation, why there are two natural bases for the vector boson plane, and what the transformation between them means. The first basis, $\{B, W^3\}$, is aligned, naturally in one sense, with the wavevector and wavefront of the wave of the present; the second basis, $\{\gamma, Z^0\}$, is aligned, naturally in another sense, with the wavevector and wavefront of coprogressing light waves. Since, in Unity theory, we already know the physical nature of light as a shear displacement of the leptonic W dimension, we are led immediately to the following conjecture.

Conjecture. *Physical interpretation of the vector boson plane.* The (B, W^3) fields represent variations in the magnetic potential in directions parallel and perpendicular to the wave of the present. The rotated (γ, Z^0) fields represent variations in the magnetic potential in directions parallel and perpendicular to coprogressing light waves.

Of the two, the (B, W^3) structure may be thought of as more fundamental. However, as with the Foldy-Wouthuysen basis, its waves are not observable. Deeper things never are. A transverse wave of the B field, i.e. a B boson, would travel in the x_{sub} direction, which is not a dimension of space, and would immediately be left behind the wave of the present. Such a B boson is identical, in almost every respect, to a light wave; it is simply going in the wrong direction to coprogress. And exactly the same is true of transverse W^3 waves: light travelling in the direction of progress. Such W^3 bosons, propagating at a, would overprogress and duly disappear from our ken. So, the B and W^3 fields are not observable.



What is observable, then? Well, since all small-disturbance plane waves must travel at a, the only waves that can remain within the wave of the present must travel in precisely the direction of the photon arrow in the diagram above. They must coprogress at b, with a component through space at c. These are the light waves we see. Hence, Unity theory dictates that observable plane waves only exist in the (γ, Z^0) coordinate system, where the rotation is defined by the angle of progress θ_p. Note that this logic, which is based on Unity's axiomatic structure, is independent of the electroweak theory of Weinberg. In the language of Unity theory, the rotation is given as

$$\gamma = \sin\theta_p W^3 + \cos\theta_p B$$
$$Z^0 = \cos\theta_p W^3 - \sin\theta_p B.$$

But this is precisely the mathematics of the Weinberg theory! So, we come to the obvious but important conclusion that the weak mixing angle θ_W must be the angle of progress θ_p: the angle at which a light wave must travel to coprogress with the present. There can be little doubt about this correspondence. The fourfold structure of the proton, which is responsible for the progress of the present, gives us a theoretical value for θ_p. Four orthogonal waves, all resonating in S^3, can only coprogress if their wavevectors lie along the edges of a hypercube whose longest diagonal lies in w, which dictates that the angle of progress must, in the first-order approximation, be $\theta_p = 30°$. Hence, Unity theory produces a theoretical justification for the value of the weak mixing angle, which is measured empirically to be $\theta_W \approx 29°$.

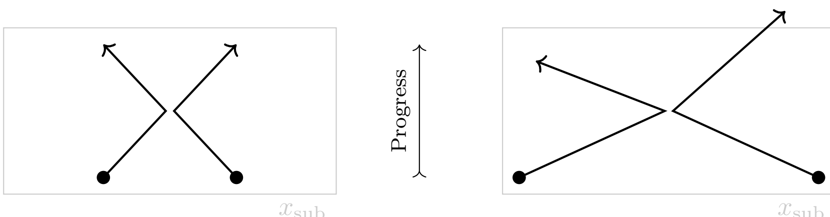
This is another major vindication of Unity. Not only does the *existence* of θ_W emerge naturally, but its quantitative *value* does too. Furthermore, there was here, as elsewhere in Unity theory, no possibility of tuning. The only numerical fact on which the theoretical angle of progress depends is the three-dimensionality of the baryonic component of the inner dimensions, and that is non-negotiable. Unity requires a three-dimensional inner space. Hence, there are only two explanations of Unity theory's derivation of the weak mixing angle: 1) the theory is broadly correct, or 2) coincidence. We are beyond the stage at which the latter remains a credible scientific option.

7.2 The Z Boson

Where does this leave the Z^0 boson? Well, since the photon γ is defined to be the coprogressing component of shear-rotational disturbances of the leptonic W dimension, the orthogonal Z^0 is, therefore, the non-coprogressing component of shear-rotational disturbances of the leptonic W dimension. Now, we must be careful how we interpret this. Obviously, the Z^0 *boson*, that is to say, the observable particle measured fleetingly in collider experiments, is not a non-coprogressing plane wave. Such a wave, while possibly stable, would nonetheless be ephemeral: it would disappear in w, orthogonally to the present, never to be seen again.

⦿ Definition: *Ephemeral.* An ephemeral wave is stable relative to the universe, but does not coprogress with the present, even approximately.

Conservation of w-momentum tells us that we cannot produce such ephemeral waves from stable, coprogressing matter. However, this doesn't mean that all elements of the present must coprogress *exactly.* Indeed, Continuity dictates otherwise. Just like an ocean swell, the wave of the present is bound to have components that edge forwards in w and edge backwards in w, i.e. components that, however briefly and marginally, over or underprogress. In particular, these must emerge at high energies.



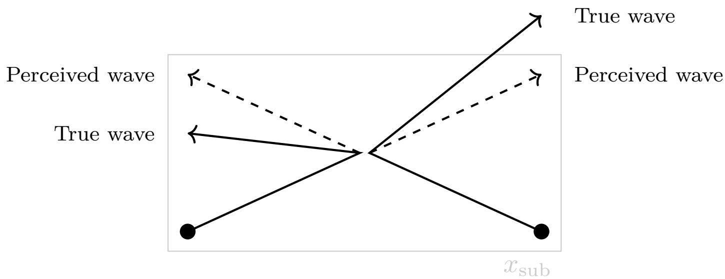
Low energy

High energy

An analogy for this is a shot in a game of pool. To start with, every ball is on the two-dimensional surface of the table. And, if the white ball is struck softly, viz. at low energy, the balls remain on the surface of the table. Any small differences in radius, i.e. any detail in the vertical dimension, is negligible, and the balls behave as if restricted to a two-dimensional world. But, if one hits the white ball hard enough, those small differences start to dominate. The pool balls take to the third dimension, and duly leap off the table.

At low energies, below those attainable in a collider, the present is restricted, to a very good approximation, to coprogression. Hence, for low energy particles, the w dimension can be ignored entirely, projected out of the mathematics: all light-like waves can, in that scenario, be thought of as travelling through space. No observable w waves exist. But, if we raise the energy level of collision sufficiently, that stops being true. As the energies increase, becoming comparable with progress itself, small discrepancies become significant. Two high-energy particles, each coprogressing to a good approximation, as the particles above are, may hit each other and "bounce off the table", at least marginally and temporarily.

Such deviations must, of course, obey conservation of w-momentum. So, while high-energy collisions will certainly produce significant w-momenta differing from the baseline of the wave of the present, those momenta must be symmetrical; overprogress must be matched with underprogress. How do these anomalous momenta manifest themselves? Well, their direction of travel, ahead of or behind the present, is, of course, not observable. Any measuring instrument we could ever conceive of or build is orthogonal to w, and hence cannot measure that dimension directly.



Collision producing weak boson mass

What *can* be measured, however, is the quantity of classical energy *stored* in the w dimension. In collision, kinetic and rest energies in the spatial and inner dimensions may be converted, albeit very briefly, into excess progress energy contained in w-momentum, before reemerging; this process is modelled mathematically as the conversion of energy to Z^0 boson "mass", which subsequently decays. The question, then, is how a Z^0 boson comes to gain its *particular* "mass" of 91.2 GeV [22].

As we have seen, electroweak theory implies that this mass is, in fact, momentum in w, just as a photon's energy is momentum in x.[2] But there is no resonance to be had in w, which is, despite the existence of the wave of the present, an open dimension to matter. The present does not have sharp edges. So, at first glance, we might expect a w wave, which cannot resonate by itself, to act like a massless photon. And a photon's energy is dictated by the Planck-Einstein relation $E = \hbar\omega$, depending only on frequency. Why does the Z^0 boson behave so differently? Specifically, why do all Z^0 bosons have the *same* mass?

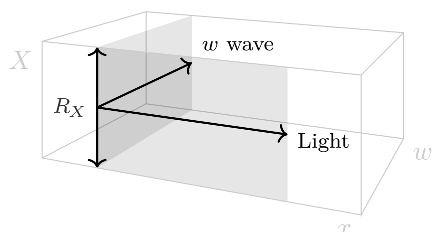
This question requires significant unpacking before it can be answered clearly. The concepts of old physics do not apply to it in a simple manner; they must be fettled for application. The first thing to note is that the broader, qualitative question "Why isn't the Z^0 boson *massless*?", which has caused so much fuss in quantum field theory, is already answered in the Unity model. The Z^0 has mass by definition. A w wave, such as gives the Z^0 boson its identity, must contain progress energy over and above the baseline of the wave of the present. A w wave, being orthogonal to the photon, can contain no kinetic energy. The γ field has all the KE. Hence, whatever energy the Z^0 contains must register as "rest" mass.

[2] Note that, here, we are using a coordinate system relative to the present. Hence, x refers to the spatial direction of travel of a photon, rather than the wavefront dimension of the present, which is notated x_{sub}. Likewise, w is orthogonal to the photon, unlike w_{sub}, which is orthogonal to the present.

As we seek, then, to explain the quantitative Z^0 boson mass of 91.2 GeV, we observe that almost all w waves do not, in fact, have an energy of 91.2 GeV. Their masses are variable. Most mathematical Z^0 bosons are *virtual particles*, which, in Unity theory, means they are waves that don't fill the present. Virtual particles are local wavelets, not globally coherent configurations. The mathematics is the same, of course, because geometry is local, but virtual particles, since they do not resonate, do not pick up eigenvalues of mass. Hence, our question regarding weak mass is not "Why do all Z^0 bosons have the particular energy 91.2 GeV?" That is a non-question, since its main premise is false. Rather, we ask: "Why do w waves of sufficient energy *resonate* at 91.2 GeV, thus manifesting themselves as Z^0 bosons?"[3]

Let us construct the relevant resonance. Since the Z^0 is defined as having a polarisation orthogonal to that of the photon, a Z^0 may be thought of as a longitudinally polarised photon: where the γ field describes variations in shear-rotational displacement *orthogonal* to a coprogressing wavevector, the Z^0 field describes variations in shear-rotational displacement *parallel* to one.

How can such variation generate a resonance? In which dimensions can it resonate? Well, a w wave cannot resonate in the outer (w, x, y, z) dimensions, as they are effectively open, nor, of course, in the W dimension itself, whose gauge-symmetric shear displacements are the ones being modelled by the γ and Z^0 fields. The only possibility for resonance is in a baryonic inner dimension, one of (X, Y, Z). Therefore, the electroweak resonant space is (w, x, X), where w and x are taken relative to the photon.

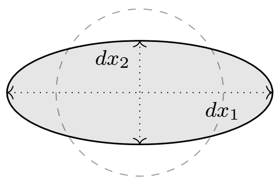


To construct the observable Z^0 particle, we require both the w wave and a resonant R_X wave, as depicted above. But a combination of such waves does not, on its own, make a Z^0 boson. What we need is *interaction* between the two, so as to allow for the transfer of energy between x and w dimensions. But waves, according to $\Diamond_a \Psi = 0$ superpose linearly, so any mass-energy in the R_X wave is bound to be independent of any mass-energy in the w wave. In the first-order approximation, there can be no interaction, hence there can be no weak mass. The Z^0, then, cannot be seen as a linear wave obeying $\Diamond_a \Psi = 0$: it must be viewed as a nonlinear, *second-order* phenomenon. This is an important point. Dimensional interaction, in Unity theory, requires the nonlinearity of $R_8 = 0$; linear quantum mechanics does not suffice.

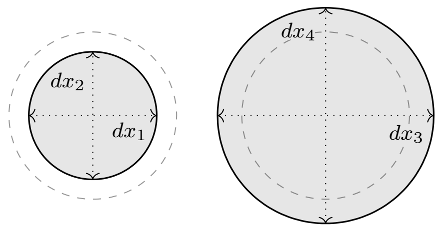
[3]Here and elsewhere, we make a firm distinction between, on the one hand, w waves, which are the non-coprogressing components of light waves, and, on the other, Z^0 bosons, which are massive resonances at 91.2 GeV. The former are essentially zeroth order magnetic waves, while the latter are the second-order resonances that allow interaction of those zeroth order waves with first-order fermions.

By comparison, a photon does not effect dimensional change: a photon is electrically neutral, and emission, as described by QED, merely converts one type of kinetic energy, that of an excited electron, into another, that of a photon. This is why QED is an abelian theory. But both the strong and weak interactions involve the transfer of energy from one dimension to another. In the strong case, energy is transferred within inner space; in the weak case, energy is transferred between different components of the Unity group. In the interaction currently under discussion, the neutral-current interaction mediated by the Z^0 boson, energy is transferred between w and x, with an energy ceiling dictated by resonance in X.

To model such an interaction, we must consider second-order solutions of $R_8 = 0$. Such solutions are depicted in the following diagram, in which the discs enclosed by dashed circles represent flat area elements.



First-order exchange



Second-order exchange

⦿ Definition: *Second-order exchange wave.* A configuration of substance, satisfying $R_8 = 0$, in which simultaneous expansion of two dimensions of substance is traded off against simultaneous contraction of two others. Geometrically, this constitutes a planar, as opposed to linear, expansion/contraction.

The polarisation of any symmetrical second-order exchange wave must be in four dimensions, as depicted above.[4] Now, we have already considered a four-polarised wave: the proton. But the proton's paired helices are *out of phase*, which is why it remains first-order, with mass dictated by the first-order mass unit

$$\frac{m_e c^2}{\alpha} = 70 \text{ MeV}.$$

A second-order wave, on the other hand, must have twin helices that are *in phase*, with two dimensions expanding simultaneously. This wave has the same frequency as the proton, yes, but the energy *associated* with that frequency is much higher. It is given by the second-order mass unit

$$\frac{m_e c^2}{\alpha^2} = 9.6 \text{ GeV}.$$

[4]There are, in fact, asymmetrical solutions to $R_8 = 0$ in which e.g. the baryonic dimensions trade against the leptonic. They aren't relevant here, but it is likely that they form the physical basis for the *nuclear force*, by exchanging expansion/contraction between the leptonic and baryonic components of the inner group.

The quantum-mechanical energy operator $\hat{E} = i\hbar\frac{\partial}{\partial t}$, with which these second-order masses are not compatible, no longer applies in this domain.[5] Quantum mechanics must be superseded by non-abelian quantum field theory; linear mathematics won't do. All of the heavy particles of the Standard Model—the weak bosons, the third-generation quarks, and the Higgs boson—partake of this second-order structure.

A Z^0 boson mediates the transfer of outer-dimensional energy: progress and kinetic. Its resonant R_X wave must, therefore, be a second-order exchange wave with polarisation in the outer dimensions. This is on top of any light-like magnetic shear in the w wave, which effects no dimensional transfer of energy; such shears may be superposed freely in $R_8 = 0$. It is this underlying shear that unifies Z^0 with γ; however, such shears, which are zeroth order, have nothing to do with the *quantised* mass of the observed Z^0 boson, which emerges from the resonance of the R_X wave.

Now, the weak interaction is independent of the strong, which means that a weak interaction can involve no rotation of inner space, that is to say, no rotation from X to Y. Furthermore, the weak bosons can have no net colour charge, so their X-momenta must be zero. So, the minimal resonance in inner space, as with the pion, must be a standing wave, of integer spin, in a single inner dimension X. This is the weak energy-storage silo. A Z^0-mediated weak interaction, at resonant energies, involves transfer of energy among the outer dimensions, *via* X. While a low-energy interaction, mediated by a virtual Z^0 boson, may be thought of as involving a direct exchange of energy between w and x, a high-energy interaction is bound to generate resonance. Such a resonance dictates the *energy ceiling* of the interaction, which takes the form of weak boson mass.

To quantify this mass, we can work from the proton. A proton has four polarisation dimensions, and four orthogonal wavevector dimensions. The linear approximation of its mass is $16 \times m_e/\alpha = 1120$ MeV. A second-order weak resonance has the same number of polarisation dimensions, but only one wavevector dimension. This gives dimensionality 4 compared to 16 for the proton. However, a weak boson must be a standing wave, which doubles this value to 8, half that of the proton. Hence, a theoretical assignment, proposed with some caution,[6] is

$$m_{\text{weak}} = 8 \times \frac{m_e}{\alpha^2} = 77 \text{ GeV}/c^2,$$

which is close to the observed mass of the weak bosons. Indeed, if we consider this as the mass of the second-order resonance itself, i.e. a theoretical value for m_W, then electroweak theory tells us that combination with the photon increases the effective mass of the Z^0 according to

$$m_Z = \frac{m_{\text{weak}}}{\cos\theta_p} = 89 \text{ GeV}/c^2.$$

[5] It isn't yet clear what the precise definition of energy should be at second-order. To work with the substance equation at second, third and fourth order is beyond the scope of this book. Establishing clear higher-order definitions for concepts such as energy is a major task in Unity theory.

[6] Whenever there are factors of two involved, there is always scope for assigning such factors incorrectly. It is possible, for example, that the frequency is halved and the mass unit doubled, or something similar. This remains to be ascertained in future work.

This is very close to the observed value of 91.2 GeV, and the correct side of it: we know that the weak resonance is exceedingly unstable. While Unity theory should overestimate the proton mass, as it does by 1120 MeV $>$ 938 MeV, it should underestimate the energy stored in a weak resonance, as it does by 89 GeV $<$ 91 GeV.

We should retain a somewhat higher level of skepticism regarding these second-order results than the first-order ones presented in earlier sections on quantum mechanics. Many aspects remain opaque: in particular, the much-discussed Higgs theory, which we address in an appendix. Haziness in the details does not, however, point to invalidity of the overall picture, merely to an early stage of painting.

7.3 The W Bosons

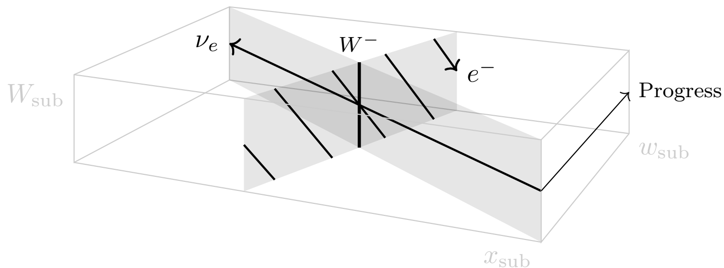
Extension to the charged-current interaction is straightforward. Our theoretical value $m_{\text{weak}} = 77\ \text{GeV}/c^2$ is very close to the observed value $m_W = 80\ \text{GeV}/c^2$ [14], and, just as with the Z^0, it is wrong in the right way: the weak bosons decay rapidly, which means that a configuration formed of their constituent elements is energetically favoured, i.e. of lower energy, when compared to the weak boson configurations themselves. We have proposed that this value m_{weak} corresponds to the energy eigenvalue of second-order resonances in X. This proposition applies equally to charged bosons.

A charged $W^\pm$ boson mediates a different transfer of energy to the Z^0, albeit one that partakes of the same resonant space. It is the resonant space, dictating mass, that the weak bosons have in common, but it is the different dimensions of energy transfer that give the weak bosons their different characters. The Z^0 boson transfers energy between space x and the dimension of over/underprogress w, with a mass ceiling dictated the baryonic inner dimensions. The $W^\pm$ bosons, on the other hand, transfer energy between space x and the leptonic W dimension,[7] but they share the same mass ceiling as the Z^0, which is dictated not by the dimensions of transfer, but by resonance in X. The resonant space for a Z^0 boson is (w, x, X), while the resonant space for a W boson is (W, x, X). Up to a factor of $\cos\theta_W$, as described in the Weinberg theory, the masses, therefore, are the same.

It is with reference to the W boson that we begin to see the symmetry of the weak interaction, which we will address explicitly in due course. A word on notation here. In the charged-current interaction, there is no departure from progress; hence, we can work relative to the present, referring to W and x and leaving the angling of those dimensions towards progress implicit. Note, however, that x, say, is an oblique, *coprogressing* direction, as distinct from x_{sub}. In this language, a charged weak boson mediates rotation, i.e. dimensional transfer of energy, between a coprogressing electron, which resonates in W, and a coprogressing electron neutrino, which travels in x.

[7] The coincidence of notation here, between the W boson of electroweak theory and the W dimension of the Unity model, is unintended, but not unwelcome. The charge of the $W^\pm$ bosons is, after all, positive/negative momentum in the leptonic W dimension.

To maintain symmetry, we must assume that, while an electron has configuration $e^- : \hat{W} \,\big|\, xy$, an electron neutrino has configuration $\nu_e : \hat{x} \,\big|\, Wy$, with polarisation in an inner dimension. Now, a weak W^- boson decays into an electron and an electron neutrino. So, a W^- boson must be an interacting, second-order *superposition* of an electron and an electron neutrino.



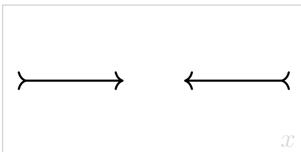
Note that the W^- doesn't *resonate* along the black line. The W^- superposition resonates in the dimensional component *not* depicted, baryonic inner space X. A full W^- configuration, then, consists of a standing R_X wave in that dimension, necessarily bosonic, with four dimensions of polarisation, plane versus plane. These dimensions must include W and x, which are the dimensions of energy transfer, and, as before, for $R_8 = 0$ to be satisfied, two other dimensions. We assume here that these dimensions are the other two dimensions of space y and z.[8] As before, such a wave has two wavevector directions—a standing wave in X—and four dimensions of polarisation (x, y, z, W). This gives the same resonant mass, $m_{\text{weak}} = 77$ GeV$/c^2$, which we propose as a theoretical approximation for the observed W boson mass $m_W = 80.4$ GeV$/c^2$ [14]. Because the electron, electron neutrino and W boson all coprogress, no adjustment by a factor of $\cos\theta_p$ is necessary.

7.4 Symmetry and Symmetry Breaking

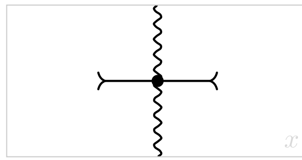
And so, on to a question that has major ramifications, mostly by process of elimination, for the gravitational aspects of Unity theory. Where does the SU(2) symmetry of the weak interaction come from? The U(1) and SU(3) symmetries of the electromagnetic and strong interactions emerge from the structure of the inner group U_X, whose leptonic and baryonic components offer those symmetries as the spaces of rotations of, respectively, real- and complex-valued functions in S^1 and S^3. The set of shear-rotations around S^1 has gauge symmetry given by the circular group U(1), while the set of rotations of complex-valued energy distributions in inner space S^3 has gauge symmetry given by the special unitary group SU(3). At first glance, this leaves the weak interaction (and gravity, for that matter) homeless. A second glance, however, says otherwise.

[8] This is an assumption of convenience, and shouldn't be taken as more than a guess. It is certainly possible that the w dimension of progress in involved, or, as is more likely, that the polarisation space of a weak boson is a non-trivial, oblique four-dimensional space within the five-dimensional domain (w, x, y, z, W). In this book, we make no firm assertion as to its direction.

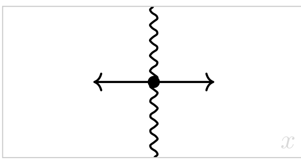
There are two distinct weak interactions, whose mathematical unification derives only from the resonant space and hence energy ceiling of which they both partake. Below that ceiling, they are very different beasts. They are, for some purposes, rather like a human being weighing 80 kilos and a yellow-fin tuna weighing 80 kilos; unified by mass, yes, but otherwise rather dissimilar. The neutral-current interaction involves elastic energy transfers in the (w, x) plane, while the charged-current interaction involves inelastic energy transfers in the (W, x) plane. While there is certainly commonality in mass and symmetry, weak symmetry *breaks* in two different ways, specific to the individual interactions.



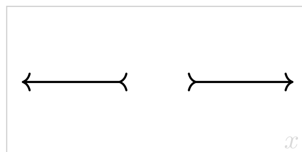
1) Approach of fermions



2) Creation of Z^0 boson



3) Decay of Z^0 boson

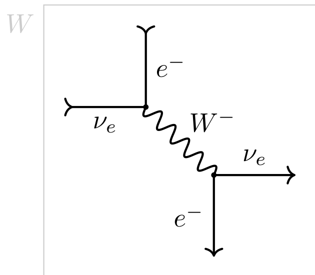


4) Departure of fermions

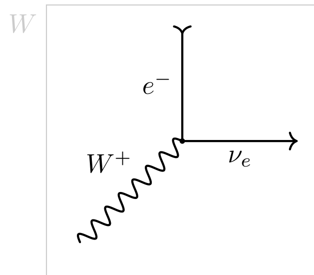
Consider the difference in elasticity. The neutral-current interaction, as depicted above, is elastic for a simple reason: there are no observable waves that travel in w, the dimension of over/underprogress. Energy that is observed must, by definition, begin and end in kinetic form, whatever happens to it in between. But since there are no w waves that can store energy for any length of time, energy fleetingly stored in w must, if it is to be observed, return as kinetic energy. There is nowhere else for it to go. This manifests as an *elastic* transfer of momentum.

This is why there are no "flavour-changing neutral-current interactions", as they are known in particle physics. Such interactions would have to turn a coprogressing wave into an over/underprogressing pair. This is possible, but only momentarily in the form of a Z^0 boson, as any permanent energy in the w dimension would be ephemeral. It would simply disappear. In a neutral-current interaction, the excess energy in w must immediately decay back into KE, and the original particles are restored elastically. Momentum is transferred, yes, but nothing else changes.

The (W, x) plane, however, is different. There *are* coprogressing, stable, observable waves in both the W and x directions, and they have very different characteristics; the electron has negative charge and significant mass, while the electron neutrino has neither. Hence, as well as temporary superpositions, in which (e, ν_e) pairs exchange momentum, *permanent* rotations can also be enacted. For instance, a W^+ can transform rest energy in the W dimension, in the form of the negative charge of an electron, into kinetic energy in x, in the form of an electron neutrino. This is described in particle physics by the interaction $W^+ + e^- \longrightarrow \nu_e$. Under the bonnet of these symbols, a W^+ boson is really a second-order superposition of a positron and a neutrino. The positron annihilates with the electron, while the neutrino is left to travel on. It is the fact that the superposition is second-order that makes this a weak interaction, rather than an electromagnetic one.

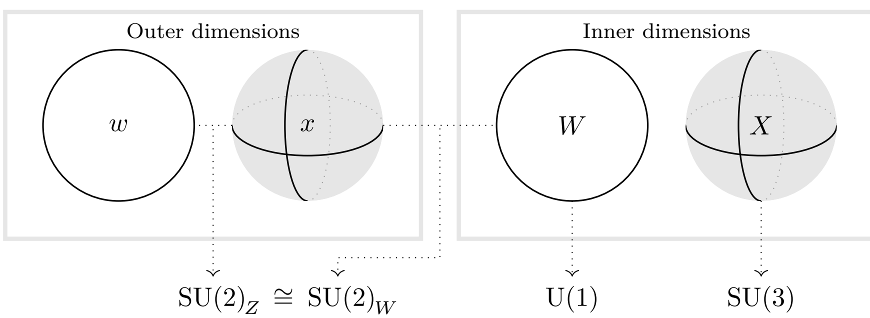


W^- superposition



Rotation by W^+

How does all of this relate to the symmetry of the weak interaction? Why, if these two interactions are so different, do they share a single SU(2) symmetry? Well, in each case, neutral- or charged-current, rotation of fermionic waves is enacted in a two-dimensional *plane*. And the waves involved, which are prototypically electrons and their neutrinos, are described, as we know, with complex-valued functions. Hence, their transformations, as depicted above, are given mathematically by the group of rotations of a complex-valued plane: the special unitary group SU(2). In the Standard Model, this is the symmetry group of the weak interaction.



So, the Unity model produces the symmetry of the weak interaction just as naturally as it does those of the electromagnetic and strong interactions. In the Standard Model's overall symmetry group U(1) × SU(3) × SU(2), the leptonic U(1) and baryonic SU(3) factors are the gauge symmetries that exist within the two components of the inner dimensions, while the weak SU(2) factor is the symmetry that exists between the dimensions of space and 1) the w dimension of progress, in the case of the neutral-current interaction, and 2) the W dimension of leptonic mass, in the case of the charged-current interaction. To speak of the (non-gauge[9]) symmetry of the weak interaction is, essentially, to speak of the fact that the perceptible dimensions of space x and the imperceptible dimensions w and W are *locally* identical, a fact which comes directly from the axiom of Unity.

Just as naturally, Unity tells us why weak symmetry is *broken*. In the case of the neutral-current interaction, the symmetry of the outer dimensions (w, x), while it holds locally and hence at very high energies, is broken globally by the fact that the wave of the present has a particular thickness δw, travels in a particular direction $\hat{w}$, and progresses at a particular speed b. The existence of the wave of the present, with its singular angle of progress $\theta_p \approx 30°$, picks out, in a consistent manner, one specific axis of every (w, x) plane to be the direction in which magnetic radiation can coprogress. It is defined by $\hat{x}' = \cos\theta_p \hat{x} + \sin\theta_p \hat{w}$. This is the only direction in which stable plane waves can move within the present, and hence it is the only direction in which a long-range force can exist. That force is electromagnetism.

What we *perceive* is then decidedly asymmetric. The local (w, x) plane symmetry still exists, hence the underlying mathematics, but a truly photon-like wave travelling in w, producing shear-rotational displacements of W, is not observable. Were it to exist, it would be forced to leave the present immediately and permanently. Such waves are ephemeral: they move perpendicular to our perceived reality. Hence, to present-based beings such as ourselves, the short-range, neutral-current interaction looks nothing like long-range electromagnetism.

> Electroweak symmetry is broken by the (w, x) structure of the wave of the present. In this plane, electromagnetism is picked out by coprogression.

In the case of the W-mediated charged-current interaction, the relevant plane is (W, x), which, again by homogeneity, must be symmetrical locally, i.e. at high enough energies. At, say, the baryonic scale of a proton, i.e. a good way below the W-cline, the leptonic W dimension is big enough to act like an outer dimension. Hence, locally, on the level of substance, there is full symmetry between the elements of the leptonic (e, ν_e) doublet; they are fermionic exchange waves going in different directions.

But globally that symmetry is broken. We, as material beings ensconced in the wave of the present, live *above* the leptonic W-cline, but *below* the universal x-cline: the particles that make up our bodies are built of momenta in W; those particles are subsequently perceived as moving in x. As far as perception/non-perception goes, the asymmetry is total. To a human being, the W dimension is a closed, imperceptible circle, known only up to U(1) gauge symmetry, whereas the x dimension is open, vast and eminently perceptible. With symmetry broken, the leptonic W drops back behind the scenes, and space becomes the stage of the theatre of reality.

[9]The descriptor "gauge", while appropriate regarding electromagnetism and the strong interaction, is not appropriate regarding the weak. There is no sense in which the symmetry of the weak interaction is a *gauge* symmetry: the relevant dimensions are fully marked out as different by the topology of the universe, quite independently from any choices or non-choices of gauge.

Note that, once again, we require no auxiliary hypotheses to explain something for which the old paradigm requires many. In twentieth century physics, symmetry breaking was postulated, based on no known physical mechanism, to have occurred within the first few moments following the Big Bang. A cause had to be concocted, and it arrived in the unsatisfactory form of the ubiquitous champagne-bottle potential. But no explanation has ever been given as to why such a weird potential, whose properties just happen to generate the symmetry breaking we see in experiment, exists in the first place. The old paradigm exempted itself from having to make sense in such ways.[10]

This is a philosophical point, very much against the tenor of the times, to which we have returned again and again. Over a century, science, that pinnacle of Western reason, has undergone a long and gentle corruption, in which many fine tools of rational thought have been set aside to accommodate a fallacious worldview. Such is the importance of this message, it warrants saying repeatedly. While there is, of course, something comforting about the familiar, that does not excuse the blindness of the many clever people who, so as not to disturb livelihoods, stories and statuses built on old ways, have hampered and continue to hamper human progress by shouting down alternatives to dogma. Christians saw the pagans do this; scientists saw the Christians do it; let us hope, for our own sakes, that we, the thinking people of the world, do not succumb to yet another iteration. As individuals, we are at our finest when admitting our mistakes; how much more then civilisations and epochs?

Again, plainly: we in science, like those before us in Abrahamic religion, have had it wrong. Reality, it turns out, just isn't as we thought it was. As such, we, the scientific educators of the Western world, are due a long hard look at ourselves. Many, in recent years, have taken the easy way out, and have taught models as fact. Science, in power, has forgotten: *noblesse oblige*. To teach something that one does not properly understand, as so many have done, is fundamentally dishonest, unless (and this is a crucial *unless*) one continually points to and focuses on one's lack of understanding. This is a hard task, yes, but not an impossible one; Feynman did it throughout. Only such honesty conveys the right to the title "teacher".

To a rational mind, unblinkered by prior attachment to this or that long-accepted truth, the facts now speak loudly. In physics, as in so very many regards, the spatial paradigm, as employed in the West since time immemorial, is simply not good enough. It is empirically incorrect. It does a far worse job of explaining what is going on, even in the most basic, qualitative facts, than the *single sentence* of the axiom of Unity, from which all physics flows so readily. The question, in the end, is, which would we rather have? An ugly patchwork of this and that, endlessly tinkered with to keep the status quo, or something infinitely simpler, which offers infinitely more?

[10] There are explanations in the literature as to the origin of symmetry breaking. But not all science is good science. Most of those explanations are based on impressive-sounding yet hollow phrases such as "tachyon condensation". Ad hoc fictions do not count as explanations. As Einstein rightly said, if you can't explain it to a six-year old, you don't understand it yourself. It is highly doubtful that anyone has ever attempted to explain tachyon condensation to a six-year old, for the good reason that it is essentially nonsense.

8 Unity and the Standard Model

This section, which tidies up some loose ends in particle physics, can be bypassed by those readers who are already convinced of the broad validity of Unity theory and wish to proceed to its cosmological implications. New ideas are introduced regarding the higher generations of the Standard Model, particularly relating to neutrinos, strangeness, charm and the top resonance, but these are relevant only within particle physics; in particular, we can address gravity, general relativity and the cosmos, as we do in subsequent sections, without reference to them. However, since Unity theory is able to resolve, without undue mathematical exertion, some significant conundra here, this section merits a place in the main flow of the book.

Such is the magnitude of the paradigm shift proposed by Unity theory, and such is its potential benefit to our self-destructively materialistic culture, we must test it as extensively as is possible. Our civilisation is deeply wedded to the view that reality takes place on the stage of space, and, as a result, ideas such as those contained in Unity theory can and do promote fear. In the long term, this feeling is misguided, but it is nonetheless very real. The truth is always useful, but rarely pleasant in the first instance, especially to those to have long denied it. Hence, it is crucial that the testing for Unity theory goes *far* beyond the realms of "reasonable doubt".

The Standard Model, which is an extraordinary achievement in many ways, falls short when it comes to the most basic of tests: that of making sense. We have already addressed some of the ways in which this happens. The quark model, as applied to the stable nucleon, is the most significant. But we would be remiss, both in terms of explaining the old paradigm and validating the new, were we not also to address the areas in which the Standard Model *does* have empirical validity. Now, to a large extent, Unity theory agrees with the Standard Model. While there are certainly marked differences in concept, those are, almost entirely, independent of the core mathematics, which is, of course, the only aspect of a theory which can ever be said to have empirical validation. Any subsequent *interpretation* of the mathematics, which necessarily inherits its strengths and weaknesses from the underlying worldview of the interpreter, must *also* pass the test of making sense. That is the way in which the old view fails.

Let us see whether Unity theory can make sense of the rest of the Standard Model. Now, such an analysis, as presented in a book like this one, must necessarily be brief and broad: particle physics is a vast field, and we could never expect to address any significant proportion of its detail at this early stage of work. Hence, in this section, we limit our analysis to the *physical nature of higher-generational matter*.

Such unstable matter, produced in high-energy collisions, is emphatically within the domain of empirical validation of the Standard Model. Indeed, unstable matter is precisely that domain. It was the discovery of the higher generations of matter that birthed the Standard Model, which has subsequently enjoyed such quantitative success. But, despite and because of that quantitative success, major qualitative questions remain. Why are there unstable, higher-mass versions of the fundamental particles? Why do there seem to be precisely two generations beyond the first? Why are the masses of these particles as they are? Is the "top" really the top? We approach these questions from the bottom up, beginning with the leptons.

8.1 Leptons

First, the *muon*, the most intensively studied of all the higher-generational particles. A muon is a heavy electron. It has the same charge $-e$, and the same behaviours with respect to the fundamental interactions. The difference is its mass, which is some 207 times larger than that of the first-generation electron. Let us derive its structure. The muon, at around 106 MeV [23], is on the same mass scale as the neutral pion, at around 135 MeV, which means that the muon's extra mass must be baryonic, that is to say, it must resonate in the inner space dimensions. Also, the muon's charge is the same as the electron, which means that the electron and muon must have the same leptonic resonance in W; such is the only way in which the electron and muon could come to have such similar behaviours.

In Unity theory, a muon is an electron with a baryonic mass component. Since that baryonic mass is orthogonal to leptonic mass, such a particle retains leptonic properties by definition. But a muon is classified as a lepton due also to a *lack* of strong interaction. This means that a muon cannot contain baryonic charge, not even positive and negative baryonic charge summing to zero. Yet a muon clearly has baryonic mass. This seems contradictory, in quantum-mechanical terms. In the linear approximation, charge and mass are identical. But, in the higher generations, we are beyond the linear realm. The existence of the muon poses a question:

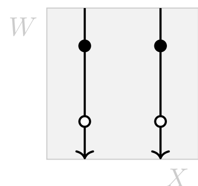
Is there a nonlinear solution to $R_8 = 0$ containing X-energy but no X-momentum?

The objects of study of quantum mechanics are transverse exchange waves satisfying $\Diamond_c \Psi = 0$. The electron, the pion and the proton are all, to a good approximation, waves of this description. These are the most natural type of fermionic wave, hence their ubiquity. But they are not the *only* type of exchange wave, as we have seen with reference to the second-order weak bosons. $R_8 = 0$ is a flexible equation, and it offers countless configurations. One of these is the *longitudinal* wave, the pressure wave in substance. Whatever their precise mathematical form, such waves must exist, for the same reasons that sound waves exist in all material media. Produce compression, such as with the sudden motion of a drum head, and that compression must propagate, dissipating energy away from the source. We don't need Riemannian tensors to tell us that there must be such sound-like solutions to $R_8 = 0$.

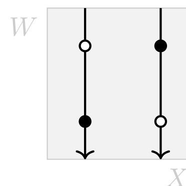
The electron has no need of such solutions. Its fermionic exchange wave is polarised in the outer dimensions, which are open; it travels in W and resonates in W. But a charged muon, while travelling similarly in W, resonates in X. Its charge is clearly leptonic; its mass clearly baryonic. So, since its wavevector is in W, it can only pick up baryonic mass via a *polarisation* in X. This sets the muon apart from the pion and the proton, whose *wavevectors* are in X, and are, therefore, susceptible to the strong interaction. So, a muon wave must compare with the electron as

$$e^- : \hat{W} \,\big|\, xy,$$
$$\mu^- : \hat{W} \,\big|\, Xy.$$

But the X dimension is topologically closed, where the x dimension is effectively open. Indeed, the X dimension is not only closed, but it is 137 times *smaller* than the W dimension. So, how can a muon wave exchange expansion of the X dimension with expansion of the outer y dimension? Well, to expand the entire X dimension at once would be one possibility, but such a wave couldn't resonate in X, which would rule out its having a specific mass eigenvalue on the pion scale. No. Instead, the muon wave must involve expansion of one half of the X dimension and contraction of the other.[1] That way leptonic behaviour is preserved, while massive resonance is established in X.



Electron



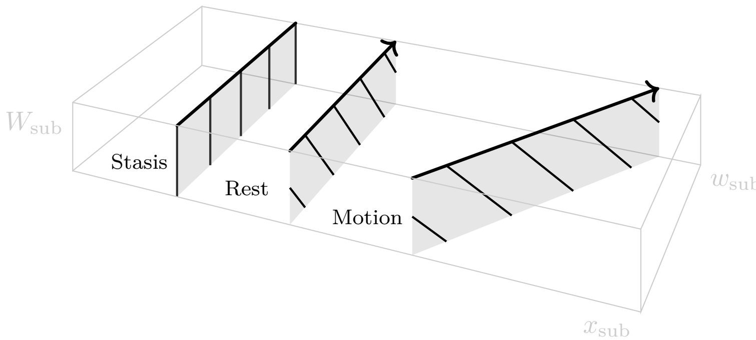
Muon

How do we model such a thing mathematically? Without much difficulty, in fact. Again, we don't need to return to the Riemannian geometry, and can work with linear waves. We model the resonance in X as a standing *longitudinal* wave. Hence, a muon may be thought of as a repolarisation of an electron $xy \to Xy$, combined with two pressure waves travelling in $\pm X$. The leptonic behaviour of the muon is given by the charged wave travelling in W, while the extra baryonic mass is provided by the longitudinal pressure. As standing waves, these have no electromagnetic or colour charge.

And how can we test this hypothetical structure? By deriving the observed muon mass. Now, at first glance, it would seem that our standing longitudinal wave should have the same mass as the pion, seeing as it resonates in the same space and has the same dimensionality. This is not far from the truth: the neutral pion and muon masses are similar, at around 135 and 106 MeV. However, that analysis misses one key ingredient. It is, of course, the same ingredient that resolves so many of the apparent paradoxes that riddle the old paradigm. As with regard to the proton, when considering the higher generations of the Standard Model, it isn't possible to work solely relative to the wave of the present. At high energies, all degrees of freedom are on (or rather off) the table. We must also consider the role of *progress*.

[1] This solution may seem somewhat unnatural, but this is to be expected. Higher-generational matter is precisely what ensues when energy levels rise high enough to spill out of the obvious resonances. The electron is truly simple; the muon, on the other hand, is the simplest of a complicated bunch.

⦿ Definition: *Stasis.* Zero velocity in (w, x, y, z). In contradistinction to *rest*, which is zero velocity in (x, y, z).



As a thought experiment, consider a static electron, such as would get left behind by the wave of the present. By extension of the logic with which we derived special relativity, since a moving electron has a higher frequency than a resting electron, a resting electron duly has a higher frequency than our hypothetical static electron. Nevertheless, all three have the same *mass*, since acceleration into the outer w direction (stasis to rest) is mathematically identical to acceleration into an outer x dimension (rest to motion). All relativistic arguments regarding x-acceleration, or the rest-to-motion transition, apply equally to w-acceleration, or the stasis-to-rest transition.

As a hypothetical static electron w-accelerates to become a resting electron, its frequency increases, but, in the same breath, the component of its total energy directed in W decreases relative to that increased amount. Overall, the two effects cancel exactly. By dint of this cancellation, then, an electron maintains precisely the same W-momentum in all three states, i.e. an electron has an invariant mass, whether it is static relative to substance, at rest relative to the wave of the present, or in motion relative to both.

Now, until this point in the work, we have been able to enact our theoretical mass calculations without reference to the *relativistic* effects of the progress of the present. We have observed that the presence of the w dimension affects the dimensionality of the proton, yes, but even there, where the dimension of progress is very relevant, we didn't consider the Lorentz-like increase in energy between stasis and rest. We didn't need to. Thus far, all of our mass calculations have been carried out relative to the *observed* electron mass m_e. And, in regard to relativistic increases in energy in stasis-to-progress, the electron, proton and pion are all in the same boat. They pick up matching increases in energy, and so all have the same ratio of observable-to-unobservable mass. Such considerations can, therefore, be neglected within that set of particles. The same isn't true, however, of matter whose structure involves the longitudinal waves discussed above. Why not? Well, a static electron resonates in W, that is to say, along its *wavevector*. Hence, when its wavevector tilts forward of W to allow it to coprogress with the present, the need for resonance dictates an increase in energy. That increased energy is already contained in the observed electron mass, and we don't notice. The same is true for a pion, resonating in X. But a muon's baryonic mass, resonating in X, does not resonate along its wavevector. It is a nonlinear, *transverse* resonance. So, as the muon accelerates from stasis to progress, its leptonic frequency must increase in energy, but its baryonic frequency need not. Hence, while the pion, proton and electron have their energies scaled by the same amount in the stasis-to-progress transition, the muon does not.

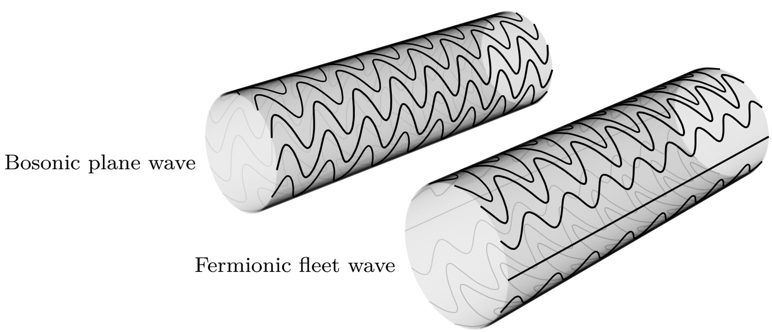
The scale factor is easily calculated. The effective decrease in muon energy is given by the increase in energy of the other particles. Mathematically, this is a Lorentz-like factor $\gamma_b = \cos\theta_p$. Hence, the first-order approximation for the rest energy of the observed muon is calculated to be

$$m_\mu = \cos\theta_p m_\pi = \frac{\sqrt{3}}{2} \times \frac{2m_e}{\alpha} = 121 \text{ MeV}/c^2.$$

As expected, this is a little higher than the observed energy around 106 MeV. A large mass defect around 13%, which is greater than that of the pion but less than that of the proton, is in line with the muon's long lifetime.

The above tells us that our proposed physical structure for the muon is, at least in its broad brush strokes, appropriate. So, henceforth, we will assume that a muon is locally similar to an electron, the only difference being that, while an electron is a plane wave, a muon is not. An electron is constant across X, and is therefore completely independent of the baryonic inner dimensions; a muon, however, while travelling in W, varies along its *wavefront.*

⦿ Definition: *Fleet wave.* A wave with constant wavevector and non-constant wavefront. Fleet waves are higher harmonics of plane waves.



This kind of wave, which is necessarily nonlinear, is only stable with polarisation in a closed inner dimension, otherwise the energy contained in the non-constancy of the wavefront must dissipate immediately in that direction, generating non-constancy of wavevector. Only if that energy is contained in a closed inner dimension can the overall wave maintain its structure. In visualisation, the difference is this. A plane wave can be described with the movement of a single ship or aeroplane. A fleet wave must be described with the movement of a fleet of ships or a squadron of aeroplanes, where differences exist between the individuals, despite coherent motion of the whole.

To begin with, consider a pair of waves, such as those depicted on the last page, travelling in W and Hopf-polarised in X. The plane wave is then the beta boson $\beta_X : \hat{W} \,\big|\, X$, shear-rotating the X dimensions. The fleet wave, on the other hand, is the fermionic muon $\mu : \hat{W} \,\big|\, Xy$, exchanging (non-constant) expansion in X for contraction in y. The muon can be seen, therefore, as the first *harmonic* of the beta boson. The electron, the beta boson and the muon, then, are simply different polarisations, of increasing mass, of the same underlying W-wave.

Alternatively, consider a similar pair of waves, but now travelling in x and polarised in W. The bosonic plane wave depicted is then the photon $\gamma : \hat{x} \,\big|\, W$. But what is the fermionic fleet wave? Since there is only one type of fermion that propagates at the speed of light, there is only one possible answer: this must be the structure of the *neutrino*. Specifically, with its polarisation in W, this is the electron neutrino $\nu_e : \hat{x} \,\big|\, Wy$. The photon is the fundamental, a plane wave with full gauge symmetry around W, and the electron neutrino is its first harmonic. Little wonder, then, that photons and electron neutrinos are emitted together from the bellies of stars.

This formulation resolves many of the puzzles of neutrino physics. What is the mass of the electron neutrino? Well, like most questions that resist answering despite decades of intensive effort, it is not that everyone has failed to answer the question, but that the question itself is ill-defined. The neutrino does have a mass of sorts, because it has a non-zero W-derivative. However, it also travels at the speed of light, because that mass is not resonant. The neutrino, in short, does not obey special relativity, which is why it has caused so many problems. In fact, the only sensible value for the mass for the electron neutrino is m_e, the mass of the electron. The two are created together from a weak W^- boson, so they must have, at least initially, the same variation around the W dimension.

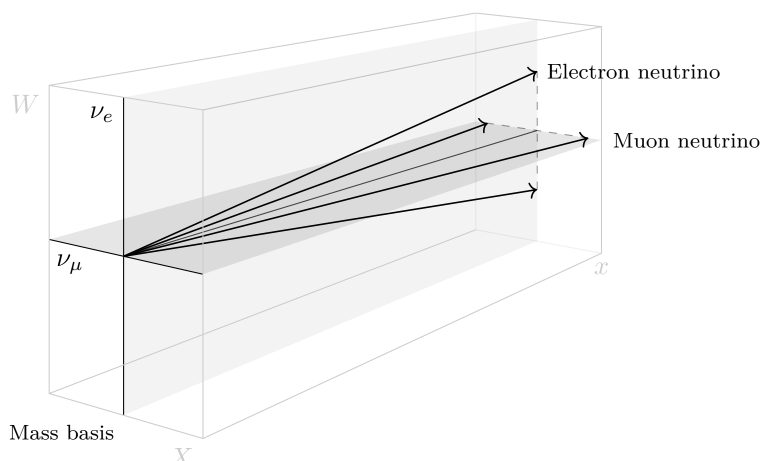
But this isn't mass as we know it. The neutrino has no charge, so this W-gradient isn't topologically fixed. It can and does rotate its way into other inner orientations, thus generating the phenomenon of *neutrino oscillation*. It isn't resonant, hence is independent of the energy in the neutrino; an electron neutrino may, like a photon, have any wavelength, hence any energy, all the while retaining the same W-mass. This behaviour has nothing in common with classical mass. Indeed, the neutrino breaks just about every rule the old paradigm has. It doesn't obey special relativity; it doesn't obey $E^2 = p^2c^2 + m^2c^4$; it has electromagnetic mass that isn't linked with electromagnetic charge; it is a massive wave that can travel at the speed of light. Essentially, the old paradigm can't cope with it. But Unity theory can, at least in principle.

The structure of the second-generation muon neutrino follows immediately. The muon neutrino is, of course, produced with the muon, which, as we now know, has fleet variation in baryonic inner space X. Hence, so does the muon neutrino. Paired with the muon $\mu^- : \hat{W} \,\big|\, Xy$, we therefore have $\nu_\mu : \hat{x} \,\big|\, Xy$. The muon neutrino has non-resonant baryonic mass, in a polarisation orthogonal to that of the electron neutrino. These fleet variations are orthogonal but not topologically distinct; hence, the electron and muon neutrinos form two vectors in a neutrino mass basis, and must, according to

Continuity, morph into each other in oscillation. Again, the most obvious value for the mass of the muon neutrino is the energy of the muon, at 106 MeV, but it is important to recognise that this energy has, in the end, little in common with either the classical word "mass", or even the quantum-mechanical mass operator defined earlier in this book. Things just aren't that simple.

In the new paradigm, there is *no* term of classical physics that has unambiguous meaning across all domains of application. Seemingly robust terms like "mass" and "momentum" fail when the dimensions over which they are defined expand and contract locally. Even the primary concept "energy" is not immune. Rates of change with respect to time can only ever be measured by rates of change with respect to space. And the presence of energy involves a nonlinear alteration of the very dimensional structure against which that energy is measured. So, contrary to the old dream of the classical rationalist, all absolutes are imperceptible.

Having established the structure of the electron and muon neutrinos, we are now in a position to address a key question of particle physics: What is a generation? The answer is clear. The generations of the Standard Model represent *degrees of freedom*. A neutrino is a fermionic exchange wave travelling in x, with polarisation in the inner dimensions. Its wavevector offers no flexibility, but its polarisation does. A neutrino can have fleet variation in any of the dimensions of the inner group $U_X = S^1 \times S^3$. The W degree of freedom is represented mathematically by the electron neutrino, and the X degree of freedom is represented by the muon neutrino. The first-generation neutrino is the least massive, as its wavefront variation is spread out over the (comparatively) large W dimension.



Note that, in the above diagram, the departures from travel in $\hat{x}$ have been greatly exaggerated. In fact, these departures are so slight, as required by non-resonance, that neutrino speed is practically c. This is in agreement with the empirical fact that cosmic neutrinos arrive with their photons.

In the *weak eigenstate* in which an electron neutrino is created, there is variation in W. This is a departure from plane wave nature. As the wave moves, this departure from W symmetry must generate W-momentum. This is the closest thing a neutrino gets to classical mass. Its wavevector picks up a small component in W, small enough that no longitudinal resonance is generated. Having picked up a mass, the wave travels as a mass eigenstate; the neutrino, in travelling, has a form of *transverse* resonance. We may visualise it as a fermionic wave "rattling around" the inner dimensions, like a bullet fired down a pipeline in zero gravity. The particular values of the mass basis are dictated by the fact that the "pipeline" is not, in fact, circular, but has the transverse structure of the inner group, complete with a scale factor α between the fermionic S^1 and baryonic S^3 components. So, the "rattling" is, in fact, around a "pipeline" with a somewhat complicated cross-section. The principle, however, is the same.

We now have a clear conception of the nature of the neutrino, and of the first two leptonic generations. What of the third? What is a tau neutrino? Well, to answer this, we ask: What degrees of freedom remain? The electron and muon neutrinos have polarisations $\nu_e : \hat{x} \,\big|\, Wy$ and $\nu_\mu : \hat{x} \,\big|\, Xy$. Given the symmetry of the inner space dimensions, these two span the inner group; there is, after all, no observable difference between $\hat{x} \,\big|\, Xy$ and $\hat{x} \,\big|\, Yy$. But another possibility remains, viz. fleet-wave polarisation in *two* symmetrical inner dimensions: $\nu_\tau : \hat{x} \,\big|\, XY$. The basis $\{\nu_e, \nu_\mu, \nu_\tau\}$ is linearly independent, and spans all first-order fermionic exchanges in the inner group. Combinations of these three allow for fermionic exchange between any of (W, X, Y, Z) and (x, y, z). Hence, $\{\nu_e, \nu_\mu, \nu_\tau\}$ forms the full neutrino mass basis.

Theorem. *Leptonic generations.* In a universe with $3 + 1$ inner dimensions, there are necessarily 3 generations of leptons.

The above applies to leptons generally, not only to neutrinos, because whatever leptonic wave may travel in $\hat{x}$ as fermionic radiation may also travel in $\hat{W}$ as fermionic matter. Hence, the neutrino basis $\{\nu_e, \nu_\mu, \nu_\tau\}$ corresponds to a basis $\{e, \mu, \tau\}$ for massive leptons. In the case of the first-generation (e, ν_e) doublet, the polarisation of the neutrino is in W, hence the two elements of the doublet have rotated polarisations. In the other two doublets (μ, ν_μ) and (τ, ν_τ), the polarisations are orthogonal to both $\hat{W}$ and $\hat{x}$, so no such rotation is required: only the wavevector changes. We can summarise the leptonic configurations as follows:

	Electron	Muon	Tau
Massive Leptons	$e^- : \hat{W} \,\big|\, xy$	$\mu^- : \hat{W} \,\big|\, Xy$	$\tau^- : \hat{W} \,\big|\, XY$
Neutrinos	$\nu_e : \hat{x} \,\big|\, Wy$	$\nu_\mu^- : \hat{x} \,\big|\, Xy$	$\nu_\tau^- : \hat{x} \,\big|\, XY$

The massive tau lepton is the last piece in the puzzle. Direct visualisation of the wave structure gets harder here. However, a broad picture may be hypothesised, with due caution as to the details. The second-generation muon, as we now know, is an electron with variation across a single baryonic inner dimension. Hence, the muon is the leptonic equivalent of a *pion* $\pi^0 = u\bar{u}$, with a closely related theoretical mass given by $m_\mu = \cos\theta_p m_\pi$; the muon is, essentially, a leptonic electron superposed with a longitudinal quark pair. Now, extend this analysis from a single inner dimension into all three inner dimensions. In the baryonic inner dimensions, this takes us from a pion resonance to a *proton* resonance. The tau particle, we must therefore presume, consists of a leptonic electron superposed with a longitudinal proton pair. The muon is the leptonic pion; the tau is the leptonic (doubled) proton. Following our prior logic regarding the muon, this dictates a mass for the tau somewhere between $\cos\theta_p \times 2 \times m_{\text{obs}}$ and $\cos\theta_p \times 2 \times m_{\text{the}}$, which gives an energy of $1625 - 1940$ MeV. The observed mass $m_\tau = 1777$ MeV/c^2 lies in the middle of this region [22].

8.2 Hadrons

We now have a broad understanding of the nature of the generations of the Standard Model. They represent degrees of freedom. However, having established a guideline with the lepton generations, we cannot conclude that the hadron generations are exactly equivalent. After all, while there seem to be three generations of each, there is no reason why those three should match up exactly. And, indeed, they don't. There is no symmetry, in this regard, between the hadrons and the leptons. The usual conception of the Standard Model, in which the lepton and hadron generations are seen as equivalent, is erroneous; it represents a hoped-for symmetry, not a real one. As discussed above, the second- and third-generation leptons correspond to the pion and proton resonances, both of which are first-generation hadrons.

Nevertheless, the overall idea regarding degrees of freedom does generalise. It is our guide in what follows. We begin with a quick recap. It is clear, in the new paradigm, that the up/down quark model is a fiction; the mathematical difference between the up and down quarks, which is that of electromagnetic charge, lies, as we have seen, not in the quarks themselves, but in the beta boson. In other words, the quarks themselves, insofar as they exist at all, can be considered as independent of electromagnetic charge. In light of this fact, we have redefined the up and down quarks in terms of unity quarks and beta bosons, where the unity quark may be thought of as *the* first-generation quark, and the beta boson as the carrier of negative charge in nucleons. The mathematical definition of the unity quark u and the beta boson β_X is given, in terms of the old `u` and `d` quarks, as follows:

$$u = \tfrac{2}{3}\mathtt{u} + \tfrac{1}{3}\mathtt{d}$$
$$\beta_X = \mathtt{d} - \mathtt{u}.$$

In this way, the proton and neutron can be represented as

$$p = \mathtt{uud} = 3u$$
$$n = \mathtt{udd} = 3u + \beta_X.$$

From the above, it is clear that neutron decay $3u + \beta_X \to 3u$ has nothing to do with quarks. It is the emission of a beta boson, which decays to a fast-moving electron and associated neutrino. However, the decays of *higher-generational* quarks, for example those weak transitions which violate conservation of strangeness, are not simply decays of beta bosons; they must be considered as changes in the quarks themselves.

> In what follows, we should remind ourselves that the quark is not a particle in the sense that a proton or an electron is one: there is no specific wave configuration to which the word "quark" refers. Rather, the word "quark" describes resonant energy in a single dimension of inner space. This warrants repetition, because old conceptions, even obviously erroneous ones, die hard. No one would claim that the spatial components of momentum (p_x, p_y, p_z) represent distinct particles; yet this is analogous to the twentieth century view of the quark.

Unsurprisingly, the quark concept is most powerful on its home turf, which is the second generation of the hadrons, particularly in the form of the quantum number *strangeness*. It was the advent of strange particles that prompted the whole endeavour, leading to the attempt, post hoc, to apply the quark model (square peg) to the domain of first-generation nucleonic matter (round hole). The concept of strangeness, however, predates the quark model, and, as a piece of experimental phenomenology, suffers from no such ill effects. So, we won't ask "What is the physical nature of a strange quark?", as there is no precisely defined entity "quark" to carry the epithet "strange". Rather, we ask a well-defined question: "What is the physical meaning of strangeness?"[2]

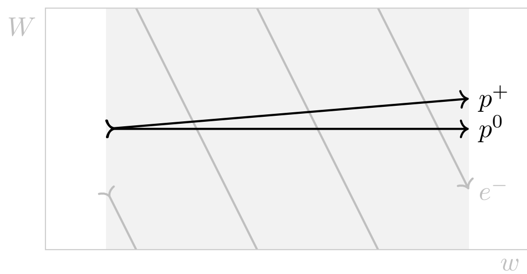
Consider the degrees of freedom available. In the first generation of hadrons, the proton already uses all three dimensions of inner space. So, what remains? The w and W dimensions. Now, it is safe to assume that using the former, i.e. departing from coprogression, requires much higher energies than the latter. But strangeness requires only slightly elevated energies: the strange Λ^0 baryon has a mass only 19% greater than the proton. Hence, there is really only one possibility: we must assume that the quantum number *strangeness* corresponds to the W degree of freedom.

How could a proton make use of this degree of freedom? Well, in the old paradigm, a proton has fixed charge $+e$. But, in the new paradigm, protons have that positive charge by dint of their classical momentum in W, which is only quantised in *observation*. All observation is observation by electrons, and electrons are charge-quantised by their resonance in W. According to Unity theory, the charge of a proton is not fixed. However, the same logic applies, of course, to the strange particles themselves, which means that any hadronic resonance utilising the W degree of freedom must, in order to be observable, have unit charge.[3]

[2]Suppose we were to ask the question "What colour is a teal-coloured unicorn?" The question is ill-defined, since unicorns don't exist. Nevertheless, because the descriptor "teal-coloured" has a meaning, the question still has an answer of sorts. But that answer only exists insofar as it is the answer to a different, well-defined question: "What colour is teal?"

[3]Multiples of unit charge are also possible, as in the Δ^{++} baryon, but such configurations aren't relevant here. We are looking for the *lowest-energy* resonances that use the W degree of freedom.

Let us perform a thought experiment, in which we construct two such particles. We begin with a particle that, while it certainly exists physically, does not enter the annals of experimental physics by this name: the *neutral proton.* A p^0 consists of four orthogonal four-helical waves, symmetrically resonating in the inner space dimensions: it is a standard proton in every sense except for its classical momentum in W, which is zero. In the diagram below, the W-speed of the p^+ has been greatly exaggerated: the angle between the (w, W) wavevectors of the p^+ and p^0 is, in fact, $\theta \approx 0.05°$, as defined by $m_p \tan\theta = m_e \tan\theta_p$.



Now, suppose we (hypothetically) disintegrate this neutral proton into two sets of two four-helices, stylising a process that must occur regularly, in some fashion, in particle colliders. Each of these two half-protons must then form a meson, i.e. a particle resonating in a single inner space dimension, since isolated colour charges must, by energetic favourability, anti-align to produce no net colour charge, viz. zero momentum in inner space. So, our neutral proton has split apart, let us assume symmetrically, into two mesons, each of which contains half of the proton's energy.

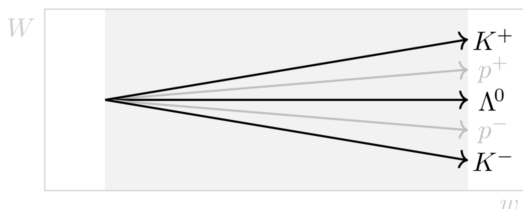
In the most obvious disintegration of this type, both half-protons have zero charge. This is eminently possible, but the particles so produced cannot be measured in spark chambers or suchlike, because they have no charge. Likewise, if the charges are ± 0.2 or ± 1.7. Such partially-charged particles cannot interact with charge-quantised electrons. But another possibility remains. What if each *half*-proton picks up *integer* charge, by dint of a speed in W *double* that of the proton?

Such particles have low mass and unit charge, which means, whatever their actual mode of production, they should show up in colliders. We must assume, therefore, that they are already well known to particle physics. What properties do these half-protons have? Firstly, as standing waves in a single dimension, they are spinless mesons like the pion. Secondly, they are higher-generational, because they use the W degree of freedom. Thirdly, as the lowest-energy such resonances, they are strange. Fourthly, they have a mass around half that of the proton.

With this last fact, we can test the whole idea. Since half-protons are, like all mesons, unstable, they must have a smaller mass defect than the proton's. This gives us a firm range in which the masses of such particles must lie. Halving our theoretical and observed values for the proton mass, these observable unit-charged half-protons must appear somewhere in the range $469 - 560$ MeV, and a good distance from either end of the spectrum. And, hey presto, the lightest strange mesons, the charged *kaons*, come in at 494 MeV [14], exactly in line with theory. Therefore, we can state the following conjecture with a high degree of confidence.

Conjecture. *Strangeness.* The quantum number strangeness describes protonic matter waves resonating in inner space, whose speed in the leptonic W dimension is an integer multiple of that of the proton.

What is the structure, then, of a strange *baryon*, say, the neutral Λ^0? How does one construct a baryon with strangeness? Easily, it turns out. We have already done it. The neutral proton discussed above is exactly such a particle: it is a proton using the W degree of freedom. It is "going in a strange direction", as well a proton might do after a high-energy collision.[4] And when would such a neutral particle be observable in spark chambers? Only if it subsequently decays into two charged particles. In the minimal example, one of those is a proton and the other a negative pion. Hence, to be observable, the lightest such particle would require an energy somewhere above $938 + 140 = 1078$ MeV. The lambda baryon, at $m_\Lambda = 1116$ MeV [14], is the obvious candidate.



Why is strangeness conserved in strong interactions, but not in weak ones? In Unity theory, the answer is straightforward. In the (w, W) plane, a proton progresses in $\hat{w}_{\text{pro}}$, where

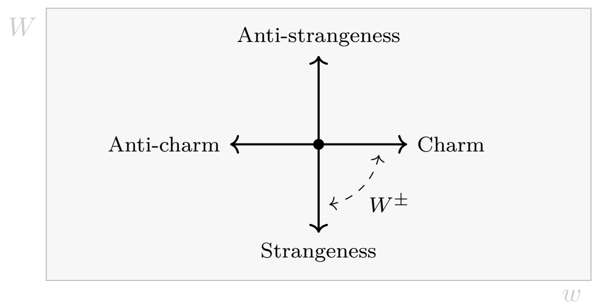
$$\hat{w}_{\text{pro}} = \tfrac{1835}{1836}\hat{w} + \tfrac{1}{1836}\hat{W}.$$

This direction defines a very slightly rotated, by only $\theta \approx 0.05°$, set of coordinate axes $(w_{\text{pro}}, W_{\text{pro}})$. The quantum number strangeness is then defined in a manner very similar to electromagnetic charge: in protonic waves, it is momentum in W_{pro}, which is conserved in creation by the law of conservation of momentum. In decay, however, while the same law applies globally, momentum in the direction of W_{pro} (which is virtually identical to charge) can be carried away by the emission or absorption of β_X particles and leptons. This allows for seeming violation. In fact, violation only occurs by convention in the nomenclature: strangeness is simply an *unusual* value of W-momentum. There is no reason why an ancillary concept such as "unusuality" should survive redistribution of momentum, as in $\Lambda^0 \to p^+ + \pi^-$. Indeed, a swift (by human standards) decay of strangeness is an obvious prediction of Unity theory.

[4]A neutral proton is like a pool ball, hit hard, that has, in subsequent collisions, leapt temporarily from the surface of the table. The leptonic W dimension is the unusual "into the air" dimension. Such behaviour can only occur at high energies: in cosmic rays or particle accelerators.

We can now turn to *charm*. Consider once again the degrees of freedom available to baryonic matter: the two axes of the (w, W) plane. The dimension of progress w is orthogonal to strangeness, and can be used, by a particle such as a proton, in a manner analogous to the "strange" speeds in W. The analogy is with the (hypothetical) transition between a positively charged proton p^+ and a positively charged kaon K^+. In such a transition, the mass of the proton is halved, while its speed in W is doubled. Overall, the charge is unaffected.

The same possibility exists in w. In a proton, there is the possibility of changing mass and progress speed by reciprocal factors, while maintaining invariant progress momentum. Such an excited particle is a pool ball that has taken to the air in w, in over or underprogression. Nevertheless, such a particle is observable, as its progress *momentum* is the same as that of a coprogressing proton. Hence, when it decays, it will produce daughter particles whose tracks are visible in spark chambers.



Speeds relative to ●1st gen

Charm is, in this view, just another unusual form of momentum, and, as such, its conservation needs no explanation.[5] Its violation in weak decays is equally natural, as the weak interaction may, as already discussed, rotate w-momentum into W-momentum. In e.g. neutron decay, a weak boson rotates a fermionic (ν_e, e^-) doublet in (x, W) space. But all substance is the same. Hence, a transfer of momentum in the (x, W) plane is identical to a transfer of momentum in the (w, W) plane. The latter, given our proposed meanings for strangeness and charm, is a rotation of a fermionic (s, c) quark doublet.

The second-generational (w, W) plane depicted above is the natural milieu of the quark model. While the first-gen up/down quark model is, to a large degree, fiction, the second-gen strange/charm quark model is not. While strange quarks and charm quarks are not in any way fundamental physical entities—the second-generational (s, c) resonances have different frequencies in mesonic and baryonic contexts—nevertheless,

[5]Strangeness and charm, and the reason for their partial conservation, can be seen clearly by analogy with the classical non-law of *conservation of speed*. From a symmetrical zero-momentum starting point, one cannot generate asymmetry; hence, any speed generated rightwards must match any speed generated leftwards. Speed is conserved in creation. But, from an asymmetrical starting point, one can reestablish symmetry by violating the conservation of speed, for instance in the perfectly inelastic collision, at zero net momentum, between two objects with different masses. In the classical model, both are brought to rest, and conservation of speed is violated.

when we speak of, say, a "charm quark decaying into a strange quark", we are describing a genuine physical process. We are referring to the transfer of charmed w-momentum, that is to say, quantised w-momentum with unusual speed, into strange W-momentum, that is to say, quantised W-momentum with unusual speed.

And so to the third generation. Beyond the Standard Model, it is clear that the generations of the hadrons, despite a mutual origin in degrees of freedom, are very different from the generations of the leptons. This, combined with the failures of the up/down model, should make us very suspicious of the third generation of "quarks". Certainly, something exists in the third generation; *what* it is remains to be seen. As ever, we should remind ourselves that, just because we use the expression "top quark" doesn't mean that the observed resonance at around 173 GeV is a configuration akin to those named strange and charm. Indeed, as we shall see, the top quark has almost certainly been significantly miscategorised. "Quarks", as far as such things exist, are single dimensions of inner space and the resonant energies contained therein. The top resonance, as we will denote it in Unity theory, is nothing of the kind.

What is the third generation of hadrons, then? Well, having used up the (w, W) plane in the second generation, we seem to have run out of dimensional degrees of freedom. But we are now at very high energies indeed, where new possibilities appear. As we know from our discussions of the weak bosons, there are *second-order* resonances above the linear ones, and, we may suppose, higher-order ones above those. The third-gen hadrons, we hypothesise, involve second-order resonances: planar expansions and contractions of substance as opposed to the linear ones in the lower generations. This is the physical meaning of the phrase, oft-used in particle physics: "the top quark interacts strongly with the Higgs field". In Unity theory, the Higgs field is a name for second-order expansions of substance.

Conjecture. *Third-generation hadrons.* The third generation of hadrons is formed of quadratic expansions/contractions of substance.

We have proposed that second-order waves, resonating in the baryonic inner dimensions, partake of the second-order mass unit $137^2 \times m_e = 9.6\ \text{GeV}/c^2$. We cannot fail to notice that the upsilon meson Υ, which, in the Standard Model, is formed of a bottom quark and its antiparticle, weighs in at 9.5 GeV/c^2 [24]. Now, there is considerable scope for theoretic variation here, particularly concerning assignment of factors of two. We might expect that, by analogy with the pion, the lightest particle containing a second-order resonance should come in at $2 \times 137^2 \times m_e = 19.2\ \text{GeV}/c^2$. However, the upsilon has a lifetime of only 1.2×10^{-20} seconds; it isn't anything like as stable as the pion. So, there is every chance that it is a *single* second-order quark, rather than a standing wave. It's difficult to tell. We are best off simply noting that there is a resonance at almost exactly the expected value 9.6 GeV, and that said resonance represents the lightest particle of the third generation of hadrons. This corroborates our conjecture that the third-generation quarks are, in fact, second-order fermions.

This conjecture is further borne out with reference to the *top resonance*, at around 173 GeV [14]. It has long been a mystery why this so-called "quark" should have turned out to be such a behemoth. The standard explanation is: "It derives its mass from its coupling to the Higgs Boson", but that is no explanation at all; it is a rephrasing of the question. In Unity theory, however, we can answer simply. We *must* do, indeed; that's the beauty of the thing. Why does the top resonance have a mass that isn't quark-like? Obviously, because the top resonance isn't a quark.

The top resonance has little in common with the unity, strange and charm quarks. It doesn't form baryons or mesons. It doesn't have a well-defined charge. It isn't confined. It is far heavier than the other quarks, and has a far shorter lifetime. In fact, according to this latter fact, it doesn't even warrant the status of "particle". What has this resonance done, then, to deserve the name "quark"? Nothing, other than the need to fill a (fallacious) gap. So, let us consider the top resonance afresh, without the need to twist its nature to maintain a tenuous symmetry in the Standard Model.

According to Unity theory, the weak resonance at 77 GeV is available to all particles resonating in the inner space dimensions. Murphy's law applies; at energies greater than the weak boson mass, we *must* see second-order resonance. At that stage, the *rgb* quark model, whose axes refer to single dimensions of inner space, has broken down grievously. When all expansions and contractions of substance are second-order, involving, at minimum, planar trades, it becomes something of a nonsense to speak of quarks at all, even to deny their existence. So, let us forget these mathematical unicorns, and think about the physical logic of the thing.

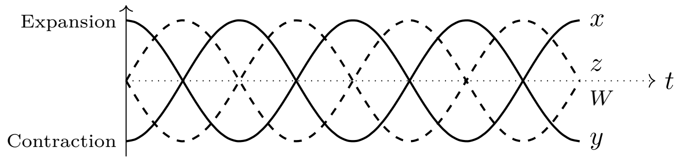
Top resonances are produced by smashing high-energy protons (and antiprotons[6]) together. So, what is the most obvious explanation for the physical nature of a top resonance? Well, there is no reason to believe that the resonance takes place in a single dimension of inner space, which is the defining feature, as far as there is one, of a quark. To engineer a resonance in a solitary dimension from a proton collision would be like smashing two tornadoes together and expecting an ordered easterly wind. In high-energy collisions, things go everywhere; particles leap *out* of their prior dimensions.

Given that the energies involved are high enough to generate second-order resonances (excitations of the Higgs field), and given that the raw materials are protons, by far the simplest explanation is that the top resonance is a second-order excitation of the proton itself, that is to say, a proton jolted from stable, first-order, linear exchanges into second-order, quadratic ones. The many baryons below this second-order threshold, for example the lambda baryons, are first-order excitations of the proton, in which one or more waves takes advantage of the (w, W) degrees of freedom. But, smash them together hard enough, and quadratic resonances *must* ensue.

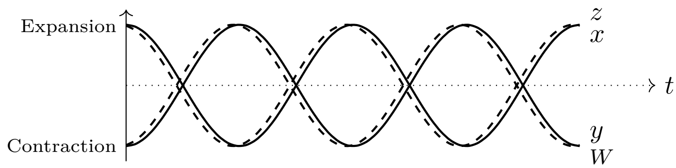
Conjecture. *The top resonance.* The 173 GeV top is a second-order proton. Its maximal coupling with the Higgs field $y_t \approx 1$ is an expression of precisely this fact.

[6]There is very little that is "anti" about an antiproton. While it does have negative charge, a proton and an antiproton are, in fact, exactly as similar and exactly as different as a pair of protons travelling in opposite directions in space. Since a proton is already a particle within the W dimension, electromagnetic charge, for a proton, is a *classical* W-momentum. While an electron and a positron are topologically distinct, a proton and an antiproton are not. Give a proton the right kind of nudge, and it *becomes* an antiproton.

Let us see how this works. Proton waves, as we know, consist of four-helices: out-of-phase fermionic waves which, in combination, exchange linear expansion/contraction between four single dimensions. A quarkish proton wave, travelling in $\hat{X}' = \cos\theta_p \hat{X} + \sin\theta_p \hat{w}$, has four dimensions of polarisation. These produce no second-order expansion, as the two two-helices rotate out of phase. As depicted previously:



But what happens if you smash protons together hard enough? Well, if it is energetically possible, those corkscrews are bound to jump *into* phase, at least now and again, creating second-order expansions (interacting with the Higgs field) such as those that make up the weak bosons:



Now, there are all sorts of resonances possible, between the many constituent parts of a proton. At this level of instability, however, the only resonances that register in colliders are those that show up again and again. And, among the continuum of possibilities, in a high-energy environment it is only the maximal resonances that are stationary. The most obvious of these is the second-order proton, in which all four of the proton's constituent waves are jolted to produce in-phase, second-order expansions, rather than their usual out-of-phase, first-order expansions. What is the theoretical mass of such a particle? Well, our theoretical value for the first-order proton mass is given by

$$m_p = 16 \times \frac{m_e}{\alpha} = 1120 \text{ MeV}/c^2,$$

which exceeds the observed value by some 16%, due to the (positive) mass defect. However, while the proton is, so far as we know, infinitely stable, the second-order proton is at the very other end of the spectrum. It is absurdly unstable, lasting for all of 10^{-25} seconds. This points to a significant *negative* mass defect, corresponding, it is likely, to third- and fourth-order effects. A simple theoretical value for the second-order proton mass is given by

$$m_t = 16 \times \frac{m_e}{\alpha^2} = 154 \text{ GeV}/c^2.$$

With a mass defect of some −11%, the top resonance appears where expected.[7]

[7] The above suggests that we should rethink the law of conservation of baryon number. Why do all baryons decay back into protons? Simple. Because all baryons *are* protons.

9 Unity and Gravity

We have now established, beyond reasonable doubt, the validity of the paradigm built on the axiom of Unity. While this doesn't, of course, imply that the axiom of Unity itself is necessarily true—the principle of relativity is a pertinent warning in that regard—it does make it very likely indeed. So, we can now turn to the *implications* of the theory, above and beyond the small scales of quantum physics. This is the domain in which Unity departs from old views not only in underlying principle, as has been the case throughout, but in phenomenology. The view of the past, present and future of the observable cosmos that emerges from Unity theory is markedly different from the one espoused by the old paradigm.

This can be seen in the very simplest of terms. According to Continuity, there can have been no Big Bang singularity. We can be confident, therefore, with Unity well established, that there *was* no Big Bang singularity. This is, in fact, a statement that requires no justification; it is self-evidently true. The idea that the universe began at a single point is essentially a nonsensical one; such an emergence from singularity breaks every law of logic, mathematics and physics we have.[1]

In this section, we begin our approach towards the question of the origin and fate of the universe. But we must exercise caution as we do so. Cosmology, the study of the cosmos, and cosmogony, the study of its beginnings, are very different from quantum theory. Quantum physics deals with quantum objects that cannot be seen, yet whose behaviour is governed by a wealth of well-verified equations; cosmology, on the other hand, deals with astrophysical objects that can be seen easily with the naked eye, yet whose behaviour is governed by a small number of poorly verified equations. Now, it may seem like heresy to observe that general relativity, the jewel in the crown of cosmology, is poorly verified. But the facts don't lie. General relativity is an extraordinary theory, and a powerful one, but it is experimentally validated in only a very narrow domain. It is well verified within that domain, yes—we can be confident that GR, or something very similar to it, governs gravitational behaviour in stellar systems—but entirely unverified outside it. Indeed, we not only lack experimental corroboration of general relativity on galactic length scales and cosmogonic time scales, we have *direct evidence of its falsehood.* The need to invoke and subsequently fine-tune dark matter and dark energy is direct evidence that general relativity is limited in applicability to a domain no broader than its current empirical validation.

It is only a small exaggeration to say that modern cosmology *is* general relativity. The Einstein field equations, and their prior Newtonian limit, are the cosmological tool *par excellence* [25]. Now, it wasn't somehow foolish to apply general relativity in domains—the distant past, say—in which, as we will see, it turns out not to be valid.

[1]It is tempting to rule out alternatives to well-established theories such as the Big Bang automatically. But it is a logical fallacy, all too often made, to imagine that disagreement with theory B, which rests on evidence A, constitutes disagreement with evidence A. It doesn't. Two contradictory theories B and C can explain the same facts A equally well. In this regard, the Big Bang theory is akin to the Ptolemaic theory of epicycles. Both enjoyed a heyday of empirical validation, yet both are incorrect.

After all, in the twentieth century, we had no other choice; there wasn't any other set of equations, nor any viable notion of how an alternative cosmology might work. We worked with what we had. What *would* be foolish, however, would be to hold to general relativity now, in domains in which it has no empirical validation, simply because it was, historically, the only tool with which to address the origin and fate of the universe. Such deference to Einstein's authority would go against his own warnings.

To apply a scientific theory correctly, it is of paramount importance to *establish the domain of validity.*[2] Classical mechanics is not the truth, yet it is useful, so long as we restrict it to classical objects; quantum mechanics is not the truth, yet it is useful, so long as we restrict it to electron-like particles; quantum field theory is not the truth, yet it is useful, so long as we restrict it to flat space in the wave of the present; general relativity is not the truth, yet it is useful, so long as we restrict it to...

And there's the rub. In the old paradigm, we do not have a domain of validity for general relativity. Yes, GR is ruled out on the quantum scale—that much is obvious, as it has no way of describing things like charge or colour charge—but, at the other end of things, we have no indication of whether and/or when GR breaks down. Almost everywhere in the cosmological literature, it has been assumed that it doesn't. Implicitly, general relativity has been taken to *be* the mathematics of the cosmos, with no qualifications or caveats above the quantum scale. This has led to erroneous conclusions, confusion, and much "science" that is really pseudoscience.[3]

To clear up the mess, we need to *derive* general relativity. It is, of course, no fault of Einstein's that he didn't do so in a rigorous sense. It was a Herculean task to produce the equations in the first place, given the extraordinarily radical thinking required. But, as so often happens when a genius such as Einstein blazes a trail, we have been lazy since. Since Hilbert's derivation from an action principle over a century ago, very little progress has been made on the *foundations* of GR. Mostly, the field equations have simply been assumed. Ambitious folk have wanted to "be scientists", so they have wielded general relativity without understanding it. Prizes have been won and reputations forged. Einstein is not to blame for this; lesser men are.

We must do better. It is only in a rigorous derivation that the domain of validity of a theory can emerge. Sometimes that domain is evident in the equations themselves—for instance, there is no mention of weak decay in the field equations—but only the most obvious boundaries appear in such a way. It is the subtle assumptions that get forgotten. Most pertinently, it is the implicit assumptions of the *Weltanschauung*—space as the backdrop to reality—that, in the absence of a valid derivation, seep into the theory unnoticed. Einstein was a genius, and it would be the greatest insult to his memory *not* to give his theory a rigorous foundation, so to establish its limits.

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[2] To claim that GR has a limited domain is no criticism of either the theory or its founder. Einstein, who valued honest thinking, would never have defended his theory beyond its domain of validation.

[3] We must be firm about the status of theories such as dark matter, dark energy, the cosmological constant and inflation. These are not scientific theories; they are essentially grand works of fiction. Again, it wasn't foolish to write or read them, just as neither was Tolkien nor are his readers fools. But fiction isn't science: engineers don't consult the runes of dwarfs, nor do biologists study elf immortality.

9.1 Energy and Attraction

It is well known that Hilbert, in the months following Einstein's publication of general relativity, derived the field equations from an action principle [26]. This was immediately welcomed by Einstein and others as a significant step forward. It wasn't obvious, however, and hasn't been ever since, *why* it was so. The Hilbert action is as simple as it could be, which is always an encouraging sign, but nevertheless, while it allows for a rigorous algebraic derivation of the field equations, it itself has stood underived. Hence, the Hilbert action has often appeared as something of a mathematical addendum to courses on relativity, rather than as its foundation.

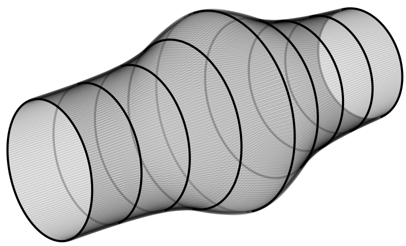
In Unity theory, the situation becomes clear: the Hilbert action is, as long suspected, fundamental. Our task, in this section, is to derive it from first principles, keeping a keen eye open for any assumptions made along the way. Since the Einstein field equations follow algebraically from the action principle, any assumptions implicit in the Einstein theory must have already appeared by the time we write down the action. Thus, understanding the limitations of GR is exactly the task of understanding the physical origin of the Hilbert Lagrangian. We now proceed with this task. We begin our approach to this quantitative problem by asking the big qualitative question, which the twentieth century failed to answer: *Why do masses attract?*

The answer, in Unity theory, is reassuringly simple. Mass, as we know, is energy resonating in the inner dimensions. The smaller the circumference of the inner dimension, the greater the energy required for resonance. This is why baryonic masses are larger than leptonic masses: the S^3 component of the inner group is currently 137 times smaller than the S^1 component. But the universe is flexible. While we may *approximate* the inner dimensions as a fixed backdrop for the purposes of this or that quantum theory, we know, if we are thinking with the appropriate perspective, that they are no such thing. Indeed, the "running" of the fine-structure constant in QFT is direct evidence of this. In reality, nothing is set in stone.

Hence, the size of the inner dimensions of substance must vary, at least to some small degree, at different locations in space. And a location at which the inner dimensions are larger is energetically favourable for a particle that encounters it: the larger the closed circle around which a particle resonates, the lower the frequency and energy. So, a particle will seek out locations at which the inner dimensions, either generally or component-wise, are larger than elsewhere. Now, component-wise effects, that is to say, exchange within the inner dimensions, will cancel overall, as protons and electrons are seeking opposing goals, but an expansion of either or both components of the inner dimensions *at the expense of space* can only be energetically favourable. The contraction of space costs a resonating particle nothing.

Furthermore, the universe is nonlinear. According to $R_8 = 0$, *every* disturbance in substance, no matter how small, sets up a feedback loop. Thus, the particles that roam space aren't mere bystanders in gravity. Since it is energetically favourable for such particles to exist in an expanded inner dimension, each particle must actively *generate* such an expansion of the inner dimensions, albeit one of minuscule proportions.

Now, it is clearly a hard task (putting ourselves in a proton's shoes) to enact such a contraction of space, as opposed to, say, a local trade between inner S^1 and S^3. To generate a spatial contraction means dragging the whole of the cosmos inwards! Tough, yes. But that only limits the *magnitude* of the effect, not its presence. And, since enlarged inner dimensions is energetically favourable for *all* matter, *all* matter contributes. Every atom expands the inner group, at the expense of the outer.



This tiny, nonlinear expansion of the inner dimensions at the expense of the outer dimensions, negligible for quantum considerations, manifests as *gravity*. It becomes energetically favourable for neighbouring atoms to approach each other, as the inner dimensions are larger in the vicinity of mass. And that's that. Note that we have needed no Riemannian sledgehammer here. The question "Why do masses attract?" is a simple nut, and Unity is able to crack it easily.

A gravitational potential well is a localised enlargement of the inner dimensions.

What is the *symmetry* of gravity, then? It is that between the repeated factor of the Unity group: the fundamental symmetry of an eight-dimensional universe. Whatever the details, there are undoubtedly solutions of the substance equation in which the inner component U_X expands locally at the expense of the outer component U_x. These are *fourth-order* expansions of substance: hypervolumes expanding against hypervolumes. Their energies, were we to attempt to produce them as locally observable excitations, would likely partake of the fourth-order mass unit:

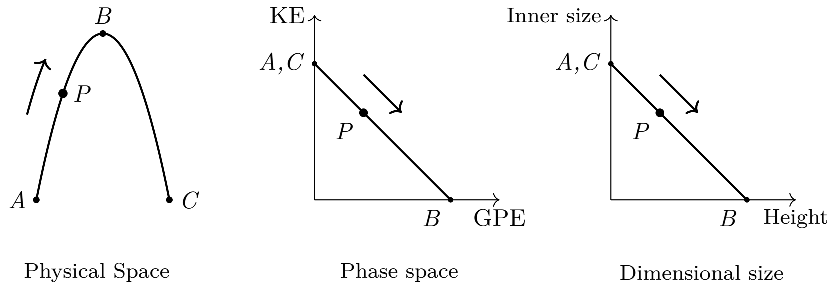
$$\frac{m_e}{\alpha^4} = 180 \text{ TeV}/c^2.$$

Given the monumental energies involved, it is no surprise that we haven't seen such configurations in colliders. The top resonance is only *second*-order; these gravitational resonances would be at least a thousand times more energetic.[4] On a cosmological scale, however, the local energies involved make little difference. Unlike the other interactions, which twist and trade within the inner group, gravity is *cumulative*, and every atom in a planet, star or galaxy contributes to an extremely broad, extremely gentle expansion of the inner dimensions. This is why things fall towards the Earth.

[4]It is likely, in fact, that there are no fourth-order gravitational *resonances*. There will certainly be observable third-order resonances, however, such as $G_3^0 : \hat{W} \,\big|\, S^3S^3$, somewhere upwards of 1.3 TeV.

9.2 The Gravitational Lagrangian

Throw a ball up in the air, and the protons and electrons that make it up are forced, as they depart from the Earth, into a region of space with slightly tighter inner dimensions. The resonances that make up the mass of the ball duly gain in energy. The frequencies increase. We describe this increase in energy ΔE_{inner} as gravitational potential energy above and beyond invariant rest mass. As the ball descends, then, it experiences an expansion of the inner dimensions, and GPE is converted back from inner-dimensional potential to outer-dimensional kinetic energy. This process takes place according to the *action principle*, so as to maintain material coherence in the waves that make up the ball.



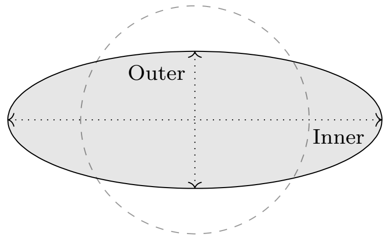
The ball toss depicted above is well understood in Newtonian terms. Unity theory's only addition, at this stage, is the graph on the right, showing the physical reason for the existence of the gravitational well. That gives us a firm qualitative understanding of what is going on: we know why masses attract. So, we can now proceed to the *quantitative* side of things, general relativity and beyond. We know what gravitational wells are, and what equation they must obey, the substance equation, $R_8 = 0$. The big question now is: How do particles interact with a gravitational potential? To answer this, we need the action principle. We must construct a *gravitational Lagrangian.*

> The Einstein field equations of general relativity, and their nontrivially limited domain of validity, emerge in deriving a Lagrangian $\mathcal{L}_{\text{grav}}$ from $R_8 = 0$.

Any overall expansion/contraction of the inner- and outer-dimensional components of the universe must obey $R_8 = 0$. The Ricci scalar R_8 encodes the local size of an eight-dimensional hypervolume element, in terms of the departure from flat. Now, the Ricci scalar is defined as the trace of the Ricci curvature tensor: $R = \operatorname{tr}_g \operatorname{Ric}$. So, R_8 is a scalar sum across the eight dimensions of the Unity group. We can express it, therefore, in terms of the inner- and outer-dimensional Ricci scalars, as $R_8 = R_{\text{inner}} + R_{\text{outer}}$, where R_{inner} and R_{outer} encode the local size of four-dimensional hypervolume elements. So, R_{inner} describes the local size of the inner group U_X, and R_{outer} the local size of the outer group U_x. This gives the substance equation as

$$R_{\text{inner}} + R_{\text{outer}} = 0.$$

In English, $R_{\text{inner}} + R_{\text{outer}} = 0$ reads as: "Any expansion of the inner dimensions as a whole must be traded off against a contraction of the outer dimensions as a whole." The substance equation is a gravitational Hamiltonian, expressing the constant local density of substance in the universe. In the diagram below, in which each axis represents the local size of four dimensions of substance, $R_{\text{inner}} + R_{\text{outer}} = 0$ states that the black (hyper)ellipse has the same eight-dimensional hypervolume as the flat (hyper)disc.



Gravitational fourth-order exchange

Its companion Lagrangian (density) is

$$\mathcal{L}_{\text{grav}} \propto R_{\text{outer}} - R_{\text{inner}},$$

where the choice of sign reflects the fact that high R_{outer} corresponds to small outer dimensions, hence large inner dimensions, hence low gravitational potential, hence high kinetic energy. $\mathcal{L}_{\text{grav}}$ is a measure of the imbalance between inner and outer components. This is specifically a *Lagrangian*, because such an imbalance dictates, in any test particle moving against the background, the transfer of complex phase between inner- and outer-dimensional wave components. Circumference is directly proportional to energy, which forces a particle to choose the specific trajectories of free fall.[5]

Note that $\mathcal{L}_{\text{grav}}$ does not itself determine the shape of gravitational potentials. For example, assuming $R_{\text{inner}} = R_{\text{outer}} = 0$, we can still produce either a flat vacuum or gravitational waves. Both are vacuum solutions. $\mathcal{L}_{\text{grav}}$ doesn't encode the *shape* of the potential, only the *effect* of that shape on matter.

Now, to derive general relativity, we must make two approximating assumptions, both of which have major significance to cosmology. These assumptions are the same as those required to produce the quantum equations of motion. We have used them throughout this work. For application in the laboratory, $R_8 = 0$, which governs the underlying substance of the universe, must be dimensionally reduced by assumption. It turns out that the first such approximation rules out GR's application to both the distant past and regions of high gravity, and the second rules out its isolated application to regions of very low gravity. Needless to say, both of these restrictions have profound implications for cosmology. They require careful analysis. We begin by stating the underlying assumptions, without which general relativity does not apply:

[5]Free fall is not, as has been suggested, merely the following of straight lines in curved space.

Assumptions of General Relativity:

1. *Small inner dimensions.* We approximate $\mathcal{L}_{\text{grav}} : U \to \mathbb{R}$ as constant across the inner dimensions.
2. *No radiative gravity.* We assume that $\mathcal{L}_{\text{grav}} : U \to \mathbb{R}$ contains no kinetic energy. Mathematically, $\mathcal{L}_{\text{grav}}$ has no time dependency.

The first assumption, of small inner dimensions, is, of course, implicit in the old paradigm, which assumes their nonexistence. It is a most crucial fact, and has hitherto been entirely overlooked in mainstream cosmology. This assumption is certainly valid at the present time and in regions of space such as the Solar System, where the gravitational potentials are small. It clearly isn't valid in regions of extremely high gravity, where the inner dimensions, by definition, get large, nor, as we will see, is it valid far into the past or the future, in which epochs the relative sizes of the inner- and outer-dimensional components of the universe differ greatly from their current values. Nevertheless, the assumption of small inner dimensions is a very reasonable one in the domains in which general relativity has been validated empirically, that is to say, in the Schwarzchild-modelled regions of space surrounding stars and planets.

Why must we assume small inner dimensions? Because, as it stands, $\mathcal{L}_{\text{grav}}$, while it encodes the size of four-dimensional hypervolume elements, is nonetheless a field defined over all *eight* dimensions of substance. As a function, the domain of $\mathcal{L}_{\text{grav}}$ is the Unity group, $\mathcal{L}_{\text{grav}} : U \to \mathbb{R}$. We require the assumption of small inner dimensions for the same reasons we require gauge symmetry in quantum mechanics. Indeed, the assumption of small inner dimensions *is precisely* the assumption of gauge symmetry across the inner group.[6] Under the assumption of small inner dimensions, we can project $\mathcal{L}_{\text{grav}}$ onto the outer dimensions. We notate this projection $\mathcal{L}_{\text{grav}} \to \mathcal{L}_{\text{g}}$. Our gravitational Lagrangian becomes the following field:

$$\mathcal{L}_{\text{g}}(w, x, y, z) = R_{\text{outer}}(w, x, y, z) - R_{\text{inner}}(w, x, y, z).$$

What of the w dimension, then? Well, given the progress of the wave of the present, space-like position along the w dimension corresponds to time t. While the expansion of the inner dimensions has an effect on the running of clocks, it doesn't slow down the progress of the wave of the present, which is orthogonal to such expansion. So, the progress of the wave of the present can, at least to a first approximation, be taken as independent of gravity. But, in order to set up a *direct* correspondence $w = bt$, we have to assume that the gravitational potentials have negligible variation in time, because, without this assumption, the gravitational fields would have changed in the spatial future, i.e. forward of progress, before the present ever got to them.

[6] Allowing for a small abuse of mathematical terminology, we can consider the assumption of small inner dimensions as equivalent to the assumption of the existence of *eigenvalues* of $\mathcal{L}_{\text{grav}}$.

We assume, therefore, that $\mathcal{L}_{\mathrm{g}}$ has no time dependence. This permits us to equate $w = bt$ and work in spacetime (t, x, y, z). Two points regarding this assumption:

- Ruling out variation in the background potentials doesn't rule out foreground variation against those potentials. Setting $\frac{\partial}{\partial t}\mathcal{L}_{\mathrm{g}} = 0$ permits the Schwarzchild metric and subsequently allows for all of the empirical validation of general relativity, such as with regard to the precession of Mercury.

- Ruling out variation in the background potentials doesn't rule out gravitational waves, which are time-variant, yes, but transmit no gravitational force. $\mathcal{L}_{\mathrm{g}}$ measures the collective expansion of (x, y, z); a fermionic gravitational wave trades x expansion for y, leaving $\mathcal{L}_{\mathrm{g}}$ unchanged.

The last ingredient is the pseudo-Riemannian negative metric. Under the assumptions of Unity theory, we are now working in (t, x, y, z) spacetime, with a $(+, +, +, +)$ metric signature. The Ricci scalar R_{outer} encodes the contraction of space, while R_{inner} encodes the corresponding expansion of the inner dimensions. This latter expansion corresponds, in turn, to a reduction in the apparent passage of time, for much the same reasons as we discussed earlier with reference to special relativity: if the inner dimensions are larger, matter waves take longer to circumnavigate them. Hence, while R_{outer} describes the contraction of space R_{xyz}, R_{inner} describes the dilation of time R_t. With an appropriate negative metric signature $(-, +, +, +)$ we can, therefore, express the reduced gravitational Lagrangian $\mathcal{L}_{\mathrm{g}} = -R_{\mathrm{inner}} + R_{\mathrm{outer}}$ as a single Ricci scalar:

$$\mathcal{L}_{\mathrm{g}} \propto R_t + R_{xyz} = R.$$

As with Minkowski space, the negative metric signature of Einsteinian spacetime allows us to encode relativistic effects—contraction of space and dilation of time—with mathematical ease. All that remains is to include the constant of proportionality, as dictated by reproduction of the Newtonian limit. This is

$$\mathcal{L}_{\mathrm{g}} = \frac{1}{2\kappa} R,$$

where κ is Einstein's gravitational constant. To produce the *action*, then, we integrate this Lagrangian density over spacetime. The relevant volume element dV is usually expressed in terms of the four spacetime coordinates as $dV = \sqrt{-g}\, d^4x$, where $\sqrt{-g}$ is the magnitude of the determinant of the metric tensor. This gives the full action as

$$S = \int \left(\mathcal{L}_{\mathrm{M}} + \frac{1}{2\kappa} R \right) \sqrt{-g}\, d^4x.$$

The above is precisely the Hilbert action, from which the Einstein field equations emerge algebraically in the calculus of variations. Having arrived at general relativity's foundations, we have arrived at general relativity. We have shown, then, that Unity produces, in approximation, the gravitational theories of both Newton and Einstein.

9.3 The Limits of General Relativity

We can now turn to a key question: What is the domain of validity of Einstein's general relativity? The field equations emerge as a limiting case of $R_8 = 0$, but are not, therefore, universally applicable. Since, according to the axiom of Unity, we require at least eight dimensions of substance to match the phenomenology of quantum physics, the universe is dimensionally broader than 3+1. General relativity, however, takes place against a backdrop of three dimensions of space and one of time. Those dimensions, in contradistinction to the prior Newtonian theory, are flexible, and interact with any foreground matter found against them; however, flexible as they are, they are still a *background*. General relativity is classical: it is a theory of a spacetime stage on which material players dance. The Newtonian stage was solid stone; the Einsteinian stage is more like a crash mat. But in both theories, the universe is only what is perceived.

We have established, with reference to quantum physics, that matter is a topologically nontrivial affair. What we model as a single location in space is, in fact, the sum, in perception, of five imperceptible dimensions: the four inner dimensions (W, X, Y, Z) and the w dimension of progress. An electron, in the Unity paradigm, is an energetic substance wave moving around the leptonic W dimension. Now, in quantum physics, we have been able to view the leptonic W dimension as essentially independent of the larger space dimensions. The Schrödinger and Dirac equations are derived by assuming a constant circumference $|W|$, thus a constant mass resonating within it. General relativity offers flexibility in this regard, describing the possibility of static exchanges between the inner and outer dimensions. But its equations are nevertheless formulated with reference to a backdrop of space.

In our derivation of the Hilbert action, we assumed (and had no choice but to assume) two things: 1) full symmetry in the inner dimensions, allowing the dimensional reduction $\mathcal{L}_{\text{grav}} \to \mathcal{L}_{\text{g}}$, and 2) time independence in $\mathcal{L}_{\text{g}}$, allowing conversion from (w, x, y, z) to (t, x, y, z). These are only ever approximately true, and there are many non-negligible physical scenarios in which they are decidedly false. Hence, general relativity only applies in some very specific scenarios.

Firstly, what happens where gravity is strong? Well, in the locations currently described as black holes, the inner dimensions cannot be small. The word "gravity" refers to an enlargement of the inner dimensions, so the phrase "strong gravity" translates exactly as "large inner dimensions". We must assume that at, say, the centre of the Milky Way, where current theory places a super-massive black hole, the inner dimensions are very significantly enlarged. What effect might this have on matter? Consider the proton. With reference to the leptonic W dimension, the baryonic proton is a particle with a specific location. It is not, in fact, gauge symmetric in W. We can ignore this behaviour if the inner dimensions are small: atoms occupy points in space. But, if the inner dimensions are large, we cannot. Increasingly, as the W dimension gets larger, protonic nuclei must begin interacting nontrivially *within* the inner W dimension.[7] All sorts of effects must come into play. In very high gravity, an atom's

[7] This behaviour is already evident with heavy nuclei, as explored in an appendix to this book.

nucleus may string itself out in W, so that all of its protons are colocated at a single point in space. Or the baryonic and leptonic X and W dimensions may equalise in size, allowing for stable resonances of five orthogonal waves. Or the proton resonance may break down altogether. It isn't at all obvious what happens. Of one thing we can be sure, however. The presence of large inner dimensions renders the assumption of space as the backdrop to reality not just a poor approximation, but entirely incorrect.

> The equations of general relativity do not apply to regions of very high gravity.

A large chunk of twentieth century cosmology is rendered obsolete by this fact. For one, there is no *a priori* theoretical justification for black holes, as previously imagined. The Schwarzchild metric applies outside stars, yes, but it breaks down as the density increases. To model the interior of a region of space with extremely high density, one must return to the eight-dimensional substance equation $R_8 = 0$ and consider variations not just in space and time but within large inner dimensions. We must consider not only the fact that the photons in such regions shear-rotate more substance, but also the underlying possibility of the chaotic breakdown of matter itself. It may be that black holes are black simply because their interiors are incoherent, permitting no stable solutions to R_8. It may be that no such entities exist.[8] Perhaps light can *always* escape? Who knows. The qualitative point, however, stands regardless.

General relativity's second major domain limitation is *temporal*. We know, from a century of high-powered astronomical observation, that space is expanding [27][28]. We will return to this important piece of information in the next section. At this point, we note simply that the expansion of space is incontrovertible evidence that the sizes of the dimensions of the universe are non-constant. There was clearly an epoch, in the cosmological past, in which the outer dimensions of space were much smaller than they are today. And, according to $R_8 = 0$, any expansion must be matched by contraction. Hence, in the very distant past, when the outer dimensions were significantly smaller, the inner dimensions must have been significantly bigger. But general relativity does not apply when the inner dimensions have non-negligible size, which categorically rules out the application of GR to the distant past. This renders most of twentieth century cosmogonic theory incorrect, and casts significant doubt on much of cosmology too, given that objects in the distance are always objects in the past.

All is not lost, however. In the current epoch, the imbalance between the inner and outer dimensions is immense, with at least three decades of orders of magnitude separating the sizes of space and inner space. It is likely that GR would still hold well, even with a 10^{10}-fold increase in the size of the inner dimensions and a consequent 10^{10}-fold decrease in the size of the outer dimensions. With such flexibility, much astrophysical theory will be unaffected by GR's limitations. Likewise, it is possible, though far from guaranteed, that black holes do indeed exist.

[8] Historically, there has been a great deal of over-confidence regarding hypothetical entities such as black holes. As it stands, theories of black holes have neither theoretical nor empirical validation.

But that's as far as the salvage operation goes. Much must be discarded. Crucially for our understanding of the reality we live in, the *very* distant past, such as is currently described as "the early universe", is emphatically beyond the domain of general relativity, even in approximation. Hence, all cosmogonic ideas and theories based on the Einstein field equations, including but not limited to the Big Bang, inflation, dark matter, dark energy, the quark epoch, baryogenesis and recombination should be deprecated. Those theories, it turns out, were built on sand. General relativity is simply not a cosmogonic theory: it does not apply when space is small and the inner dimensions are consequently large. This is a stark realisation, yes, but there is just no way around it: much of twentieth century cosmogony must go the way of the epicycles.

> The equations of general relativity do not apply to the distant past or future.

By way of an example, consider the evidence for the accelerated expansion of the universe, such as required the theoretical introduction and subsequent fine-tuning of dark energy and the cosmological constant. The acceleration of expansion was proposed on the evidence of *standard candles*: supernovae that explode with a characteristic and recognisable brightness. This level of brightness allows measurement of their distance from us, independently of their redshift. It has been observed, therefore, that redshift has increased with time. Hence, it has been concluded that the expansion of the cosmos is accelerating. However, while the underlying astronomical evidence stands firm and valuable, these theoretical conclusions do not. In the distant past, the inner dimensions were larger, which must have a profound effect on phenomena such as supernovae. Larger inner dimensions means lighter protons, and smaller amounts of energy released in nuclear fusion. So, while such candles may be standard across space, they are certainly not standard across time. A less energetic supernova shines less brightly. Hence, anyone observing it, unless they take the expansion of the inner dimensions into account, must measure distance incorrectly.

And the above is only the surface of the problem. A deeper and more significant issue presents itself, when one considers the wave of the present. In Unity theory, the cosmos and the universe aren't the same thing. The cosmos is our view of the wave of the present, which is a configuration progressing across the substance of the universe. That wave is highly coherent and highly stable; it must be, otherwise we wouldn't be here. However, the fact that the relative sizes of the inner and outer dimensions change means that, on the grandest scales, the stability of the present isn't a given. Indeed, if we consider the phenomena, we can be very sure that the wave of the present, as we currently know it, is of finite age. With inner dimensions larger than a certain value, the proton itself must become unstable, since high energy is what holds it together. And protons are the engine of the present. It is their configuration that drives progress. So, we must conclude that, back in the mists of time, there was an epoch when the universe existed, but our cosmos didn't. This prompts a very different view on cosmogony to the one that currently holds sway.

9.4 Galactic Rotation Curves

We will address the origin and fate of the cosmos in more detail in the next section. For now, let us stick to more accessible affairs, so as to continue to establish the veracity of Unity theory. It would be a poor show indeed were Unity theory only to serve as a wrecking ball. If the theory is to be useful, it should offer cosmological *solutions* as well as cosmological problems. One of these, in which Unity can do what general relativity cannot, concerns the enigma of flat galactic rotation curves, such as prompted the dark matter hypothesis.

It is has long been evident to freethinkers that the ΛCDM model is scientifically unsatisfactory, being as it is a classic case of fine-tuning [8][9]. Dark matter was introduced for one purpose and one purpose only: to reconcile flat galactic rotation curves with Einstein's general relativity, against which they provide significant evidence. Dark matter has never been observed in any other scenario, and there is no evidence for it other than in the phenomenon for which it was created. As various theorists have pointed out, this makes it non-science.

Now, we have established that GR has a limited domain of applicability. So, we shouldn't be surprised that the evidence regarding galactic rotation curves disagrees with theory. However, the spiral arms of a galaxy are certainly within general relativity's scope: the regions in which we find disagreement between GR and the astronomical evidence are regions of very *low* gravity not far into the past, which might suggest that, even according to Unity theory, general relativity should hold. After all, in that domain, the inner dimensions are certainly small. However, the assumption of small inner dimensions is not the only approximation involved in the construction of general relativity.

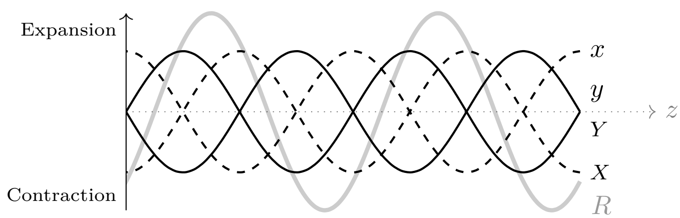
It is well known that, in the relevant limit, general relativity resolves to Newtonian gravity, following an inverse square law. In the language of Unity theory, a static central mass maintains a static enlargement of the inner dimensions; that enlargement then tapers off away from the central mass, and the force so generated falls away according to Newton's law of universal gravity

$$F = \frac{Gm_1m_2}{r^2}.$$

Since Newtonian gravity is a limiting case of GR, this force exists in Unity theory, and in exactly this form. However, Unity theory also allows for another aspect of gravitational force, which is not permitted by either the Newtonian or Einsteinian theory: propagating waves in the gravitational *field*. Now, general relativity allows for gravitational waves, which are undulations in space. Such undulations also exist in Unity theory: they are fermionic exchange waves. However, the "gravitational" waves of GR do not, in fact, transmit gravity. They are first-order radiative fermions—macroscopic neutrinos, if you will—exchanging first-order expansion and contraction between two dimensions of space. Such exchanges have no impact on the gravitational potential; gravitational force is determined by the *overall* size of the inner group, which is unaffected by GR's vacuum solutions.

But is there a wave that *transmits gravity*? Static Newtonian gravity, by definition, permits no such solution. And neither does general relativity, a fact which can be seen in two ways. In our derivation of the Hilbert action, it was axiomatic: we assumed time-independence in the background potentials. In the resulting equations, it is mathematically evident: GR's travelling vacuum solutions, governed by $R = 0$, have only three dimensions to play with, namely the three dimensions of space, which rules out their collective expansion.

The substance equation $R_8 = 0$, however, *does* allow for such transmission. For example, at first order, there is a solution in which two dimensions of space (x, y) trade off, out of phase, against two dimensions of inner space (X, Y), and the configuration is then transmitted in z. Mathematically, a variety of such solutions exists. We needn't go into their details here, as the logic is as simple as that of dropping a rock into a pond: whatever the details, waves will ensue. If we disturb things gravitationally, that is to say, in terms of inner-dimensional size, those disturbances must propagate. We will call such waves *gravitons*.



First-order graviton $G_1^0 : \hat{z} \,\Big|\, xyXY$

Just as a photon transmits electromagnetic disturbance, a graviton transmits gravitational disturbance. And, unlike the waves of general relativity, a graviton transmits *force*. As such a disturbance approaches a matter particle, that matter particle is energetically attracted towards the graviton's source by the expansion of the inner dimensions in that direction. For a short while, this exerts a force, and the matter particle accelerates. After the graviton passes by, the force acts in the opposite direction, but it is now weaker as the graviton spreads out. Overall, a small velocity is given to the matter particle, towards the source disturbance. This is exactly the same manner in which the photon transmits the electromagnetic force.

Now, the static electromagnetic force obeys Coulomb's law, falling off with r^2. It's obvious why: intuitively, the force spreads out over spheres of increasing surface area. The *radiative* electromagnetic force, however, as carried by the photon, falls off *linearly* with r, as described earlier with reference to Thomson's argument. So it is with gravity. Static Newtonian gravity, the low gravity limit of general relativity, falls off according to an inverse square law. *Radiative* gravity, however, as carried by the graviton, must fall off *linearly* with r.

Hence, in the outer reaches of galaxies, there are *two* distinct gravitational effects: Newtonian gravity and the graviton force. Near the centre of a galaxy, Newtonian gravity is far stronger, as the static masses of the stars are overwhelming compared to the inner disturbances of those masses. So, the graviton force is, in many scenarios, negligible. But not *all* scenarios. Far from it, in fact. Since the graviton force drops off as r compared to Newtonian gravity's r^2, there must come a point, regardless of how comparatively weak the graviton force is, when the graviton force comes to *dominate*. Beyond a certain radius, the overall gravitational force, which is simply the sum of the two effects, must drop off linearly, as Newtonian gravity itself becomes negligible.

As a first-iteration proposal, consider the force law

$$F = \frac{Gm_1m_2}{r^2} + \frac{Hm_1m_2}{r},$$

where H is a second gravitational constant, far smaller than G. In the low gravity regime, when r is large, the Newtonian contribution is negligible, and we are left with only the graviton force. For circular motion of a mass m around a galaxy of mass M, we have, from Newton's second law,

$$\frac{HMm}{r} = m\frac{v^2}{r},$$

which gives $v^2 = HM$. This is constant in any given galaxy. The linear velocity v of stars in the low gravity regime is, therefore, modelled as independent of the radius. This yields a galactic rotation curve tending asymptotically to flat, in agreement with astronomical observation [29][30]. This resolves the issue, without recourse to auxiliary hypothesis.

Unity theory predicts radiative gravity and, therefore, flat galactic rotation curves.

In the first-iteration form proposed, however, the law only holds within particular galaxies. To fit rotation curves more generally, we would need differing (and hence fine-tuned) values of H. Now, to some extent, this is to be expected. After all, the strength of the graviton force, unlike Newtonian gravity, must depend on factors beyond the Newtonian mass. Given that gravitons are *emitted* in nuclear reactions, the age of the galaxy must have an effect. Furthermore, since gravitons, like photons, are absorbed by the matter with which they interact, unlike the static potentials of Newtonian/Einsteinian gravity, the shape of the galaxy must come into play too. For example, in a galaxy with a significant central bulge, gravitons emitted in that bulge have a greater chance of making it to the outer reaches unabsorbed than they do in a flat disc galaxy.

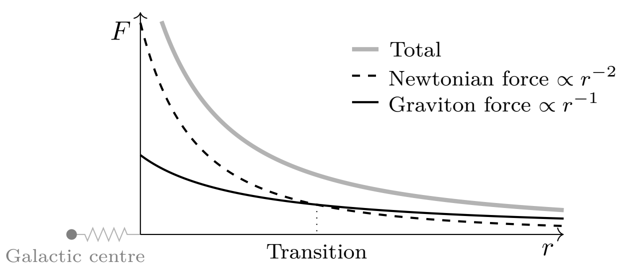
The relative impact of the above effects is yet to be determined. For now, we will set such extras aside, to focus on the obvious dependence: force F on galactic mass M. But one major point stands out. Unlike in Newtonian gravity, where symmetry dictates linearity in M, we have little reason to suspect that the graviton force is *directly* proportional to the mass of the galaxy. The graviton force, after all, is asymmetrical. And a survey of the phenomenology corroborates this. In fact, the evidence points to a specific, nonlinear dependence: $F \propto M^\eta$, with $\eta \neq 1$. We investigate this next.

9.5 MOND

In assessing the nature of the graviton force, we do not need to sift, ab initio, through the astronomical data, because there is already a theory which very effectively summarises the phenomena. This is Milgrom's *Modified Newtonian Dynamics* [31]. This theory has stood for some forty years as the only real challenger against the unscientific dark matter hypothesis. In many ways, it has outdone its opponent. In most ways, indeed. The issue with it, however, has been its lack of a theoretic basis. While its description of the phenomena has always been decidedly superior to that offered by dark matter, it does involve an apparently ad hoc adjustment to either Newton's second law or universal gravity. Those aren't laws to be trifled with.

But, as ever, Unity theory has good news. If, as a second-iteration force law, we consider a particular nonlinear dependency of emission on galactic mass, the graviton model produces Milgrom's theory in full. This means we can now dispense with the ad hoc *interpretations* of MOND phenomenology, which were its weakness, while bringing all of its *facts* within the sphere of Unity theory. This is a positive step from both points of view. Unity gives MOND a theoretic basis; MOND gives Unity the evidence for it. We can import, more or less wholesale, the excellent and somewhat maverick work of the MONDians into the new mainstream, and, in doing so, fill the void left by our trenchant bulldozing of the dark matter hypothesis.

At the heart of Milgrom's theory is the realisation that galactic rotation curves can be predicted, to a high degree of accuracy, from the distribution of visible baryonic matter alone [32]. The simple importance of this fact cannot be overstated. It is damning for the dark matter hypothesis. Milgrom found that, phenomenologically, while galactic rotation curves don't match Newtonian gravity, they *do*, albeit to an unexpected formula, match the amount of baryonic matter observable within galaxies. In other words, M is what matters. The evidence, collated in MOND, suggests the following: towards the centre of a galaxy, a reciprocal square law holds; in the outskirts, however, a reciprocal law holds. We have already derived this, as represented below:



But what Milgrom noticed, beyond this graph, was that, across many galaxies, the *transition* between the two regimes takes place not at a consistent radius r_{crit}, as might be expected, but rather at a consistent gravitational *strength*, i.e. at a consistent *acceleration*. Milgrom calculated this to be $a_0 = 1.2 \times 10^{-10}$ ms^{-2}. Above this acceleration, Newtonian gravity dominates; below it, MOND takes over.

Now, in MOND, there are no underlying physical principles, and the transition between these two regimes—Newtonian gravity and "deep MOND"—is expressed, in the mathematics, with one or other empirically determined interpolating function. We can improve on this here. In Unity theory, we have no choice but to model the combined gravitational force as a *sum* of two components proportional to r^{-2} and r^{-1}. This dictates the structure of the mathematical law precisely in that regard: the overall force must be given by

$$F = F_{\text{Newton}} + F_{\text{graviton}}.$$

Precisely what form should our second-iteration graviton force law take, then? Well, since galactic rotation curves are, as Milgrom noted, determined to a good approximation by galactic mass alone, we need only determine the nature of the M dependency. We expect contributions from age, shape and so forth, yes, but the evidence suggests that those contributions are small, except insofar as they themselves depend on M. So, for some constants H and η, we have

$$F_{\text{graviton}} = \frac{HM^{\eta}m}{r}.$$

We ask, then, what the values of these constants are. Now, H must simply match experiment. We have no choice there. The index η, on the other hand, remains to be determined. In the long run, it may succumb to theoretic derivation; however, such a derivation, which would require an astrophysical theory of graviton emission, is well beyond the scope of this book. Given the near impossibility of direct observation of gravitons, such analysis may remain hypothetical more or less indefinitely. So, in this book, we will determine a value for η empirically, by picking its value so as to reproduce MOND. Since MOND's fit to the phenomena is strong, this seems a good place to start.

The value of η that reproduces MOND and therefore the phenomena is $\eta = \frac{1}{2}$. This corresponds to a graviton force proportional to the square root of galactic mass. The algebra is simple. The pertinent fact is that, with η chosen in this way, the two accelerations are both expressible in terms of the same combined variable M/r^2, as

$$a = G\,\frac{M}{r^2} + H\sqrt{\frac{M}{r^2}}.$$

To reproduce MOND's transition at consistent acceleration, then, all we have to do is set H such that, when Newtonian gravity produces an acceleration of $\frac{1}{2}a_0$, so does the graviton force. Substituting the relevant value of $M/r^2 = a_0/2G$, some elementary algebra yields

$$H = \sqrt{\frac{a_0 G}{2}}.$$

With this value of H, the Newtonian force and the graviton force are equal whenever the overall acceleration is a_0. The combined force law then reproduces MOND in full, without any need for adjustment of Newton's laws. And this removes the key obstacle to MOND's acceptance into the mainstream. Not only that, the graviton force law then offers a number of avenues for further theoretic development, in which we either adjust the index η or include variables other than galactic mass. There are many possibilities. Here, by way of facilitating future study, we summarise the first three iterations of the graviton force law, in order of increasing flexibility.

Iteration	Combined Force Law	Phenomenology
1	$F = \dfrac{GMm}{r^2} + \dfrac{HMm}{r}$	Single galactic rotation curve
2	$F = \dfrac{GMm}{r^2} + \dfrac{HM^{\frac{1}{2}}m}{r}$	Modified Newtonian Dynamics
3	$F = \dfrac{GMm}{r^2} + \dfrac{HM^{\eta}m}{r}$	Large-scale structure?

We leave the ideas open-ended here, as this book isn't about deciding on this or that formula. The important thing to note, in all of the above, is that Unity theory effectively resolves one of the largest problems in cosmology, and in an elementary fashion. Radiative gravity does not exist in the classical paradigm, yet it must exist in Unity theory. And the evidence, both in theory and practice, is overwhelmingly in its favour. In any given galaxy, a rotation curve tending to flat is predicted by Unity theory, without recourse to any additional hypotheses whatsoever. Compare this to the ΛCDM model, which, in order to explain flat galactic rotation curves, proposes, without any logical justification elsewhere, an invisible substance permeating the universe which cannot be measured in any way except by the very phenomenon it is purported to explain. There really is no contest.

9.6 Implications for Unity Theory

The evidence of galactic rotation curves—gravity on the grandest scale—must be taken as another significant vindication of Unity theory. Prior to our derivation of general relativity and its limitations, it was already clear, in the quantum domain, that the structure of reality is, to a first approximation and up to any errors in deduction, as proposed in this book. A theory should not, however, be applied beyond its domain of empirical validation, whatever its theoretical justification. All physics is simplification, and it is often only possible to find out exactly where simplifying assumptions have been made after the event, when the evidence disagrees.

But Unity theory has now passed one of the last major tests remaining to it: the generalisation from quantum to universal scales. Its philosophical first principle resolves the enigma of flat galactic rotation curves in precisely the same breath as it produces the Schrödinger and Dirac equations, special relativity, the action principle, the proton mass, the weak mixing angle, and the symmetries and theories of all four fundamental interactions. There is no other physical theory that can offer such a wealth of simple explanations across such a broad reach of domains.

But, *de omnibus dubitandum.* Is there, in light of the facts above, *any* plausible way in which Unity theory can, in its overall view of reality, be incorrect? Is there any way in which the universe proper and the perceived world of appearances can retain their historical identification? Well, we can only put the results of this book down to one of three things: coincidence, error, or truth.

1. *Coincidence.* As scientists and mathematicians, we cannot countenance this. Even to have derived the Schrödinger equation alone stretches that possibility. To have derived the rest of quantum mechanics then renders it out of the question. By this stage of the work, with the list of results derived, both qualitative and quantitative, stretching across multiple domains and scales into many tens, towards hundreds, coincidence is entirely impossible.

2. *Error.* This is not, of course, beyond the realms of possibility. Only the most foolish of authors would claim immunity from either a) errors of judgement or b) unconscious bias. There will undoubtedly be some, if not many, of both types of lapse in this book. Wrong turnings will certainly have been made, both in incorrect application of logic and in unconscious tuning of facts to suit theory. *But even this can only go so far.* The mathematical spaces and physical reality described in this book can be difficult to visualise, yes, but the mathematics itself is not overly complicated; it is accessible to an undergraduate in any scientific discipline, and offers little scope for the obfuscation by complexity present in so many late twentieth century papers. Essentially, Unity theory is very simple. For such simplicity to produce so many different results, even in a logically fallacious manner, is *still* a long way beyond the realms of possibility.

3. *Truth.* The results that emerge do so because the axiom of Unity is true.

So, either this book is a colossal work of fiction, riddled throughout with elementary errors of judgement, logic and mathematics, or Unity theory is essentially true. There is no other possibility. Even if only half of the content of this book is valid, Unity theory must essentially be true. Even if only a *tenth* is true, the same still applies. The weight of evidence is just too overwhelming. Barring obvious, repeated, catastrophic fallacy, we cannot but conclude that reality is deeper than the material world of appearance.

The human importance of this conclusion, for our age and ages to come, is such that I will risk a smattering of personal pronouns. With coincidence ruled out, there are really only two possibilities. Either I am utterly deluded, writing meaningless drivel in Cloud Cuckoo Land, or Unity theory is, in its broad brush strokes, true. Given the solace, the hope, the new beginnings that Unity theory's facts can offer to a world grown sick, it brings me much joy to be able to stick my mathematical ego over the parapet and say: it's definitely the latter. Materialism is dead.

10 Unity and the Cosmos

With general relativity established as a limiting case of Unity theory, invalid when the inner dimensions are large, we are faced with a simple fact: our current cosmogonic models are incorrect.[1] Those models depend on the mathematics of general relativity, with the Friedmann equations or similar used to describe the historical behaviour of the universe [33]. But, as we now know, the Friedmann equations do not apply to the distant past. Hence, all conclusions drawn from them must be discarded.

The "primeval atom" idea, as first proposed by Lemaître nearly a century ago [34], is one such. It has come to be accepted as something alarmingly close to gospel truth that the universe began at a single location, with a so-called "Big Bang". Yet this is almost certainly false. There is no point in beating around the bush here. While those lacking imagination may find the falsification of such a long-cherished idea abhorrent, those with respect for the truth must recognise that the Big Bang theory, like all theories of physics, rests on assumptions and, *ipso facto*, is only as true as those assumptions turn out to be. Since the application of general relativity to the early universe is logically fallacious, they have turned out to be false.

Einstein himself, along with many others, was skeptical about the notion that the universe could have begun at a singularity, and for very good reason. Such a state is, in the most basic sense, theoretically impossible: *natura non facit saltus*. There is no evidence whatsoever to support the idea that anything physical can spring into or out of existence. At the quantum level, when particles are "created" or "annihilated", there is no physical entity that does so. Nature is continuous. What happens at moments of creation/annihilation is that a certain configuration of substance is rearranged to form another. What "springs into existence" is an *idea*, in exactly the manner that a sandcastle is created by a child on a beach. The sand was there before the castle, and will still be there when the castle is washed away.

> Unity rules out creation and annihilation, other than of second-level configurations. Via Continuity, Unity dictates that substance is temporally eternal.

According to Unity theory, it is nonsensical to speak of the *creation* of the universe, in either a scientific, philosophical or religious context. Since the universe exists, the universe has always existed and the universe will always exist.[2] There are, in fact, pressing theoretical reasons for the falsehood of the Big Bang theory, before we even consider the evidence. And the evidence speaks likewise: it does not imply the truth of the Big Bang. To read the data—the expansion of space and the nature of the

[1] We use *cosmogony* to refer to the history, and especially the initial formation, of the cosmos (not the universe), as opposed to *cosmology*, which studies its present structure.

[2] While spatial infinity may reasonably be viewed as logically impossible, temporal infinity cannot be seen as so. Time does not "stretch out in front of us". The w dimension of progress does, yes, but that is a physical dimension, with finite circumference. Time t, the temporal parameter, only measures *change*. There is no contradiction in the idea of instantaneous change occurring for ever.

cosmic microwave background—and to conclude, thereby, that the universe began at a single point is an unsupported theoretical leap. Now, there is nothing automatically wrong with such a leap, as long as it is in the right direction. But it wasn't. The Big Bang[3] is essentially a naive model, logically unjustifiable even in the old paradigm, and requiring of all sorts of arbitrary fine-tuning to have it agree with astronomical evidence. In Unity theory, we consider it obsolete.

We require an alternative. If the universe is eternal, how come space is expanding? What is the cosmic microwave background if not the echo of a past explosion? These are two major questions. Fortunately, here as elsewhere, they have simple answers, answers that can be understood at many levels of mathematical modelling. We begin, of course, at the simplest level: the qualitative level of topology. But we should not mistake this simplicity for weakness. Physics has, in recent years, come to take too much pride in precision. There is a grave danger, rarely recognised, in Kelvin's view that, scientifically, only quantity matters. The "precise" mathematical models of the Big Bang theory, which seem to fit the data so well, have feet of clay. The foundations of the modern ΛCDM model are dark matter, dark energy and inflation. But none of these things exist. They have been made up to fit the data. In the cosmological realm, where evidence is scant, simplicity isn't weakness; it is *strength*. It is only if a model holds together at the most basic level that it then warrants subsequent precision.

Now, Unity theory does offer quantitative modelling to the same degree as the old paradigm does. We have $R_8 = 0$. However, building models takes time. In Unity theory, we have eight physical dimensions of substance; even reducing space and inner space to single x and X dimensions, we are left with four topologically nontrivial components, rendering precise modelling extremely difficult. The nonlinearities of Riemannian tensors cause enough headaches in three-dimensional general relativity. While not wishing to dissuade those brave souls willing to approach the beast, we must be honest about the scale of the task: explicit modelling in eight-dimensional Riemannian tensor algebra is the stuff of mathematical nightmares.

But there is hope yet. According to Unity theory, the eight-dimensional universe partakes of a great deal of symmetry. Such symmetry allows us to make simplifying assumptions without incurring error. And one symmetry stands out above all, as both the grandest and the simplest. This is the core symmetry of the universe: the factorisation of the eight dimensions of substance into two four-dimensional components. This is the symmetry of gravity, broken in the current epoch, which exchanges expansion and contraction between the inner- and outer-dimensional components of the Unity group. At this, the very broadest scale of modelling, we decompose the universe as $U_x \times U_X$, treating U_x and U_X as identical in every manner but size. It turns out that this most elementary of symmetries holds the key to the construction of a viable alternative to the tired old theory of the Big Bang.

[3]In this book, we use the term *Big Bang* to refer to the primeval atom theory. By considering it obsolete, we do not consider theory regarding, say, the surface of last scattering to be so. Where there is astronomical evidence, that evidence stands. The name "Big Bang" was coined in criticism, so it is appropriate to keep it for what it purports to describe, namely an explosion.

10.1 The Cosmos within the Universe

Before we begin, a reminder of the distinction between the cosmos and the universe. This distinction has not been necessary in prior cosmologies, because we have hitherto assumed that space (cosmos) and reality (universe) are essentially the same thing. As we have shown, they are not. But any historical elision of ideas carries with it linguistic baggage. This makes it important that we separate the concepts very explicitly and are strict in our subsequent usage. In particular, while the *universe* is eternal, the *cosmos* is not. Let us begin by unpacking this statement.

In Unity theory, the universe consists of one substance. That substance, governed by $R_8 = 0$, is fixed in quantity. The substance equation, which may by now be considered verified, dictates that substance cannot be made or unmade. Reality must be viewed as a single thing, a constant "amount of universe". This idea has the benefit of being eminently visualisable. The universe, according to $R_8 = 0$, is an eight-dimensional ball of substance. There is no physical mechanism whereby that substance can be created or destroyed; indeed, below the clines, those terms are meaningless. They are only valid when referring to *configurations* of substance. An electron can be annihilated, but the underlying substance carries on just the same. This happens in exactly the manner that ocean swells may disappear, without any harm coming to the underlying water.

The cosmos, in contradistinction to the universe, is a *configuration* of substance. A star is not a lump of substance; a star is an exceedingly complicated waveform moving across the face of substance. When you look up at the Moon, you aren't seeing a solid object passing through the dark of space. No. You are seeing the crest of a wave. The motion of that wave gives the impression, then, of a physical space through which the Moon moves. But were the Moon to collide with an anti-Moon, were its mass to explode to pure energy according to $E = mc^2$, nothing would have been destroyed; rather, waves moving in the inner dimensions, containing rest energy, would have been redirected to become waves moving in the outer dimensions, containing kinetic energy. And this is true of every physical thing in the cosmos. Hence, since every element of the cosmos is a configuration of substance, the cosmos itself is so.

It is reasonable to assume, therefore, that the cosmos, as opposed to the universe, *can* be created or destroyed; the eternal nature of the universe, which is theoretically necessary, does not carry over into into second-level configurations, of which our cosmos is one. Indeed, the evidence, as it already exists in cosmology, is clear. The cosmos is not eternal. Cosmology, as it has hitherto existed, has not been, as supposed, the study of the universe; it has been the study of a particular wave, rolling across the face of the universe. So, while it remains incorrect to say that the cosmos was created in a singularity such as the Big Bang—singularities are equally impossible on any theoretic level—it *is* nevertheless correct to say that the cosmos, as a configuration of substance, came into existence at a finite time in the past.

So, the universe is eternal, but the cosmos is temporary. Logically, this leaves only one possibility. The substance of the universe has housed and will continue to house an eternal succession of waves such as the one we call the present: one cosmos must come into existence, remain for a while, then dissipate. The cosmos in which we live, such as has been in existence for some billions of years, must be but one example of a cosmos, one of a temporally infinite line of configurations of substance. If this were not so, there would be no answer to the oft-neglected question: "Why now, in all eternity?"

⦿ Definition: *Cosmic cycle.* The life-cycle of a cosmos, as a coherent configuration of substance. Equivalently, the life-cycle of a wave of the present.

In Unity theory, we require a broadening of horizons. Cosmology, hitherto, has been the modelling of the cosmos. But, according to any frank appraisal of the phenomena, there are physical elements of reality that, in a rational, scientific manner, do not belong to the cosmos. Such an idea is easily dismissed out of hand as "metaphysical speculation" by those lacking in the imagination to cope with it, but that does nothing to detract from its truth. There is nothing paranormal about this idea. The facts simply don't support the theory that the cosmos is the full extent of reality. So, if we wish to behave as true scientists, true seekers after knowledge, we are bound to adjust our concepts accordingly. We are bound to model not only the observable cosmos, but the universe that underpins it. This takes cosmology into a new realm.

Here, we consider the changes in the universe that drive cosmic cycles. Despite fundamental differences, the universe and the cosmos are not unrelated. Far from it. The cosmos is a configuration of the substance of the universe, and, while the universe may be eternal, unchanging in its essence, it is by no means immutable in form. Indeed, we know for a fact that the opposite is true. Every photon that emerges from every star is a ripple in the substance of the universe; every hydrogen atom is a stable exchange of expansion and contraction between the dimensions of space. These are changes in the fabric of the universe at the quantum level; but the same changes, obeying the same universal physical law, must also take place at the very *largest* scales.

10.2 Equality

Space is expanding. Regarding that fact, the evidence is unequivocal. The *nature* of this expansion has, however, long been a source of confusion among physicists and philosophers. Many folk have reasonably pointed out that an object cannot expand with reference to itself. Now, there exist many bogus "explanations" of this fact, most centred around the idea that cosmological expansion is an expansion of space relative to the metric of general relativity. This is little more than mathematical obfuscation. Having fancy terms for things does not change the underlying facts. Fancy terms exist to justify what people *want* to be true, not what *is* true. The truth needs no such embellishment. It is, of course, true that an object cannot expand with reference to itself. So, the expansion of space is, in fact, yet more proof that space is not the backdrop to reality.

In Unity theory, things are simpler. Space is expanding, yes. In reference to what? The universe. Space consists of only three dimensions out of a total of eight;

hence, space is expanding relative to the inner dimensions. Since substance cannot be created, this is not only theoretically but axiomatically necessary: there can be no expansion without contraction. Symmetry dictates that, since the three dimensions of space are expanding, the three dimensions of inner space are contracting. This expansion/contraction is, more than likely, complex in its geometric details, involving nontrivial shear-twisting of circular dimensions, but that doesn't change the overall idea. It makes detailed modelling tough, but detailed modelling has been overrated. Of far greater importance is the big picture: how does the universe work?

Among mathematically viable solutions to the substance equation, the simplest account of the observed expansion of space is that it involves an exchange between the inner- and outer-dimensional components of the Unity group $U = (S^1 \times S^3)^2$. In making this approximation, we make no claim that more complex changes, such as variations in α, are not also taking place, but any consideration of such higher-level changes would be speculative at this stage. Only one level of modelling is appropriate: to treat the universe as simply as possible, as two four-dimensional components. The outer dimensions are big and getting bigger; the inner dimensions are small and getting smaller. This accounts for the observed expansion of space without the need for any mathematical jiggery-pokery. Space is expanding in the only way something *can* expand, by getting bigger compared to something else which is not.

Having established a broad framework, let us run the clock backwards. The outer dimensions are getting bigger, so they were smaller in the past; the inner dimensions are getting smaller, so they were bigger in the past. Reach back into the early years of the current cosmic cycle, and we end up with a very different picture to the one presented in the Big Bang theory. Yes, the outer dimensions were far smaller then. But, by symmetry, the inner dimensions must have been far bigger. According to the substance equation, it is impossible to change the amount of universe there is.

> A point of language. We have defined *inner* and *outer* as relative to human scale. Outside the current epoch, such identities are not fixed. But, in cosmogony, we need to be able to refer to the identities of the components of the Unity group as they persist from cycle to cycle. So, we use x, representing (w, x, y, z), and X, representing (W, X, Y, Z) as *permanent* labels. In the current cosmic cycle, U_x is outer and U_X inner; in the past, however, the roles were reversed.

In the current epoch, the Unity group is $U = U_x \times U_X$, with the outer dimensions big and getting bigger, and the inner dimensions duly small and getting smaller. What is increasing, therefore, is a *ratio* of sizes, not an *absolute* size, as is implicitly claimed by the primeval atom theory. But run an increasing ratio back in time, and you don't get an impossible 0, as is implicit in the Big Bang fiction. You get *1*, unity, equality, perfection. Symmetry dictates that, at some point in the past, the two components U_x and U_X, presently the caverns of space and the hearts of matter, were the same size. There was no nonsensical singularity, no division by zero, no generation of a universe from nothing. Quite the contrary. There was a state of perfect *Equality.*

⦿ Definition: *Equality.* The state of the universe in which there are no inner and outer dimensions: the U_x and U_X components of the Unity group are the same size. This state defines the beginning and end of a cosmic cycle.

According to Unity theory, somewhere in the tens (or perhaps hundreds) of billions of years ago, the universe consisted of two equal four-dimensional components: a decreasing U_X component, eventually to host the resonance of matter and so to enable the formation of the present, and an increasing U_x component, eventually to become the spatial backdrop of those matter-based beings who would evolve billions of years down the line. So, while the Big Bang, with its limited perspective, posits the birth of our cosmos as the beginning of all things, Unity theory, on the other hand, takes a far longer view: we propose that a broader, undying universe *birthed* our cosmos.

Averaging the sizes of the inner and outer dimensions of the present day, which we can take, to the nearest ten orders of magnitude, as 10^{-10} and 10^{30} metres, we propose that the universe has an eight-dimensional hypervolume of the order of

$$V_8 \sim \left(10^{-10}\right)^4 \times \left(10^{30}\right)^4 = 10^{80}\ \mathrm{m}^8.$$

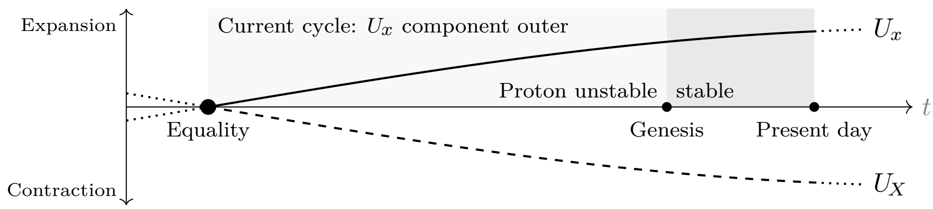
At Equality, then, all eight dimensions of the universe had circumferences somewhere in the vicinity of 10^{10} metres. This number is comparable, for purposes of visualisation, to the size of the Solar System. If it seems strange to imagine that the entire universe could be so compacted, remember that, at Equality, the universe was an *eight-dimensional* ball the size of the Solar System. Such an entity has the hypervolume V_8.

What was the universe like at such a time? Well, the fact of primary relevance is that such an eight-dimensional ball has *no small dimensions.* Every dimension is big. Not cosmologically big, but still far from small. In such a state, there can be no matter. Resonance around a dimension the size of the Solar System is a logical impossibility. Nor can bosons exist, as bosonic waves need shear rotation around a closed dimension. There is only *fermionic radiation*, such as GR waves $G : \hat{z} \,\big|\, xy$, neutrinos $\nu_e : \hat{x} \,\big|\, Wy$, and electron waves $e^- : \hat{W} \,\big|\, xy$. With every dimension large, these three are identical; at Equality, even the concepts "mass" and "momentum" are fully unified. At that moment, the universe is an eight-dimensional fermionic sea.

How did the cosmos, coherent and stable, come to be born from such entropic chaos? Well, equal size doesn't signify equilibrium. At Equality, the universe is minimally expanded/contracted, but it therefore contains maximal *oscillatory* energy. The universe's pendulum is at its lowest point, yes, but therefore swinging fastest. At Equality, one component of U is getting bigger and the other smaller. And this oscillation must contain energy as defined in the broadest domain, the third/fourth-order energy of $\mathcal{L}_{\mathrm{grav}}$. At Equality, while the *cosmos* was void, the *universe* was in motion.

Let us roll the clock forward again. As the new inner dimensions U_X got smaller, the energy travelling in those dimensions, such as now forms baryonic and leptonic mass, must, eventually, have begun to resonate, and thus to gravitate. It is likely that this happened long before the resonances we now know as protons were stable in their current form. Prior to the birth of the present, large-scale structure began to form.

Eventually, when the inner dimensions got small enough, the proton became stable. At this point, the macroscopic kinetic energies of the universe coalesced into coherent waves themselves: the proton now had a specific speed of progress dictated by its fourfold structure, and a coherent wave of the present was therefore energetically favourable. With the formation of a wave of the present, the cosmos in which we live emerged. We term this moment *Genesis*.



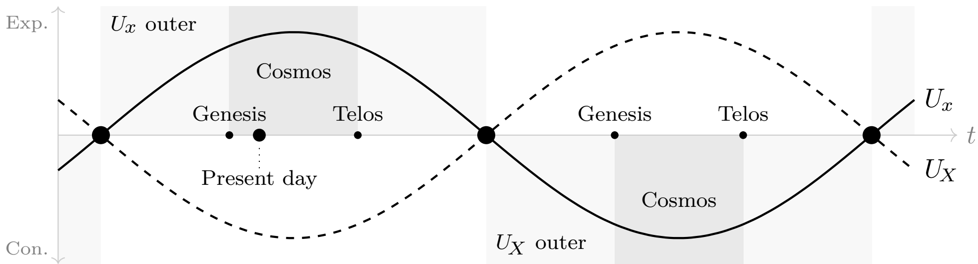
There was certainly a gestation period, of very significant but as-yet undetermined length, between Equality and Genesis. To reach proton stability, the current inner dimensions U_X had to shrink from the size of the Solar System to, presumably, not much bigger than they are today. Hence, it is highly likely that the fives of billions of years of observable cosmological history represent, in fact, only a small proportion of the time elapsed since the last state of Equality. It is quite possible that hundreds of billions of years have passed since the universe was last in full symmetry, and that, for the majority of that time, there was no matter. There was no light. The universe existed, but there was no cosmos.[4] Then, as an energetically favoured state, the present cohered some billions of years ago. Eventually, we ensued.

Now, let us roll the clock forward yet *further*, far beyond the present day. As the pendulum swings away from Equality, there is only one possible cosmological future. As the inner dimensions continue to get smaller, the proton will become more and more energetic. Increasingly, the energy of the universe will be stored in universal potential energy—the departure of the universe from dimensional symmetry—and baryonic mass. Logically, the expansion of space cannot continue indefinitely, as the inner dimensions would then become infinitesimal, requiring infinite energy in resonance. Instead, at a certain minimal size of the inner dimensions, the expansion of the universe will be spent. This is the furthest point of the pendulum's swing.

On energetic grounds, the universe must then return towards Equality. This will mean a reversal of the expansion of space. The proton will remain stable for a subsequent age, but will, all the while, become less and less massive. Eventually, perhaps tens or hundreds of billions of years in the future, when the inner dimensions have regrown larger than they are now, the proton will once again become unstable. The fourfold protonic resonance will no longer contain enough energy to fend off random fluctuations in substance. Protons will begin to decay.

[4] It is far from an unscientific description to say, of that moment, as the book of Genesis does: "The world was without form, and void, and darkness was upon the face of the deep." We scientific folk have been far too hasty in our judgements of ancient wisdom.

Beyond a certain point, the proton will no longer even be metastable, and the wave of the present itself will break down. We term this *Telos*. That will be the beginning of the end of this cosmic cycle, as the universe heads back towards Equality. The next cycle will then begin, as the universe once again turns inside out.



10.3 The Evidence

The above account agrees with Unity theory. But to what extent does it agree with the astronomical evidence? We should bear in mind, as we attempt to answer this question, that, unlike in quantum physics, the bar for agreement with evidence is set very low. This is no insult to astronomers and astrophysicists; it is simply the nature of the game. The old paradigm, in the shape of the ΛCDM model, is, scientifically speaking, of poor quality. Both of its eponymous elements, namely Λ, representing dark energy, and CDM, representing cold dark matter, are ad hoc hypotheses introduced for purpose, and they require fine-tuning to have them agree with the data. We have already established that both are unnecessary. In order to be superior to ΛCDM, therefore, Unity theory requires only that it explains the data *qualitatively*, since any quantitative success that ΛCDM has had is scientifically meaningless. Again, we must stress that this is no insult to the scientists that have used this model: there wasn't anything else. If you have no mug, you have to drink from a soup bowl.

The Big Bang theory, in both overall concept and mathematical detail, is the child of two major sets of empirical data: 1) emission spectra from distant stars, and 2) cosmic microwave background radiation (CMB). These are by far the biggest players in any empirical comparison, and a cosmological theory must stand or fall by its agreement or disagreement with them. We will address those two in due course. But there are also various other sources of information regarding the early cosmos which we should consider, if only to demonstrate that they are of lesser importance. We will deal with the two best known of these here, before returning to the big guns.

Firstly, the *relative abundance of primordial elements*. This has been of relevance within the Big Bang model, as a way of choosing between different versions of the same. However, as the Equality and Big Bang models bring somewhat similar views to bear on the formation of nuclei, it will be of little use in discriminating between them, at least for now. Both models claim nucleosynthesis at a time when the dimensions of space were smaller and the density of kinetic energy much higher. In both models, there is a first moment at which atoms become stable, and the formation of the nuclear structures of the universe involves a history commencing from that point. Essentially, once the proton is stable, Equality contains the Big Bang theory, at least as far as atoms are concerned. Hence, the relative abundance of primordial elements is not relevant to the task in hand.

Secondly, *large-scale structure formation*. This has proved to be yet another problem for the old view. According to the Big Bang theory, not enough time has passed for the large-scale structure of the cosmos to have formed under the influence of gravity. Now, the graviton force offers a solution to this problem—at cosmological scales, the graviton force is far stronger than Newtonian gravity—which favours Equality. One might suppose that the graviton force could be imported into the Big Bang model, so to stand against Equality. But not so. Since the graviton force involves the inner dimensions, it and a singularity are mutually exclusive. The Equality model also offers a far greater timescale over which large-scale structure can form, which coincides with the data. With the inner dimensions fairly small, prior to the stability of the proton, we must assume that proto-particles existed, such as the early electron. These will have had no means of surviving as point particles, but they will nonetheless have gravitated weakly. It is likely that the large-scale structures of the cosmos—superclusters, filaments and walls—were already well on the way to formation long before the wave of the present formed. Hence, large-scale structure formation favours Equality.

Now, let us proceed to the big players. The *redshift data*, which seems impossible to interpret in any manner other than as an expansion of space, is, as already discussed, firmly in favour of Equality over the Big Bang. Both models describe the homogeneous expansion of space, which offers nothing to choose between the two in quantitative, mathematical terms. However, in logical terms, the Big Bang model is at a distinct disadvantage. In the old paradigm, in which space is the backdrop to reality, the empirically verified expansion of space can only be interpreted as an expansion of the *universe*. However, as discussed, it is logically contradictory, at a basic level, to state that an entity is expanding, unless that expansion takes place in reference to another physical entity. The Big Bang theory requires all sorts of complicated arguments regarding "expansion with respect to the metric", none of which make sense. Unity theory, however, requires none. We have already introduced and validated the relevant theory with regard to the fermionic electron and the Schrödinger equation that governs it. Therefore, with regard to the redshift data, there is no contest.

And so we come to the *cosmic microwave background*, the apparent smoke of the Big Bang's gun. The CMB is one of the primary objects of astronomical study, and for good reason: it is the only direct evidence (as far as such a thing is possible) we have regarding the ancient past. And this is even more true in Unity theory than it was in the old paradigm. Unity theory implies that things were very different in the past, not merely in the content of space, but in the very fabric of reality. In the past, space wasn't even space. The fluidity of the Unity model casts doubt on all historic conclusions based on astral data. Stars were very different in the distant past: while the physical laws of the *universe* were the same back then as they are now, the physical laws of the observable *cosmos* were not. The constants α, α_s, m_e, m_p and $\hbar$, all of which depend on the dimensional structure of the present, have undoubtedly changed over time. It will be a major task of new cosmology to unpick the riddles so posed.[5]

But the CMB is different. Because the CMB doesn't emerge from this or that star, one doesn't have to make assumptions about this or that star in order to analyse it. It is a much purer form of data than that of so-called "standard candles". This places it in a position of primary importance when it comes to cosmogony and Unity theory. Now, both the Big Bang theory and the theory of Equality propose that the cosmos was, in the distant past, a sea of radiation. Hence, both explain the CMB in a qualitative sense. This puts Equality theory on infinitely stronger ground than steady-state theory, which previously faced up to the Big Bang. Steady-state failed because it couldn't explain the CMB. Equality, however, passes this test with flying colours. In Unity theory, the CMB is what remains of the sea of radiation that filled the universe when it was an eight-dimensional ball the size of the Solar System. At that point, there were no photons, at least not as we know them today. However, as the inner dimensions shrank, incoherent kinetic energy was forced, by the energetic favourability of coherence, to form gauge symmetric radiation. That radiation is still coursing through the cosmos today.

Equality matches the Big Bang in this regard. And, unsurprisingly, outdoes it elsewhere. Consider the *horizon problem*, regarding the homogeneity—observed primarily in the CMB—of the universe at scales beyond those dictated by the speed of light. How have different locations in the universe, beyond each other's information horizons, come to be almost identical? In the Big Bang theory, one has to introduce the preposterous *inflation*: a gargantuan, almost instantaneous expansion of space in the moments following the purported Big Bang. Prizes have been won for this theory. But, as a vocal minority have repeatedly pointed out, it is not only a ludicrous idea without physical cause or theoretical explanation—Why in God's name should the universe magically expand to almost its current size in 10^{-33} seconds, breaking every rule of physical logic in the process, before abruptly transitioning to a very gentle yet nevertheless accelerating expansion?—but, even on top of its conceptual absurdity, inflation must subsequently be copiously fine-tuned to give any agreement with experimental results. Inflation really is no better than nonsense.

The Equality model, however, requires no such tuning. Firstly, it is not an ad hoc hypothesis, but emerges from the same theory that produces the Dirac equation, the proton mass, the special and general theories of relativity and flat galactic rotation curves. Secondly, it explains the horizon problem in a single fact. Separated cosmic locations are homogeneous because the universe predates the cosmos: Equality wasn't the beginning of the universe, only the beginning of this cosmic cycle, and the observed homogeneity of the cosmos is due to a much deeper homogeneity, which is eternal.

[5] There are claims of "measurement" of the constancy of α over cosmological time. However, the logic of such papers relies on many layers of theoretic assumption, the validity of which is ruled out by Unity theory. There are very few conclusions about the ancient past, and emphatically no quantitative ones, which survive the demise of the old paradigm.

Now, various authors, including Lemaître and Misner [35][36], have proposed oscillatory universes related to the one proposed in this book, in order to resolve the horizon problem in the manner described above. Those models fail, since the endless cycle of universes should descend into thermal equilibrium. The same issue doesn't, however, trouble the Equality model. At the moment of Equality, there is a finite amount of kinetic energy, which is as entropic as it could possibly be. At that point, we are already at the lowest point predicted by the Second Law of Thermodynamics. But the universe itself, beyond the cosmos, contains a far greater store of energy, which is contained in the macroscopic changes of the dimensions themselves. As the universe passes through the state of Equality, we must presume that the majority of its energy is contained in this U_x versus U_X oscillation. At that point, the universe is essentially a fourth-order particle the size of the Solar System, with a local energy eigenvalue in the region of 180 TeV. And that's everywhere in V_8. *What a store of energy!*

And now consider two subsequent Equalities, bookending a cosmic cycle. At each Equality, the total energy in the universe is the same: in the absence of matter, total thermodynamic meltdown contains no information. There is no gravity; there is no anything. Yet the vast bellows of the universe blows nonetheless, generating a new cosmos. The energy contained in the universe's *global* motion flows into the wave of the present, which is driven across its surface. Matter is created, and gravity springs into being. Soon, atoms condense, forming stars, and energy is emitted from those centres. We begin to see the effects of the Second Law of Thermodynamics. But it makes no difference at Equality: the thermodynamic sea is, in energetic terms, the same at the end of every cosmic cycle. Its details must differ, of course, such that no two instances of the cosmos are identical, but no energy can have been lost. Where would it go? Equality is a *full* reset.

As with many things, we must rethink the Second Law of Thermodynamics. It applies to the cosmos, not the universe. In a given cosmic cycle, more and more energy must be converted to the rest energy of massive particles, leaving less and less for kinetic energy, but that process is reversible. In the second half of a cosmic cycle, the Second Law is, to some extent, reversed. This doesn't mean that broken coffee cups leap from the floor to become whole, but it does mean that the average density of thermodynamic energy in space increases over time, as more and more rest energy is released from its store in the inner dimensions. The important thing is that there is no contradiction in the oscillatory model, as has previously been imagined.

Inflation, therefore, is a hypothesis without a *raison d'être*. The whole point of the inflation hypothesis was to achieve the following theoretical trick: to get from a state of singularity to a very nearly homogeneous cosmos of large but not enormous size. For the latter, there is much physical evidence, most notably in the form of the CMB [37]. It's worth laying this out the elements of this tale very explicitly, so we, as cosmologists, aren't subsequently tempted to fall back on the familiarity of inflation, which has come to be so widely accepted.[6]

[6]Widely *tolerated* is probably a better description.

Listing its ingredients, inflation says that ①, the Big Bang singularity, via ②, a near-instant increase in size by 10^{26} (yes, that's 100000000000000000000000000) times, became ③, a large, hot and very nearly isotropic cosmos. Of these theoretic elements, there is no evidence for ① and ②, other than the large amount of evidence for ③. And the first two elements involve massive suspensions of disbelief. The Big Bang singularity is physically impossible in the most basic way, and the increase involved in inflation is without theoretic parallel, either in concept, mathematics or absurdity. Neither of these two has corroboration beyond the domains for which they were made.

What about Unity theory's take on things? Well, firstly, the Equality model involves no ad hoc hypotheses. It is based on theoretic elements already verified in regard to quantum physics. The three- and eight-dimensional structures of the cosmos and universe were established as necessary with reference to quantum mechanics and the fundamental interactions of the Standard Model of particle physics. And those same structures dictate, following the simplest of symmetry arguments, that the universe must, in the distant past, have been in a state of Equality. From there, space grew, until, at Genesis, with the outer dimensions not that much smaller than they are now, the cosmos formed: large, hot, and very nearly isotropic. This is precisely element ③, as borne out by the data.

10.4 The Structure of the Present

We may now consider the Equality model verified at the expense of the Big Bang. One major question remains, however. Thus far, our discussion of cosmological matters has primarily concerned the universe, and we have yet to analyse the wave of the present in a global sense. We have a good intuition as to why the wave, and with it the cosmos, formed in the first place—it arrived with the stability of the proton resonance, which became the most coherent, thus most favoured, manner in which to store inner-dimensional energy—but we do not, as yet, have a clear *topological* picture of the present, on the scale of the universe. We address this question now.

The image used extensively elsewhere in this book, that of an isolated ocean swell, is insufficient for these purposes. It works in the domain of quantum theory, because the outer dimensions can there be considered as having the open topology of the real number line. But it breaks down as we consider the present sitting within globally closed dimensions. This becomes relevant only on the grandest scales, above the universal cline. We cannot, at that level, imagine the present as a single wave marching across a blank background, because, empirically, it cannot be so. In Unity theory, as we have seen, the formation of the wave of the present comes from a state of near homogeneity, such as produced the CMB. The universe was a sea of radiation at Equality, isotropic in all dimensions, *including* the dimension of progress w. We cannot suppose, therefore, that the wave of the present is a solitary swell against a blank w background. That model is viable locally, for quantum considerations, but needs a global interpretation.

The interpretation is this. In Unity theory, the outer dimensions are closed, having the same spherical structure as the inner dimensions. Globally, the outer dimensions are $S^1 \times S^3$, with (w, x, y, z) as local coordinates. We have defined the w dimension as the local direction of progress, leaving the three dimensions (x, y, z) to form the space of variation within the wave of the present, i.e. space as we experience it. We should note, however, that the above is no guarantee that the local w coordinate corresponds exactly to a global S^1 and that the local (x, y, z) coordinates correspond exactly to a global S^3. Indeed, while the topology of the Unity group $(S^1 \times S^3)^2$ may be considered well verified at certain levels, we have no guarantee that the S^1 and S^3 identities of the components are *permanent*, even given their topological nature; it is almost certain that the apparently nontrivial topology of the universe is generated locally, by the curvature of geodesics. We will address this point shortly. Irrespective of the details, however, it is highly unlikely that the local wavevector of the present $\hat{w}$ lines up exactly with the topological S^1 component of the outer group U_x. There is no reason why it should. Hence, we may surmise that the wavefront of the present isn't precisely oriented in S^3, but has at least a small component in S^1.

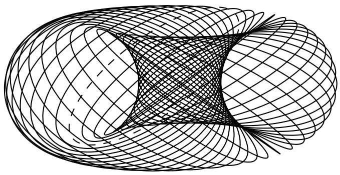
Now, from Equality, it must be true that, in this cosmic cycle as in others, the wave of the present formed more or less simultaneously (speaking in epochs) everywhere in the universe, as enforced by global changes in the size of its dimensions. As before, such simultaneity involves no violation of Lorentz covariance, as Lorentz covariance only applies to the present, not the universe. The oscillation of the universe itself, on whose face the cosmos exists, can drive changes everywhere simultaneously, without any violation of causality.

The wave of the present, and within it our image of the cosmos, came into being at a certain time after Equality. That moment, Genesis, at which the proton became stable, was the birth of the cosmos. Driven by changes in the underlying substance of the universe, it happened everywhere at once. But not, of course, by design. No sculptor's hand was required, only the physical laws governing substance, modelled, in this theory, by the equation $R_8 = 0$. We have no reason to suspect, therefore, that the wave of the present is a single isolated swell. We must assume that, on a very broad scale, every region of the w dimension is, on average, equally populated by waves of protons, such as form our present. Does this mean that there are many presents? Are there many distinct waves, progressing in train like ocean swells do, each of which contains a cosmos? Does the universe house multiple cosmoi? Maybe.

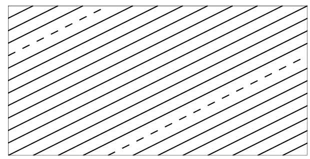
Let us address this. Consider the S^3 component of space as S^1, and hence see (w, x) as a Clifford torus[7] $\mathbb{T} = S^1 \times S^1$. We have already seen the relevant mathematics: the topology of the torus is multiply embedded in the Hopf fibration. Consider the Hopf fibration, then, in a reversed sense, with its fibres and base space switched. In this view, space, which is globally S^3, is a fibre bundle over the circle. Extending this formulation to include w, the outer group U_x can then be considered as a fibre bundle over the Clifford torus $\mathbb{T}$. So, $U_x = \mathbb{T} \times S^2$. Each point on the (w, x) torus $\mathbb{T}$ has a *six-dimensional* (x, y, W, X, Y, Z) fibre, whose product structure is $S^2_{yz} \times U_X$.

[7] A Clifford torus sits in four-dimensional Euclidean space, not three, hence its two product circles are exactly symmetrical. Nevertheless, we must *depict* such a torus as sitting in 3D. Clifford, incidentally, was an early Unity theorist.

So, we are representing the universe as a Clifford torus $\mathbb{T}$. To work with $\mathbb{T}$, we first unwrap it. Using the standard topological representation, $\mathbb{T}$ is depicted as a rectangle with both sets of parallel edges wrapped. In this formulation, the present is a line, whose constituent points represent locations in space, complete with inner-dimensional fibres. In the following diagram, we represent a hypothetical set of cosmoi on the Villarceau circles depicted earlier in the work. One wavefront (our present, say) is picked out with dashes. Unwrapped, we have the local model used throughout this book: the present as an ocean swell.

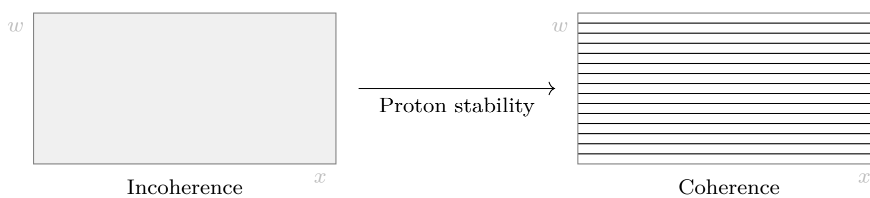


Clifford torus...



...unwrapped

In this model, let us give a second account of Genesis, keeping an eye on topological matters. We begin in the years following Equality, with the inner dimensions small, but not yet small enough to permit stable protons. At this stage, the universe is a sea of radiation and proto-matter, spread isotropically, on a global scale, through (w, x). Large-scale structure has begun to form under the influence of proto-gravity, but only in the most nebulous way. Essentially, the universe remains a sea of radiation. Now, given such an apparently symmetrical scenario, it is reasonable to wonder how the *positive* w direction emerged as the direction of progress. We will address this question in greater depth in the next section, when we consider the discrete symmetries, broken and unbroken, of the cosmos. Here, we note two facts: 1) the w and x dimensions aren't, in fact, symmetrical, and 2) the outer dimensions are matched by a set of inner dimensions. In combination, this gives ample scope for the generation of asymmetry, i.e. the picking out of a consistent direction of progress.

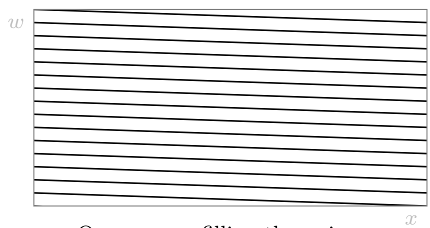


Incoherence

Coherence

When the proton resonance becomes stable, coherent waves of protons can only form if they progress at a fixed rate. The universe, then, can only settle into a globally coherent, hence energetically favoured state if the same resonance appears everywhere. To begin with, proto-cosmoi may collide, even annihilate, but, after some aeons, all waves of protons progress in a steady fashion. This is the manner in which wind forms coherent ocean swells. Now, above, one cosmos is picked out. If we view this as ours, then the universe can be seen to house many parallel cosmoi in front of and behind ours, each progressing at b according to the universal structure of the proton. There is nothing to rule this possibility out in logic. Nor is there any reason, given formation from a prior state of total incoherence, why the situation should end up identical in any two cosmic cycles. The waves that form our reality emerge naturally, as resonances, following physical law: their standardisation across different cosmic cycles is likely to be similar to that of the stripes of zebras or the spots of leopards: eminently characteristic overall, but flexible in individual pattern.

So, the idealised situation described above, with multiple cosmoi, perfectly parallel, progressing exactly in w, seems unlikely, purely by dint of the continuous nature of the universe and the asymmetries involved within each U_x and U_X component of the Unity group. Why should the wavevector of the present come out *exactly* in the direction of the topological S^1_w component of the universe? The chances are overwhelming that it shouldn't. This changes things considerably.

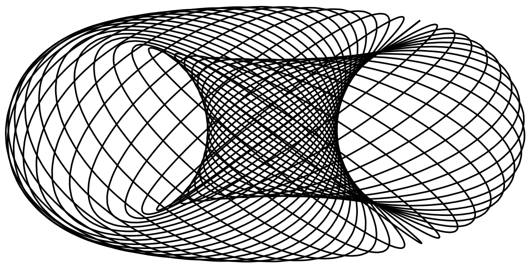


One cosmos filling the universe

Notice that the wavefront depicted is now a single *continuous* line. There is only one wave in the diagram above. That wave has a front with exactly the same spatial S^3 topology as previously, but it now winds many times around the torus, rather than just once. And this conception, while it doesn't rule out the possibility of multiple cosmoi in one universe, does make their hypothesis unnecessary. Ockham's razor suggests, therefore, that we dispense with the idea, and assume a single cosmos, *our* cosmos, coiled helically around the outer dimensions.

Let us analyse this idea in a little more depth. Consider the hierarchy of the strengths of the fundamental forces. Label the strong interaction as having strength 1. Then the electromagnetic interaction, whose dimension is 137 times bigger, is $\frac{1}{137}$ times weaker. Gravity, whose symmetry involves space entire, has dimensions that are some 10^{40} times bigger, and is some 10^{-40} times weaker. This is a simple resolution of the hierarchy problem: the strength of a force is inversely proportional to the size of the relevant dimension. Now, the *weak* force, which is related, at least in its Z guise, to the dimension of progress w, has a strength, on this scale, somewhere around 10^{-16}. This is a very rough notion, as the "strength" of a force isn't well defined. Nevertheless, it suggests that the thickness of the present δw, is, to within some, perhaps many, orders of magnitude, around the 10^{-2} metre range.

Working with this simple estimate for the purposes of visualisation, we can see the wave of the present as 1 centimetre thick in the w dimension, front to back. That leaves an immense amount of the topological S^1 component available. Hence, it is more or less certain, given the observed size of space, that the wave of the present winds a great many times around the outer S^3 component of the universe. Hence, it is highly likely that the physical diameter of the *universe* is, in fact, far smaller than the physical diameter of the observed *cosmos*. Chances are, the cosmos is coiled up around the universe, in the manner that a helix coils around a torus. In the diagram below, the cosmos depicted is a single continuous loop.



One cosmos filling the universe

Such coiling is not observable, of course. All data comes to us in the form of changes *within* the wave of the present, that is to say, it comes to us along the wavefront. Hence, we can only ever see along that wavefront, viz. along the coiled helix of the present as it winds around the universe. The geodesics that light follows as it heads to us from distant stars are actually, most likely, curved helically around the outer dimensions, and the source points of those photons, distant stars, may not be nearly as distant as we once imagined. It is a startling thought. When we look far away into the cosmos, we may be looking at locations that are, with respect to the universe, only a matter of metres away from us, in a direction orthogonal to perceived reality.

Tantalising scenarios spring to mind, involving departure from the wave of the present. For now, these are pure science fiction, of course, at least until we can construct stable matter based on something other than the proton, but we should never say never. Who knows what possibilities the future will bring? Either way, it is worth noting that, without any cataclysmic rips in the fabric of the universe, though certainly involving them in the fabric of the *cosmos*, virtually instantaneous interstellar space travel is, in the broadest sense, possible.

10.5 Discrete Symmetries

The structure described above, of a single cosmos wound around the universe, offers insights into the observed symmetries of our perceived reality, and, in particular, their unexpected violations. It has long seemed mysterious, ever since Dirac's prediction of antimatter in 1928, that the cosmos should contain almost exclusively electrons as opposed to positrons, and protons as opposed to antiprotons. Within the Big Bang model, there is no justifiable explanation for this, though a number of spurious arguments exist under the title "baryogenesis". Those are obsolete, of course, since there was no Big Bang. So, what takes their place?

Firstly, we should note that "antimatter" is a slightly nebulous concept. It refers to negatively charged protons and positively charged electrons, i.e. to the opposite of what is commonly found. Hence, on one level, it is no surprise that there is less antimatter, as antimatter is defined to be "that which is out of the ordinary". However, that ignores the fact that baryonic mass is overwhelmingly positively charged. This asymmetry between protons and electrons demands explanation. We present such an explanation here.

In Unity theory, the proton is positively charged because the electron is negatively charged. Electromagnetic charge is not symmetrical when it comes to baryons and leptons: the electron's mass *is* its charge, the proton's mass is almost exclusively *orthogonal to* its charge. It is the electron that has quantised charge, by dint of its resonance in the leptonic W dimension, and the proton that follows suit, in order to achieve the lowest-energy configuration. Hence, the issue of a preponderance of matter over antimatter boils down to the issue of a preponderance of electrons over positrons. In turn, when considered in the definitions of Unity theory, this boils down to the existence of a chosen direction for resonant energy in W.

> The question of broken *charge symmetry*: Why is there a chosen direction in W?

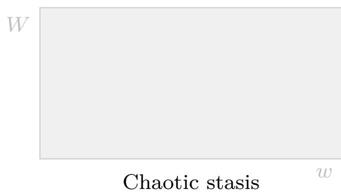
The same asymmetry exists in the outer w dimension, as we have already seen. It is clear, both on theoretic grounds and from the empirical fact of the historic stability of the cosmos, that the wave of the present does not meet significant waves coming in the opposite direction. In other words, there are no "anti-cosmoi". A chosen direction of progress exists in w. Independently of any helical winding, the massed ranks of the swells of the wave of the present proceed together, in coherent fashion. Since the w dimension is, like the W dimension, circular, this parallelisation requires a consistent wavevector $\hat{w}$, that is to say, a chosen direction of progress.

This same asymmetry does not exist in space or inner space, at least to nothing like the same degree. Both are, to a good approximation, isotropic. Hence, we may consider the question of matter/antimatter asymmetry as being tied, in large part, to the W and w dimensions, which are the equivalent inner/outer S^1 components of the Unity group. Both of these dimensions exhibit maximal asymmetry within the observable cosmos. But this very *duality* resolves the issue. Parallel flow in *one* circular dimension would require the universe to have non-zero angular momentum, which, logically, we cannot countenance. But *two* such dimensions is a different matter.

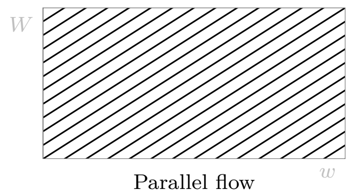
Consider a locally parallel flow of energy across the Clifford torus $\mathbb{T} = S^1_w \times S^1_W$. Such a flow marks out a local direction in both w and W. This breaks local symmetry in w and W, within the perceived cosmos. Nevertheless, the *global* angular momentum is zero. Such a toroidal flow rotates within and around itself. While perfectly continuous and everywhere smooth, the flow is only *locally* parallel. While asymmetry is outlawed, asymmetry twice over isn't. This possibility—imbalance in perception underpinned by balance in reality—only emerges in a universe of even dimension: it reflects the deep symmetry that exists between the U_x and U_X components of the Unity group.

We have resolved the first aspect of the symmetry conundrum. *How* can there possibly be asymmetry in physics? The answer is simple. Asymmetry in perceived reality demonstrates that perceived reality is not reality. But we already knew this, of course. So, on to the second aspect: the *why* of things. We have shown that asymmetry is logically feasible; chosen directions in both w and W together permit global conservation of angular momentum. But we haven't yet explained *why* such asymmetry exists. That is the next task.

If there is to be a chosen direction in both w and W *anywhere* in the universe, then Continuity dictates that it must be chosen symmetrically *everywhere* in the universe. This leaves two possibilities. On the (w, W) torus, on the grandest of scales, there could either be a) chaotic stasis, with waves moving every which way isotropically, or b) a global, locally parallel flow.



Chaotic stasis



Parallel flow

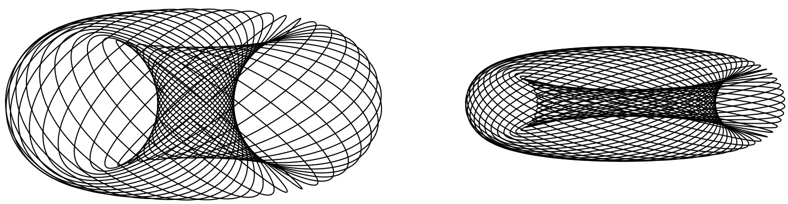
In terms of maintaining universal symmetry, both of the above are logically viable. But the evidence tells us which one is true: b) parallel flow. We know, from the empirical fact of charge and progress asymmetry, that there is indeed a chosen direction on the (w, W) torus. The question, then, is *why*. Why, following the symmetry of Equality, should the configurations that come to roll across the face of the universe end up with non-zero average momenta? Let's see.

We noted, early in this work, that the universe is only *locally* a product space. The axiom of Unity demands this, as a circular dimension has a hole in the middle. Those holes cannot be non-substance, because, according to Unity, there is no such thing as non-substance. So, the S^1 topologies of the w and W dimensions cannot reflect the existence of *true holes*, i.e. punctures in the universe, but must point instead to the twisted structure of geodesics. Riemannian curvature can, of course, *mimic* the effect of a topological hole. If a matter wave such as an electron, progressing along a helically twisted geodesic, is returned close enough to itself to allow for resonance, then torsion can *act* like a circular dimension. According to Unity, this must be the way of things.

But why should the geodesics of the universe be twisted in this way? An answer emerges from a consideration of the grand oscillation of the universe, over a cosmic cycle. At Equality, when no dimensions are small, such torsion must be as gentle as it can be. Symmetry and simplicity suggest, therefore, that there is, in fact, *no* such torsion at Equality. This idea removes, at long last, *all* secondary hypotheses from the Unity idea. In this conception, even the S^1 and S^3 components of the Unity group are themselves emergent, and, in its true essence, the universe is immaculate, a shimmering eight-dimensional sphere of pure topological, as well as geometric, symmetry.

Conjecture. *The immaculate topology of the universe.* At Equality, the universe has the topology of S^8, the eight-sphere. The product structure of the Unity group then emerges in the torsion of Riemannian geodesics, following the expansion/contraction of four-dimensional components.

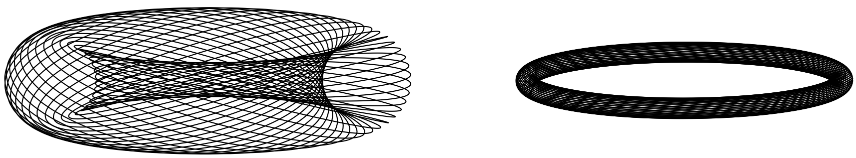
The expansion/contraction of the universe must follow physical law. In particular, it must seek the lowest-energy configuration. If fourth-order expansions and contractions, viz. scalar gravitons, can be avoided, then they will be. Likewise down the hierarchy, through third-order vector gravitons, second-order Higgs bosons, first-order fermions and zeroth-order bosons. Photonic shears are the end of the line, which is why the cosmos is full of light. And a Clifford torus *can* shear, enacting a global expansion and contraction of its major and minor axes, without any local expansion/contraction of substance itself. In the diagram below, such a transformation is enacted: the circles that form the first torus are congruent to the circles that form the second. A shear transformation has been enacted, turning square elements in rhombic ones:



As the universe departs from Equality, Murphy's law applies. Energetically, what can happen will happen. Hence, since there is a bosonic shear topologically available, it must be favoured. Whatever else goes on, as the universe expands/contracts, the toroidal shear described above *must* take place. This, then, is what picks out the w and W dimensions from among the eight, to play their subsequent special roles: they are the dimensions in which the universe itself shears, at the broadest level.

And what effect does this have on the forming cosmos? Well, as the universe expands/contracts from Equality, energy must flow from one dimension to another. As the $\mathbb{T} = (w, W)$ torus is picked out topologically, asymmetries must appear between the S^1 dimensions and the S^3 components formed as a byproduct. This S^1 versus S^3 asymmetry doubtless produces flows of energy between the components. And, at the same time, w and W are departing from their own symmetry. So, we have surface flows of energy into $\mathbb{T}$, while $\mathbb{T}$ is shearing to a state of asymmetry. With flows of momentum taking place against a backdrop of continually shearing geodesics, gyroscopic forces must come into play. The combination of energy input and universal torsion generates, in the forming cosmos, a locally parallel flow in (w, W).

But now consider once again the transformation above, by which the first torus shears to become the second. Continue that transformation, and take it to the extreme of the present day, such that the minor axis of the torus is quantum sized. At this point, the circles are so flat that the average momentum runs, effectively, around the torus's major axis. What ensues? Around the major axis of the torus, now called w, we have total asymmetry: the wave of the present progresses in one direction only. Around the minor axis of the torus, now called W, we have charge symmetry, yes, in that the total momentum around that axis is effectively zero, but nevertheless an underlying asymmetry remains in the leptonic resonances that populate the dimension. This, it would seem, is why the present progresses so coherently in w, and why virtually all resonant W-energy is negatively charged.



The question of $\mathcal{CPT}$: Why are the $\mathcal{C}$, $\mathcal{P}$ and $\mathcal{T}$ symmetries violated individually?

The above is a major question of physics, and Unity, reassuringly, offers a resolution of it. Once again, it comes down to the fact that the observed cosmos is not the full extent of the universe. While the universe is, as everyone has always known, globally symmetrical by definition, the cosmic waves that form within the universe, of which our present is one example, are not. Our perceived reality has asymmetries because our perceived reality is itself a physical entity that exists within (both dimensionally and spatially) a broader domain. With the overall idea established, let us define the discrete symmetries of the universe explicitly, and see why and when they hold in the cosmos.

Dimension	Component	Topology	Name	Symmetry
w	Outer	S^1	Time	$\mathcal{T}$
x, y, z	Outer	S^3	Parity	$\mathcal{P}$
W	Inner	S^1	Charge	$\mathcal{C}$
X, Y, Z	Inner	S^3	Inner Parity	$\mathcal{X}$

Two points warrant immediate attention. Firstly, "Time" symmetry is, in fact, something of a misnomer, as there is, by definition, complete asymmetry in the temporal parameter t. In Unity theory, nothing goes backwards in time; the statement itself is meaningless. Time is simply that which marks processes of change. Change happens; it cannot unhappen. However, the w dimension is, as we know, closely *related to* time, since the wave of the present progresses at approximately constant speed b. So, there is a symmetry *related to* time, $\mathcal{T}$; it refers, however, to reflection in the space-like outer dimension w. A reversal of w would certainly look like time running backwards.

Secondly, since S^3 is simply connected, the additional $\mathcal{X}$ symmetry—point reflection in inner space (X, Y, Z)—while undoubtedly a symmetry of the universe, doesn't feature in the laboratory. It is included here only for purposes of logical completeness. The topology of inner space implies that no distinction can be made by matter-based beings such as ourselves between its $\pm$ directions, viz. between quarks and anti-quarks. Now, since $\mathcal{P}$ symmetry is violated in the cosmos, we may be very confident that, in fact, $\mathcal{X}$ symmetry is too, but, seeing as the relevant differences are not observable, it is something of a moot point.

So, we have three symmetries of the universe, $(\mathcal{C}, \mathcal{P}, \mathcal{T})$, which are observable. And all have been observed to be broken. Why are they so? Well, $\mathcal{C}$ and $\mathcal{T}$ are not symmetries of the cosmos, because there is, at the present point in our cosmic cycle, a locally parallel flow of momentum around the (w, W) torus. The key to understanding this is the recognition, as discussed, that the (w, W) dimensions are not prefabricated dimensions in any absolute sense. We need assume no creator's hand, no arbitrary assignation of topology, only an energetic eight-dimensional sphere. Asymmetry is then dictated by the torsion of Riemannian geodesics.

Parity symmetry (and, presumably, inner parity) is violated for the same reason, but to a much lesser degree. This is due to the topology of S^3. It is w and W that bear the brunt of the shearing torsion of the universe's expansion/contraction. Indeed, as stated earlier, this is what *defines* the w and W dimensions, which emerge, in the Equality model of Unity theory, from the broader physical processes of the universe. This leaves space very close to isotropic. Nevertheless, we would expect no aspect of the cosmos to be unaffected by the expansion/contraction of the universe. Hence, it is no surprise to find that parity symmetry fails to hold.

Why does the combined symmetry $\mathcal{CPT}$ hold, then? Because applying $\mathcal{CPT}$ (and, implicitly, $\mathcal{X}$) involves reflection in *every* dimension at once. This means a total reversal of the motion of the wave of the present, in all its minutiae. Reversing (W, x, w, X) allows for travel backwards along identical geodesics. This behaviour is analogous to that of a corkscrew. Once a cork has been pulled, the corkscrew can be removed and reinserted into the same cork, backwards, without the need to make a new hole. While the geodesics of the universe bend in nontrivial ways, they do not, in themselves, have an intrinsic *direction*. Geodesics never do. They simply mark the shortest paths between points. Hence, a fully reversed cosmos, in which the electrons and protons change roles $(\mathcal{C})$, the dimensions of space $(\mathcal{P})$ and inner space $(\mathcal{X})$ are point-reversed, and the wave of the present changes direction $(\mathcal{T})$, would behave exactly as ours does.[8]

[8]The above argument resolves the long-standing mystery of *chirality* in particle physics. The concept itself needs detailed elucidation in subsequent work, but the broad idea is now easily explained. The topological W and w dimensions, which are the dimensions of weak decay, are formed from the torsion of geodesics, so it is no surprise to discover that particles of different handedness behave differently within them. In the current epoch, the universe itself is in a state of torsion, so the wave of the present is bound to follow a helical path through its geodesic structure. The substance backdrop against which the cosmos moves is, in fact, twisted like a roller-coaster; the cosmos is then the carriage that follows the tracks. We cannot feel the turns, of course, because, in both space and time, they are extraordinarily smooth, but their effects show up in the mathematics nonetheless.

11 Conclusion

The strength of Unity theory lies in the simplicity of its foundation. While the details of some of the deductions in this book will undoubtedly be incorrect, either partially or wholly, the paradigm as a whole stands independently of the frailties of any attempt to describe it. You can either accept the axiom of Unity or you can deny it; there is no middle ground. To deny it is, in one way, reasonable enough: nothing in this book *proves* that the universe is one substance. To hijack Russell's idea, it is logically impossible to rule out the existence of a multi-substance teapot orbiting the Sun between Mars and Jupiter. There can be no guarantee against evidence that emphatically breaks the axiom of Unity, because such guarantees never exist. That is the whole point of the scientific method.

However, the wide-ranging arguments presented in this book suggest that nothing in current physics is in disagreement with the axiom. While there are a great many concepts of physics, philosophy and indeed everyday life that would, at first glance, appear to necessitate multiple substances for their explanation—the numerous distinct particles of the Standard Model, for instance—these apparent contradictions fade on closer examination. Sandcastles are revealed as sand. We have demonstrated that the existence of many discrete types of particles is consistent with Unity theory: the particles exist at a higher conceptual level than substance, that is to say, as configurations of it. Unity theory describes the structure of the major elements of the Standard Model, both qualitatively and quantitatively. Now, the Standard Model is complicated, and we can make no claim of having explained or even understood it fully. But no one has done that. In the end, Unity theory, in its first iteration, doesn't have to explain and justify every nuance of physics. Given the wealth of phenomena it does successfully explain, its global validity rests on *possibility*.

The list of explained concepts and theories is long and broad: the Schrödinger, Klein-Gordon and Dirac equations, fermionic and bosonic statistics, the meaning of the Planck constant, the Planck-Einstein relation, antimatter, wave-particle duality, special relativity, the action principle, the masses of the fundamental particles, the structure of the neutron, the nature of the neutrino, neutrino oscillation, the generations of the Standard Model, the symmetries and physical natures of the fundamental interactions, weak boson mass, symmetry breaking, confinement, the Hilbert action, general relativity, galactic rotation curves, cosmological expansion, the cosmic microwave background, not to mention the twin paradox, Mach's principle, entanglement, nuclear structure and renormalisation, which we address in appendices to this book. And all of the above emerge from a single, mathematically consistent model.

We would be shooting ourselves in the foot to a most extraordinary degree were we to reject Unity theory on the grounds of its not having explained *everything*. Such a task is impossible. In any case, it seems unimaginable that the axiom of Unity could have offered more than it has. Everywhere, it has produced comprehensible solutions, where previously there was only confusion and complexity. It is beyond doubt that, in terms of consistency, simplicity and scope, the new paradigm is superior to the old.

But theoretic superiority does not necessarily equate with truth. Temporal eternity rules out design, so we cannot, on logical grounds alone, deny the possibility that the universe is, in fact, ugly—pixelated and ramshackle—as has been implicitly claimed by the old school. In this, personal choice is the deciding factor. There will be those who, so as not to have to deal with the human implications of Unity theory, will hold to the old ways, preferring to believe that the reality we live in is broadly as Newton described: a three-dimensional box with stuff in it. This is the incumbent view worldwide, such as has been disseminated to the farthest corners of the globe by centuries of Western science. And the familiar is always tempting. There is, as Max Planck pointed out, little point in attempting to teach old scientific dogs new tricks. Those who are willing to stomach ugliness for the sake of naive ideas do so not on scientific grounds but on emotional ones. There is, as such, little point entering into intellectual debate with those who deny the *possibility* of Unity's truth.

The true test of Unity will come from those hard-nosed yet personally courageous physicists who allow such possibility, and subsequently set about analysing it in a rigorous scientific fashion. There is no doubt that the content of this book is unusual in scientific terms, as it breaks through a glass ceiling that has previously been (un)seen as firm: the equation of perception and reality. However, just because Unity theory is, in old terms, somewhat wild does not put it beyond the realms of science. Science is a way of thinking, a way of analysing data, a way of drawing conclusions; it is not, as fools hold, a particular worldview. The equation of perceived reality and reality, such as has dominated the West for centuries, is a scientific *model*, not a precept of science itself. Historically, in classical and quantum physics, we have modelled reality and our perception of it as existing in the same domain, namely spacetime, but that was only ever an assumption. It has turned out, like so many hypotheses, to be factually incorrect. As a result, science is due a massive overhaul.

11.1 Validation and Falsification

Is Unity falsifiable? This question has a number of facets. The first of these is whether the axiom of Unity, the foundation of the theory, is directly falsifiable in itself. This is an important question, but it is worth noting that its answer is not as simple, nor could it ever be as simple, as some scientists and philosophers of science are keen to make out. For example, is it a falsifiable proposition that space has three dimensions? Yes it is. If space had four dimensions, we would know about it. Three-dimensional theories of classical mechanics would fail. But they don't. Space is generally agreed to be three-dimensional. However, is there any *direct* experiment which could be said to offer "falsifiability" of the three-dimensionality of space? It is hard to say. The reason is that space *is* three-dimensional. As a result, you can't find a way of bringing out any potential four-dimensionality in it, because there isn't any.

The same applies to Unity. If the axiom is false, then the universe is constructed of more than one substance. If the universe is constructed of more than one substance, then surely there should be an example of a physical experiment which demonstrates the fact. It would be most bizarre if it turns out that the world is constructed of multiple substances, but that it is simultaneously impossible to find a phenomenon that necessitates multiple substances for its explanation. The axiom of Unity is a binary true/false, and it should, if it is false, be possible to prove it false. It is, after all, a very simple fact. Now, the contents of this book suggest very strongly that it is impossible to construct such an experiment, because the axiom of Unity is true. That does not, however, mean that Unity theory is unfalsifiable. There is a world of difference between 1) true, therefore incapable of falsification, and 2) unfalsifiable due to endless tunability. In both cases, no experiment exists that could falsify the theory. As is the case with the three-dimensionality of space, the likelihood is that there is no possibility of direct falsifiability.

In science, qualitative ideas are just as important as quantitative ones, but they must be treated in a different way. The axiomatic foundation of Unity theory stands or falls by dint of its explanatory power, just as the three-dimensionality of space does. The three-dimensionality of space is a qualitative idea, but it is nevertheless falsifiable, since it is a mathematical framework *within which* a vast number of different experiments have been successfully performed. Unity, while it doesn't yet have the same depth of historical analysis, can, does and will sit the same examination. The axiom of Unity is such a fundamental thing that it probably doesn't permit direct testing, but nonetheless, it does permit *validation*.

For example, returning to the beginning of this book, the axiom of Unity produces the Schrödinger equation. There is no leeway in the derivation. If we agree with the logic of the derivation, then tests of the Schrödinger equation are tests of Unity. It doesn't matter that Unity theory was discovered after the Schrödinger theory, with the Schrödinger theory already well verified, because the derivation was not tunable. As a piece of pure mathematics, it brooks no adjustment. The same is true of special relativity, which is validated to the most extraordinary degree. The model built on Unity theory could perfectly well have produced something similar to, but not the same as, the Lorentz factor, but it didn't. It produced γ exactly, with no wiggle room. It would be unscientific to see this as coincidence.

The first and most important test of Unity, therefore, is a rigorous analysis of the logical arguments given in this book. If the logical arguments hold, then the Schrödinger equation and special relativity alone, even without the many subsidiary results that follow, are sufficient to warrant rejection of the spatial paradigm. In this, the most important arguments are the *simplest* ones. Inevitably, a more complex argument regarding a more complex subject allows for more flexibility and possibility of error. The proposed structure of the proton, for instance, is by no means set in stone in its factors of two, and work is needed to elucidate it in more detail. But the simplest elements stand on firmer logical ground. So, a primary test is this:

Do the theories of Newton, Maxwell, Lorentz, Einstein, Schrödinger, and Dirac follow logically from the axiom of Unity, as claimed in this book?

11.2 Practical Tests of Unity

The theory presented in this book finds its way into a great many subfields. This is no surprise, as its axiomatic structure is as fundamental as an axiomatic structure can be. The axiom of Unity is relevant to everything, because it underpins everything. So, within the scope of the theory, there are many subsidiary hypotheses, many of which, in turn, should allow for direct laboratory testing. However, we will not have to wait even that long. Such is the nature of the beast, there will doubtless be many experiments *already performed* which may cast light on the Unity model and serve to validate or falsify aspects of it. The scope of the theory is such that its author could never claim to be an expert in its many subfields, nor to be familiar with the vast wealth of pertinent experimental data. Hence, it is certain that copious and major relevant experimental results will have been overlooked. Such experiments offer immediate testing of the Unity model, in ways that cannot be foreseen here. It is to be hoped that experimental physicists in many fields will be able to point to prior experiments that pertain to this or that facet of the new paradigm.

Those experiments are the unknown unknowns. But there are also a number of clear ways in which the Unity model, in departure from the incumbent paradigm, offers up opportunities for *direct testing*. Inevitably, these are of secondary hypotheses rather than primary axioms, since, as we have seen, the axiom of Unity produces (so long as the logic is correct) the same theories of quantum fields and gravitation as are currently used. In the fundamental aspects, Unity agrees with current physics. It is only in various secondary hypotheses that we see differences appear between the practical predictions of Unity and the mainstream; hence, it is only with regard to those secondary hypotheses that we can achieve direct testing.

This has advantages and disadvantages. Those secondary tests cannot be seen as offering full falsifiability of Unity itself, as it is possible, indeed likely, that one or more of the secondary hypotheses of Unity theory is, indeed, false, even assuming the truth of its axiom. Nevertheless, we may assume that the axiom of Unity itself, as the *primary* entity, will stand or fall by its logical link with the *primary* equations of physics, as discussed above. Hence, we should see these secondary tests as tests not of the axiom of Unity itself, though they may certainly offer some evidence for or against it, but rather of the model that stands atop the axiom, a model which will require very significant modification and elaboration from the simple and doubtless flawed form in which it is presented here.

The secondary tests cannot test Unity itself. This, however, puts them firmly in familiar domains of practical empiricism. For example, the beta boson hypothesis. The quark and the beta boson models of the neutron offer different views, not merely at the fundamental level of substance, but at the *observable* level. Much of Unity theory talks of what is going on behind the scenes, which renders it necessarily difficult to test directly. But the structure of the neutron is a simple neoclassical fact. There seems no reason why experimental physics shouldn't be able to distinguish between the quark and beta boson models. If the up/down quark model were thus validated, that would pose a significant blow for Unity theory, as it is hard to see how a neutron could exist, within the Unity paradigm, in any other form other than as a proton tightly bound to a negatively charged electron-like particle. This wouldn't be total falsification, but it wouldn't be far off it. In this regard, as in many others, Unity can be tested.

However, we should be clear. In such regards, Unity needs no direct proof, because the old paradigm has none. The beta boson model, say, requires little to be superior to the up/down quark model, because there is no physical evidence, either direct or indirect, of the existence of up and down quarks. So, the up/down quark model and the beta boson are, as it stands, at the same level of empirical validation. The only power the up/down quark model has is that of the incumbent. But this should, of course, be disregarded in any careful scientific analysis. The scientist who is thinking clearly analyses only the facts, and pays no attention to what has been believed in the past. Hence, even if no active discrimination is possible between the up/down quark model and the beta boson model, then we should, according to Ockham's razor, adopt the beta boson model, as it is in every way simpler and more logical.

It is no coincidence that the differences between the Unity model and the incumbent paradigm lie in areas of physics that are harder to get at: the very large and the very small. This represents a challenge to experimental physicists. The difficulty will be that, in such hard-to-probe areas, *interpretation* of experimental results is every bit as important as the results themselves. Gone are the classical days of pure experiment, in which one could see sphere 1 hit sphere 2, and record momenta. Unity theory itself dictates that neutron scattering, say, will never produce an unambiguous, model-independent[1] picture of the internal structure of the neutron, because all measurement of the results of scattering experiments is measurement by electrons, and electrons are a very specific piece of measuring apparatus.

Hence, even in these secondary tests, we must look to the big picture. The question is: *does Unity work*? Across many experiments, across many fields, does the idea hold together? This is not a question that can be answered immediately, which is why the personal courage of individual physicists is going to be so important. The only reason to work with the Unity model is because one has a sense that it is, in some sense, right. A physicist who is determined to hold to previous ways of thinking will push this feeling aside. This represents a grave danger: that Unity theory will simply be rejected by some, not on logical or scientific grounds, but simply because it is too large an idea. This problem cannot be overlooked, even (especially) among the educated and clever. The incumbent paradigm—space as the backdrop to reality—is well entrenched, but very likely false, and there is nothing that alarms people used to falsehood like the sudden arrival of truth. When a view of reality is incorrect, it is human nature to defend that incorrect view, at least until such a time as the mind has made its peace with the alternative.

[1]Here, we only use the nonsensical term "model-independent" to point out its absurdity. The fact that this ludicrous term has crept into a number of fields of "science", physics included, goes to highlight the extent to which some who like to call themselves "scientists" are little more than dogmatists. What are numbers? What is statistics? What, for that matter, is the term "*model-independent*"?

So, it is crucial that we, the rational people of the world, find the courage to assess Unity theory dispassionately. No leaps of faith are required, no learning of complex mathematics. Only courage. It certainly takes courage to say "What if space isn't the backdrop of reality? What if reality is deeper than I have hitherto assumed it to be? What if the material world is just the surface?" Even to admit the possibility is to open the door, to step outside of Plato's cave. And the view that emerges, to those with the strength to open their eyes to it, is a beautiful one. Reality, life, the world we live in: these are broadened in Unity theory, from the play of mere physical matter to the representations, in perception, of a universe in which many are one, in which a perfect continuum exists between all things.

The dispassionate analysis that permits rationality in this vision begins with a logical dissection of the mathematical foundations, and continues with experimental testing of the secondary hypotheses that emerge on the basis of those foundations. Here, we list the most obvious practical tests, in order of appearance in this book.

1. **The masses of particles**. The particle masses derived in this book, of which the most notable is the proton mass, are first-order approximations based on linear wave mechanics. Using the second-order Higgs field and/or Riemannian tensor analysis, it should be theoretically possible to derive second- and higher-order approximations, and to compare these values with experiment. The proton, with its complex structure, is unlikely to be the first particle whose mass will succumb to such precise calculation; the pion and the muon seem the most obvious candidates. The long-term test will be whether the same mathematics can be used to produce the full array of particle masses.

2. **The weak mixing angle.** The proton structure given in this book dictates a theoretical value of $\theta_W = 30°$. The observed value is closer to 29°, and varies depending on the energies involved. In the same manner as with the particle masses above, it should be possible, in the long term, to derive second- and higher-order approximations for the weak mixing angle, and to compare these with observation.

3. **The structure of the proton.** It has emerged, in experiment, that the proton has internal structure. The quark model says that this structure is based on three non-identical particles, closely bound. The Unity model states that the three-quark nature of the proton is, in fact, an expression of the three-dimensionality of the inner space in which the proton resonates, and that the proton consists of four orthogonal coprogressing waves. The Unity model states that the four component waves of the proton are exactly colocated in space. A careful analysis of scattering experiments should be able to distinguish between these scenarios. Firstly, does the proton consist of three spatially separated charges, as implicitly claimed by the quark model, or does it consist of three dimensional components, as claimed by Unity theory? Secondly, is the division of electric charge between colours an asymmetrical $\left(+\frac{2}{3}, +\frac{2}{3}, -\frac{1}{3}\right)$ or a symmetrical $\left(+\frac{1}{3}, +\frac{1}{3}, +\frac{1}{3}\right)$?

4. **The structure of the neutron.** In the Unity model, a neutron contains a proton. In the quark model, it does not. This should be evident in scattering experiments. The Unity model predicts that the behaviour of the nucleons should be virtually identical with regard to the strong interaction, while the quark model predicts (only in a woolly sense; it doesn't make a firm prediction here) that the behaviours should be significantly different. With regard to electromagnetism, we have a similar situation. The quark model suggests different photon scattering behaviours from *uud* protons and *udd* neutrons. The beta boson model, however, suggests very similar scattering behaviours, since any photon that can scatter from a proton must have a high frequency that makes it effectively blind to the presence or absence of a low-frequency beta boson.

5. **The top resonance.** The top resonance, at 173 GeV, is seen very differently in the Unity and quark models. The Unity model proposes that the top resonance has little in common with the quark idea, and is instead a second-order proton, that is to say, an excited state whose large mass derives from quadratic expansions of substance, viz. interaction with the Higgs field. There are many distinctions between the two views. Electromagnetic charge is the most obvious. In the quark model, the charge of the top is strictly $+\frac{2}{3}$. In the Unity model, since the top is created in high-energy collisions and decays before it can bind with electrons, it has a *continuum* of charge.

6. **Galactic rotation curves.** Unity theory predicts the existence of a radiative gravitational force, beyond general relativity and Newtonian gravity, here called the graviton force. The graviton force, which is comparatively very weak, falls off linearly with distance, and therefore only becomes relevant in regions of ultra-weak Newtonian gravity. However, in those regions, broadly defined as those regions yielding accelerations below a_0 as defined in MOND, Unity theory predicts that the graviton force is the *only* non-negligible force. This means that Unity theory and general relativity give markedly different predictions for galactic rotation curves. Given that dark matter is an ad hoc, untested and infinitely fine-tunable hypothesis, it should be discounted from any comparison. To qualify as scientific, any analysis should distinguish only between 1) Newtonian gravity as generated by directly observable matter, and 2) Newtonian gravity plus the graviton force as generated by directly observable matter.

7. **Large-scale structure formation.** In Unity theory, the graviton force dominates at large scales. Hence, while static Newtonian gravity is responsible for structure below the galactic scale, Unity theory predicts that the large-scale structure of the universe forms under the influence of a force that drops off according to r, not r^2. Unity theory, therefore, predicts large-scale structure formation on a far grander scale than Newtonian gravity does. Analysis of the structures of the universe should be able to distinguish between formation under Newtonian gravity or the graviton force. Again, given that dark matter, dark energy and

inflation are ad hoc, untested and infinitely fine-tunable hypotheses, they should be discounted from any comparison. To qualify as scientific, any analysis should distinguish only between 1) Newtonian gravity as generated by observable matter, and 2) the graviton force as generated by observable matter.

8. **The Cosmic Microwave Background.** It is likely that we will be able to assess the graviton force without reference to the CMB; independently of the Unity model, this will tell us whether general relativity can be applied to the distant past. If the graviton force is shown to be the major cosmological player, then general relativistic models of cosmogony are incorrect, which would mean that explanations of the anisotropies in the CMB have, hitherto, been an exercise in fine-tuning. In this regard, the bar regarding the CMB is set very low indeed. As such, Unity theory needs only approximate, first-order agreement with the data to outperform the old paradigm. Once again, as we consider modes of comparison, we must be careful to ensure that fictions such as inflation do not muddy the water. Again, the comparison should be made between general relativity alone and the theory of Equality introduced in this book. Without the addition of any ad hoc hypotheses, which of the two gives a more accurate account of the phenomenology of the CMB?

11.3 Final Remarks

Unity theory matters. This is not said with a view to aggrandisement of its author, who, as neither a physicist nor a philosopher of physics, is not interested in creating or maintaining any particular version of the truth, but rather in discovering what the truth *is*. This book may or may not constitute an accurate description of the facts of the universe; regardless, the facts of the universe existed long before its writing, and will continue to exist, according to the theory, for infinite years beyond. It is more or less impossible, within Unity theory, to take an egotistical view.

Let us rephrase, then. The *facts of reality* described by Unity theory matter. They matter in the most practical, tangible way. It has long been evident, to those possessed of some perspective, that Western societies, for all their material riches, are poor in human terms. Our addiction to consumption and our consequent abuse of this planet's resources are but the most obvious and tragic manifestations of this affliction. While our lives are certainly a great deal more materially pleasant than the lives of those who lived in ages past, there is little evidence that we are better off in the ways that really matter. Indeed, the evidence seems to suggest the contrary.

This is not to bemoan the advances of science, as some cultural apologists have come to do. The long centuries of science have achieved extraordinary things, and to hark back to a rose-tinted image of primitive cultural utopia is foolishness. We are who we are. Yet those who claim that we now live in a rational utopia are equally mistaken. We have gained, and we have lost. What we have gained, we should enjoy, but that enjoyment shouldn't serve to hide what lacks. It isn't as simple as better or worse.

For some centuries now, it has been science that has led the way in telling people "how it is". And how important that was, given the superstitious mess of the previous religious paradigm. But we are now faced with a profound fact: the view espoused by modern science—the idea that material reality is the extent of reality—is almost certainly false, in a very specific way. It was the grand assumption of the Age of Enlightenment, silently made: we exist as material beings in a three-dimensional domain. There are few more keenly double-edged swords.

The importance of Unity theory is this: the deeper life of the human being, such as takes place behind the material surface we perceive, is not some superstitious fiction. It is a simple mathematical fact that the physical universe is simpler, more complex, deeper, and more deeply *connected* than the spatial paradigm suggests it is. According to Unity theory, vital questions of the human condition, deep questions of the rational divine which have in recent centuries been banished into unscientific realms become empirically real once more. Pressingly so, indeed.

Among the deepest is that concerning the seat of consciousness: "Which entity is conscious of a human life?" Now, in the old paradigm, on topological grounds, there was only one viable answer to this: the human itself. That implicit axiom sits at the core of the materialist view that has come to dominate debate in the mainstream. In modelling the conscious witness of life as an object in space, as a material thing, as a disconnected island in a foreign sea, our intellectual ancestors rendered many deep theories of mind inapplicable, much to the detriment of the life of the soul.

But they were wrong. Factually. According to Unity, the universe is a pure continuum of substance, and everything we know of, everything we model, everything we have a name for is a configuration of that substance. A photon, an electron, an atom, a molecule of DNA, a neuron, a brain, a mind, a body, a human being: these are all names for configurations of one continuous substance, sandcastles in the sand. There are no dividing lines. So, on what grounds, setting aside the logic of space, do we place awareness within the brain? The brain is an entity in *perceived* reality, not reality itself. In actual fact, our bodies aren't spatial objects moving in three dimensions, they are complex waveforms in eight. We ourselves are eight-dimensional. This may sound far-fetched to materialist-rationalist ears, the ears of the world of appearance, but that is just the way of the old paradigm. These are simply the scientific facts, as supported by the evidence of experiment.

Consciousness is a complicated thing. It's a very complicated thing. Indeed, it is fair to say that consciousness is the most complicated thing in the universe. It *demands* explanation, in any worldview. And, given that a human being is, in fact, a configuration of eight-dimensional substance, what possible reason is there for suspecting that the entity that is *aware* of a human life is a three-dimensional object in space? Only the mindset of classical physics suggests such a naive view. The error is analogous to that of imagining the icons on one's computer screen to *be* the underlying programs, as opposed to their being symbols for and thus links to what lies beneath. In this, as in so many things, we in the West have been greatly mistaken.

In fact, given the Continuity of all things, logic dictates that the most likely seat of consciousness is not the human being but rather the universe itself, which, as the higher-dimensional entity, has far greater capacity for complexity and greater access to the same information.[2] This idea, which like all deep ideas sounds like nonsense to the shallow, is expressed clearly in many philosophies, both ancient and modern, both psychological and religious, both Eastern and Western.[3]

The way we view the world matters; the way we speak of that world matters; the way we educate our children matters. In scientific society, we have, for many years now, taught our young that everything beyond perception occupies the same class of existence as the unicorn, i.e. we teach that the imperceptible does not exist. While obviously true with regard to unicorns, Santa Claus and the old gods, this view is nonetheless infantile, and sits in stark disagreement with the facts of empiricism. Three-dimensional space is but the surface of reality; to ignore what is beyond perception is utterly misguided. Imagine teaching a child about the ocean without ever mentioning the fact that it is deep. The error is not only logically laughable, it is actively dangerous. Space is only the surface of the sea. Is it really so surprising that, with such a fallacious, pernicious worldview, we have become obsessed, *incorrectly*, with physical appearance, with consumerism, with material gain and material loss, with physical pleasure, with avoiding death at all costs?

The task we find ourselves presented with is a heavy one, and many will find themselves incapable of taking it on. But, on the infinite scale of cosmic cycles, what does that matter? We are here for ever, every single one of us. We might as well enjoy it. How? Well, what matters is that enough folk—folk with the brains to think—also find the guts with which to welcome a deepening of life. Given a critical mass of such brave souls, it is possible that we, by expanding the domain of reality, may move beyond our current predicament, in which lazy cynics are lauded for despair, and may reestablish equilibria with both our environments and our deeper selves.

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[2]The logic of perception, which always relies on hard discrimination between perceived entities, doesn't hold in reality: according to Unity, all perceived entities are essentially one. This is most obvious in the classic topological question: Can you cage a four-dimensional ant in a three-dimensional box? The answer, of course, is no, for the same reason that prison walls don't stop birds.

[3]The philosophical and religious theories that most evidently coincide with Unity theory are those of: Hinduism in the Bhagavad Gita, Plato in the Allegory of the Cave, Daoism in the Dao itself, Jung in the theory of the collective unconscious, and Buddha in *tathatā*, thusness. Very briefly... The anonymous author of the Gita wrote of the knowing Self in all beings being one and the same Self, indestructible and eternal, a single universal entity experiencing all material lives. This, it appears, is literally true. Plato, in quintessentially Western fashion, proposed a scientific model for the same fact: he described the two-dimensional shadows on the cave wall as a projection of space, i.e. he wrote of perceived reality as a lower-dimensional image of the true reality of the universe. Laozi posited the eponymous Dao as permeating all material things, sitting within and generating all material things, one substance maintaining the harmony of the cosmos. Jung theorised and analysed empirically the existence of a collective unconscious, subsisting at the deepest level of mind, linking all individual consciousnesses. Buddha taught of the fundamental difference between the world of appearances, such as is received in perception, and the true world of *tathatā*, indescribable in any direct sense, which underpins it. There are numerous other philosophies, both ancient and modern, that attest to the same tale. Laozi said "What others teach, I also teach." This applies in full to Unity theory.

12 Appendices

In this section, we discuss a number of ancillary points, which, while not essential to the main thrust of the book, may nonetheless prove either of general interest or useful to workers in specific fields. Firstly, we consider three seeming contradictions, two concerning relativity and one quantum mechanics: the *twin paradox*, *Mach's principle* and *entanglement*. The relevant resolutions are brought about more by the removal of prior misconception than by any major advance in theory. These three ideas are, in fact, non-entities, errors of the old paradigm; we address and correct them here for the sake of completeness.

The fourth appendix is a philosophical discussion of a logical fallacy prevalent in physics, which we designate the *nihil ex machina* fallacy. We apply this term to the flawed trains of logic, whose prototypes are the impossibility proofs of quantum entanglement, that use a particular model to rule out potential alternatives to that model. It is common practice, among the paradigm-bound, to use the logic of space fallaciously to outlaw elements of reality that cannot be described in the language of space. We introduce this terminology here to mitigate the power of the incumbent, which can naturally call upon a broader and more readily accessible intellectual arsenal than can any challenger.

The fifth appendix returns to practical physics, and concerns the *structure of the nucleus*. Needless to say, Unity theory, with its new take on the proton and neutron, gives a rather different account of the nucleus to the incumbent one. In particular, we show that Unity theory generates, almost exactly, Linus Pauling's close-packed spheron theory. This theory is not currently in vogue, for reasons we will explain, and is rarely taught or discussed in nuclear physics circles. Much like MOND, its theoretical basis has hitherto seemed creaky. However, given its undeniable phenomenological success and the new theoretical foundation it receives from Unity theory, we suggest that it should be resurrected to form a major part of the future of nuclear physics.

The sixth and seventh appendices, concerning *bound states of the weak interaction* and the *Higgs field*, seek to mitigate the unhelpful glow of "underpinning things" that has emerged surrounding the weak interaction and the Higgs boson. In certain circles, these elements of physics have become a *cause célèbre*—"At last, we have it!"—and many spurious explanations have been produced as a result. Here, as elsewhere, we do not disagree with the mathematics, nor do we produce any new equations, but rather seek to give appropriate perspective. Due to its lack of foundation, the old paradigm is awash with purported prime movers, which have enjoyed their time in the limelight: Lorentz covariance, uncertainty, quantisation, and lately the Higgs field. Higgs himself, with characteristic modesty, would surely agree with a considered dethroning of the theory that has come to bear his name.

The last appendix addresses *renormalisation* in QFT, which has also, in the search for "fundamental physics", been elevated beyond its standing. Renormalisation, as a purely mathematical effect, is not relevant to an understanding of Unity theory itself, since it concerns second- and higher-order corrections; one can understand physical reality, in a certain sense, without ever thinking about it. Nevertheless, QFT is required to interpret many empirical results referred to in this book and elsewhere. Hence, it is important that, in seeking full mathematical consistency, we address the infinities of QFT, explain their existence, and offer a path forward. As elsewhere, it is reassuring to discover that Unity theory resolves the issue in the simplest possible fashion.

12.1 The Twin Paradox

The twin paradox of special relativity runs as follows. Consider a pair of identical twins: a sailor and an astronaut. The astronaut departs on a mission, out and back again, involving travel at a significant fraction of the speed of light. Special relativity predicts that the astronaut ages more slowly than the sailor. This is not just a thought experiment, and has been verified beyond doubt using, among other methods, atomic clocks [38]. We will use the language of twins here, for pedagogical purposes, but note that these results are essentially proven experimentally.

There is no paradox in the aging behaviour of the twins and the predictions of special relativity. Theory and experiment are in perfect agreement. The apparent paradox comes from the fact that the axiomatic structure of special relativity, as laid down in 1905 by Einstein [39], involves the *principle* of relativity. That principle states that the laws of physics should be the same in any inertial frame of reference. Hence, so the argument goes, according to the principle of relativity, since the only difference between the two twins is a relative speed, there should no distinction between them. The sailor shouldn't get a privileged frame of reference just because she stayed at home.

Now, various arguments have been put forward claiming that it is the *acceleration* of the astronaut that separates her from the sailor, who undergoes no such changes in velocity. But these arguments are incorrect. Special relativity makes the same predictions if the astronaut's clock is replaced by a pair of clocks, each moving at constant velocity in opposite directions, crossing at the far point of the journey. In other words, both theory and experiment say that it is the *absolute speed* of the astronaut that is the deciding factor. This stands in contradiction of the principle of relativity, which posits that, since all motions are inertial, no frame of reference is any different from any other. Hence the paradox.

Unity theory resolves this. Early in this work, we derived the special theory of relativity, in mathematical form, from the topological structure of matter, without any mention of the *principle* of relativity. Relativity, it turns out, just isn't the right philosophical idea. In this, Einstein was barking up the wrong tree. The special theory of relativity is, in fact, better thought of in the terms in which it already existed before Einstein provided his post hoc justification.[1] In other words, the special theory is simply the Lorentz factor γ. That's it. The principle of relativity is not only superfluous, but is actively *disproved* by the experimental evidence.

[1] This isn't a criticism of Einstein. His interpretation, dispensing with the aether, was by far the simplest given the facts at the time. At that stage, when arguments regarding the "aether wind" were raging, it was entirely inconceivable that the Earth itself is, in fact, a *configuration* of aether/substance.

There is no paradox. The twin scenario, together with its experimental validation, is evidence for two things: 1) the mathematical form of the Lorentz factor γ, and 2) the existence of a privileged frame of reference. The twin scenario tells us that a twin who stays still ages faster. Now, from a classical point of view, this made little sense, hence the paradox. To posit a special frame of reference, in the spatial paradigm, requires either the existence of an aether in space, or some kind of direct interaction with space itself. Neither of these, for various reasons, are possible theoretically, as many authors have pointed out.

Unity theory, on the other hand, has a very obvious privileged frame of reference: the *substance frame*. Substance itself does not flow, so there is a very exact sense in which one particular frame is still. Given the progress of the wave of the present, we can never experience that truly *static* frame, but that is of little consequence. There is, within the wave of the present, a *rest* frame, a frame within which one's velocity relative to the present is zero. The sailor sits within this frame, so her constituent waves travel as quickly as waves can around the inner dimensions; the astronaut, however, has a greater velocity relative to substance, so a larger proportion of her wave speed is taken up with travel. Her constituent waves travel more slowly around the inner dimensions, and she returns to Earth having aged less.

The substance frame doesn't suffer from the same theoretic issues as the hypothetical aether frame, as there is no substance in space. Objects do not move *through* substance, as they would have had to do through the aether; rather, objects are configurations moving across the face of substance. The difference is between a boat (particle) moving through the ocean (aether), and subsequently feeling drag, and a swell (particle) moving across the surface of the ocean (substance). A swell feels no drag from the ocean, because a swell *is* the ocean.

12.2 Mach's Principle

The argument above also allows us to resolve the long-standing philosophical debate concerning Mach's principle. Many eminent philosophers and physicists, Newton and Einstein included, have rightly recognised that there is a particular frame of reference which has a sense of zero rotation. The water in Newton's pail sits still compared to this frame, despite local rotation of the pail around about it. Now, Mach's principle states, in somewhat nebulous terms, that this sense of non-rotation derives from the masses of the universe on the grandest scale, i.e. that the non-rotating frame with reference to which a Foucault pendulum swings is defined by the *fixed stars*.

Again, this has caused confusion when juxtaposed with the principle of relativity. In this case, the disagreement is with general relativity, which suggests, in its mathematics, that all frames of reference, both inertial and otherwise, are equivalent. But in Unity theory, the equations of general relativity emerge without recourse to, and indeed in explicit contradiction of, this hypothesis. The axiom of Unity is, by definition, absolute: in a universe of one substance, there is only one possible true frame of reference, which is the frame of substance itself.

So, why does the *idea* of relativity emerge? Because of the structure of matter, which dictates that 1) matter must be limited by the speed of light, and 2) that all observers must measure light as travelling at the same speed c. It is the latter fact that has come, via Einstein's work, to be associated with the idea of relativity. Einstein put relativity into his axiomatic structures because he had to; there was no other choice. But general relativity, while it will no doubt remain so named, has nothing to do with relativity. It is a gravitational theory which emerges from two things: a) the topological structure of matter, yielding pseudo-Riemannian negative metrics, and b) the energetic favourability of locations in space with enlarged inner dimensions, yielding geodesic curvature and the appearance of force.

If we now consider Mach's principle within the Unity paradigm, it becomes obvious enough to be tautological. Why is there a privileged frame of reference in rotation? Because, *a priori*, there must be one, that of the universe itself. It is only the old interpretation of general relativity that has suggested to us that such a frame should not exist. But that line of reasoning is now no longer applicable. The idea of relativity is a secondary one, and has no bearing on the absolute frame of substance. So, a Foucault pendulum swings straight with reference to substance, i.e. the frame of the universe. That the fixed stars are, on average, non-rotating with respect to this reference frame is also just as inevitable.

As tends to be the way with powerful ideas, it turns out that the philosophical idea of relativity, which revolutionised late nineteenth and twentieth century thinking not just in physics but everywhere in Western intellectual life, has had its day. Einstein's work lives on, of course; his gravitational theory has a firmer foundation in Unity than it ever had previously. But the big *idea* of relativity—the notion that all things are relative, that all perspectives are equally valid, that no one point of view can be seen as any more correct than any other—is overdue for retirement. While appealing in a certain sense, it is factually incorrect.

12.3 Quantum Entanglement

Ever since Einstein, Podolsky and Rosen published their 1935 paper, *Can Quantum-Mechanical Description of Physical Reality be Considered Complete?* [40], the debate as to the meaning of quantum entanglement has simmered, if not raged. For decades, mostly due to Einstein's clout, the phenomenon was seen as theoretically impossible. Then, following Bell's 1964 paper, *On the Einstein Podolsky Rosen Paradox* [41], which offered the possibility of testing experimentally for what Einstein rightly called "spooky action at a distance", the hitherto fictitious entanglement seemed ripe for direct invalidation. But then, following various experiments beginning in the late 1970s and continuing into the twenty-first century, it was established that it *is* possible to violate the Bell inequalities, and hence to produce the entanglement first "predicted" (if only as ludicrous) in the EPR paper. For many physicists, entanglement is now an established fact. So-called *nonlocality*—the existence of effective interaction between spatially separated elements of reality—has wheedled its way into the mainstream.

As it turns out, entanglement is a small storm in an even smaller teacup, as various sensible authors, including Bell himself, have intimated along the way. For this reason, the issue is particularly instructive, as it sheds considerable light on a serious fallacy of Western thinking, such as has greatly hampered attempts to decipher the truth of quantum physics. Indeed, Bell insisted that the only thing his papers demonstrated was a lack of imagination among theorists. But his warnings fell on deaf ears. The findings of Bell and others regarding correlations in quantum experiments have been used, time and time again, to rule out the possibility of a theory like Unity. Indeed, in the construction of this work, the apparently incontestable fact that "violation of the Bell inequalities rules out the possibility of hidden-variable theories" was a major obstacle to progress. Many authors have taken this statement as ruling out *any* theory which attempts to make consistent sense of quantum physics. It seems that some folk, who should have known better, have preferred to waffle on in grandiose and complicated fashion about the ins and outs of nonlocality rather than to recognise the simple truth: there is no such thing.[2]

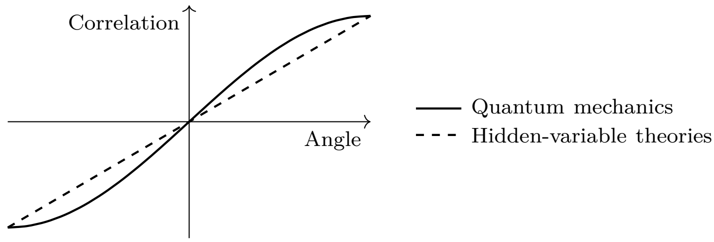
It is worth examining the issue in some detail. Many philosophers of physics, whose livings selling long books depend on the maintenance of public confusion, are wont to wheel out Bell's theorem to fend off any attempt on the truth. While entanglement is, in fact, a storm in a teacup, it is a teacup within which certain factions of the academic community live and earn. Nothing alarms a nook-and-corner scholar, long accustomed to being thought of as clever, like a debate that transcends the boundaries of his knowledge. But nothing is more necessary than that very transcendence, if we are to understand the world we live in. Deeper thinkers must be strong enough not to permit restriction of the debate. It is precisely such narrowness of vision that has painted us into our current corner. So, let us smash the teacup of entanglement once and for all.

Bell's theorem says that hidden-variable theories, that is to say, theories which read quantum probabilities as expressions of ignorance rather than physical facts, cannot reproduce the well-verified predictions of quantum mechanics. The logic of Bell's theorem is valid, and we do not contest it here. Bell's work was and is first-rate. Neither do we contest the empirical data, which has been repeated umpteen times. Over and over again, in a multitude of scenarios, Bell's inequalities have been violated. Those who place hope in "loopholes" are clutching at straws; the data itself is clear.

However, it is not at all obvious what the data *means*. Broadly speaking, Bell-type experiments show that correlations between simultaneous measurements taken at physically separated locations are described by a cosine wave, as predicted by QM, while the most a hidden-variable theory can manage is a linear relationship. The cosine predicted by QM and straight line predicted by hidden-variable theories have the same

[2]When looked at with sufficient perspective, nonlocality is an absurd notion. Indeed, it is a sure mark of either naivety or cowardice in a physicist or philosopher that he or she is willing to contemplate breaking of the law of locality. There is no difference between the words "nonlocality" and "magic". One who falls back on nonlocality for explanation is willing to forego all logical thinking for the sake of prior assumption. There is no greater crime in rational thought.

endpoints and midpoint, but they differ in between, to a small but measurable extent. The cosine function predicts stronger correlations around the quarter points. This is what has been borne out by experiment, thus ruling out hidden-variable theories.



Now, the above is all common knowledge, and we agree with it here. What is less commonly recognised is that violation of the Bell inequalities is only a matter of quantitative *degree*, not one of qualitative strangeness. Nothing shows up as "spooky", until one interprets things in terms of Bell's mathematics. In broad terms, the apparent entanglement, described by a cosine, is a perfectly sensible type of correlation between two separated events that derived from a common source. In other words, there is no evidence of spooky entanglement except insofar as is proved by Bell's theorem. This is a simple fact, but it is worth pointing out, since some authors go so far as to claim that we have "seen" entanglement. We have not. We have seen violation of the Bell inequalities, in scenarios that otherwise look perfectly sensible to common sense, and have *interpreted* that violation as entanglement.

It turns out to be much ado about nothing. The relevant piece of logic is right there, staring out of the most significant lines of Bell's original proof. Again, let us be clear: Bell's work is valid. As is so often the case with pioneering work, subsequent hijacking and misapplication by lesser thinkers is to blame for the confusion. In his 1964 paper, beginning Section IV entitled *Contradiction*, Bell opens with the following statement, here given in italics, a version of which appears in all related proofs:

> *The main result will now be proved. Because ρ is a normalized probability distribution,*
>
> $$\int d\lambda \rho(\lambda) = 1,$$

The integral across λ is a sum across all values of the eponymous hidden variable. This is a mathematically innocuous statement, with which no one could take exception. Indeed, we will not take exception to it here. We will simply point out that it only applies to one kind of variable, and not to another.

Bell's theorem applies to hidden-variable theories. It rules out the possibility that spin, or similar quantum information, is carried in a hidden variable λ. But let us think a little further about what this λ might represent. Suppose λ represents not a hidden unknown *constant*, but rather a hidden *dimension*. Since we are dealing with quantum mechanics, this would be the leptonic W dimension. Unity theory states that quantum probabilities arise from a lack of knowledge concerning the state of the inner dimensions, which are imperceptible to us. However, Unity theory does not say that that information exists in the form of a hidden variable. The symbol W represents a dimension, not a variable to be determined. While an algebraic symbol such as λ, representing a variable constant, may take this value or that value, an algebraic symbol such as W, representing an inner dimension, takes *all values simultaneously*.

There is an enormous difference between x, a single value on a horizontal axis, and x, the axis itself. Just because, for convenience, we give these things the same name doesn't mean that they are the same type of mathematical object. It also doesn't mean that they have the same mathematical behaviour. Now, the details of that behaviour aren't important here. What matters is that the Bell proof, which does apply to hidden unknown constants such as λ, doesn't apply to inner-dimensional variables, such as W, or any scenario involving them.

An electron, in Unity theory, exists in higher dimensions than those of space. Hence, its behaviour cannot be boiled down to a constant "carried" by an electron in space. An electron, in physical terms, simply isn't an entity that exists in space at all. In classical terms, we can model it as such, but it quantum terms, we can't. Underlying an electron is a hidden *dimension*, and a dimension is not a variable that permits insertion into a normalised probability distribution, such as the one described in Bell's paper. Let us lay this out explicitly, so that we can see precisely where the logic breaks down.[3] Reconsider, with due suspicion, the same integral, with W in place of λ:

$$\int dW \rho(W).$$

What is the value of this integral? It is hard to say, as the mathematics is somewhat nonsensical. But that is the whole point. Since W takes all values simultaneously, there is no way of constructing a probability distribution ρ, let alone a normalised one. The probability of *every value* of a dimensional variable is 1!

It doesn't do to delve too deeply into the minutiae of the above argument, because it is hard to discuss nonsense without writing nonsense. What it all boils down to is this: the logic that rules out hidden-variable theories does not rule out hidden-dimension theories. In other words, while the *spatial* paradigm does not permit interpretations of quantum mechanics that maintain locality, the deeper paradigm of Unity theory does. So, what does the experimental data actually show? It shows, exactly as Bell predicted, that the paradigm within which the earlier results were formulated was too narrow. His insistence that the phenomenon of entanglement is a manifestation of a lack of imagination was exactly accurate.

What conclusion should we draw? Well, since locality is an inviolate principle—its alternative being no better than crying "*Abracadabra!*"—Bell's theorem, in its ruling out of hidden-variable theories, rules out the spatial paradigm. It *proves*, in fact, the existence of the inner dimensions. Now, the existence of inner dimensions needs no further proof at this stage, but it is reassuring to know that one of the key intellectual

[3]The logic that break down here is not Bell's, which is sound. Rather, it is the subsequent *implication* from Bell's mathematical theorem to the physical phenomenon of entanglement that is fallacious.

weapons of the quantum naysayers is, in fact, the exact opposite of what it has been purported to be. It is a firm piece of evidence in *support* of a reality deeper that that seen in the laboratory.

The phenomenon of "entanglement", however, goes by the wayside. As discussed, there is nothing the slightest bit strange about the correlations seen in Bell-type experiments, other than their violation of an apparently inviolate set of mathematical inequalities, as set out by Bell. Since Bell's inequalities do not apply to the reality described by Unity theory, logic, in the form of locality, is restored. The correlations between particles emitted by a common source are just the kinds of correlations that one would expect to see between pairs of particles emitted from a common source, based on the entirely valid mathematics of QM.

12.4 The *Nihil Ex Machina* Fallacy

Here, we introduce a piece of terminology, with the hope of facilitating future discussion on topics such as the Bell theorem. The debate between materialistic rationalists—scientists in the narrow, twentieth century sense—and those capable of working with a model such as Unity is often bitter, as it is an emotional one. Some folk fight very hard to avoid any alteration to their worldview, particularly if the continued common acceptance of that worldview seems necessary for their statuses as intellectuals of prowess. These are the dangers faced by proponents of any revolutionary idea. "True seekers" like Maxwell, Einstein or Dirac don't care about status, but those with narrower minds do. No one argues about the truth. Those who know the truth simply say what they know, and couldn't give a hoot whether anyone listens. Shallower minds, on the other hand, those who want to be *known* as knowers, go to extraordinary lengths to proselytise. Ugly arguments ensue.

The danger is not to be underestimated. The demise of the erroneous Western paradigm is long overdue—it has been coming, in some senses, for at least two centuries—and such a weight of evidence has now built up that only a fool would attempt to stem the tide for sake of petty gain. But this world, in part due to the long dominance of a certain limited vision of rationality, isn't short of fools. So, those who would engage with Unity theory, in testing, criticising, validating or falsifying it, must be well prepared: a great and important task lies before us, and it will not be an easy one. To overhaul the conceptual structures that lie at the heart of a culture, nay, at the heart of a civilisation and age, is work of the most arduous kind.

The entanglement issue, as described above, is instructive, as it is typical of a certain fallacy of low-level thinking, which has been and will continue to be directed by the small-minded towards deep theories. The application of Bell's theorem to entanglement rests, implicitly, on the assumption of the spatial paradigm. And it has been used, over the course of some decades now, to deny the possibility of any alternative to the spatial paradigm, using the outlaw title "hidden-variable theories". This represents a pernicious logical error, which has seeped throughout rational thinking: the use of model A to rule out model B, when model B denies the validity of the logic employed.

⦿ Definition: *Nihil ex machina* fallacy. The use of a model to rule out possible alternatives to that model.

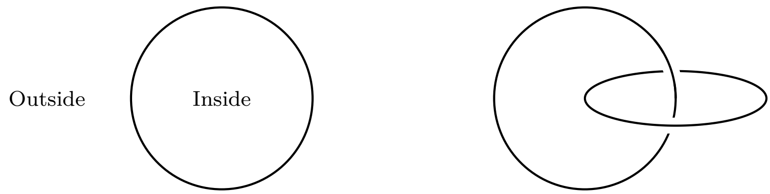
Why *nihil ex machina*? Well, the *deus ex machina* referred, originally, to the cranes (*machina*) used in Roman theatre to simulate flight and hence the divinity of characters. Gods would appear from the machinery. In literary usage, the *deus ex machina* became, then, the divine figure or event that appeared from beyond the confines of the world hitherto described, normally to resolve some issue in the plot. Now, the *nihil ex machina* fallacy has nothing to do with gods. It simply refers to the belief that there are no elements of reality beyond those currently modelled. In other words, *nihil ex machina* describes the fallacious belief that, where a theoretical issue exists within a certain model, the resolution of that issue can only emerge from elements currently existent in the model.

The entanglement issue shows this up clearly. Philosophers and scientists have stated repeatedly that Bell's theorem rules out the possibility of non-probabilistic behaviour underpinning quantum phenomena. Quantum probability is almost everywhere touted as "the fundamental nature of reality". But the rejection of such theories as might remedy the problem has been based on the assumption that all such theories must exist against a backdrop of space. The theoretic element that emerges to resolve the problem, namely the inner dimensions, has been ruled out by the problem itself! Yet—and here is the rub—logic can *never* rule out the existence of unmodelled elements.

By describing this fallacy, we are not promoting a return to mystical thinking, nor are we giving excuses for a lack of rigour. It would be stupid for someone to worship Russell's teapot, because there is no evidence for it. And, as many thinkers have rightly pointed out, it is stupid to believe in fairies simply because it is impossible to prove their nonexistence. However, theories such as Unity, which deepen the domain of reality, are not mystical ideas for which there is no evidence, nor do they necessarily lack rigour as a result. It has turned out that the Age of Enlightenment equation of "things hidden" with "things nonexistent" is empirically incorrect. That's just the way it is. All of the evidence points to the fact that space is not the backdrop to reality, and that the universe is at least eight-dimensional.

What we are looking for is a rigorous, scientific analysis of the facts. Since the broad validity of Unity theory seems now to be beyond doubt, the crucial thing is *engagement*. And that requires that clever fools not be allowed to get away with what they have been allowed to get away with for so many years: the rejection of deep ideas, out of hand, based on the logic of shallow models. A final example, given in mathematical terms, will serve to highlight this.

Consider a circle, drawn on a sheet of paper. The circle divides the paper into two parts, inside and outside. It would certainly serve as a valid piece of logic, in any mathematical proof, were we to claim that no continuous path can be drawn between the centre of the circle and a point outside its circumference, without that line crossing the circle. This fact is self-evident, i.e. as true as it is possible for something to be. We could do geometry for thousands of years, as we have been doing since the Greeks, and never find this notion coming up short. However, despite the self-evident validity of the fact that a circle has an inside and an outside, it is incorrect to claim that no continuous path can be drawn between the two. Extend the domain of the mathematical problem into three dimensions, and the solution is easy. Just go around! Now, this may seem like a cheat. But it is not one. It is simply a redefinition of the domain of reality. Only attachment to a certain preconceived image of the playing field rules out such a possibility. "Well, of *course* mathematics is enacted on two-dimensional paper". And yes, so long as one is doing mathematics on a sheet of paper, there is no path from inside to out, but, if one is doing mathematics in a three-dimensional space, that is no longer true.



Whatever logic applied in two dimensions fails to hold in three, despite its prior infallibility. Hence, it is a self-evident mathematical fact that redefinition of the domain of reality negates the validity of *all* logic formulated in the lower-dimensional domain. Even logically distinct entities referred to previously, such as "Inside" and "Outside", cannot be relied upon. The stark fact is: nothing can. To fail to appreciate this, as the clever fools of the West always do, is to fall prey to the *nihil ex machina* fallacy.

No previous logic can be assumed to survive a redefinition of the domain of reality.

Reality, in all its glorious dimensions, laughs in the face of being "proved impossible". While the third dimension of space, orthogonal to the paper, is an aspect of reality that may sensibly be left unmodelled by a mathematician, the same assumption just isn't available to a physicist, at least not to a good one, because a physicist doesn't get to choose the domain in which he or she models reality; reality itself *has* a domain, independent of how anyone decides to describe it. That's the whole point of physics.[4] Reality is a certain way. While the two share undoubted bonds, theoretical physics is not pure mathematics. And it is by no means a sensible assumption, on the part of a physicist, to assume space, or even spacetime, to be the backdrop of reality. That was an Age of Enlightenment hypothesis that has turned out to be demonstrably false. Indeed, despite our avoidance tactics, it has been demonstrably false for getting on for a century and a half. Which means that mathematical impossibility theorems, when applied to physics, are nonsensical, even facile. In a mathematical "proof" of impossibility, what rules out the pen leaving the paper? Nothing.

[4]Theoretical physics may be defined as the attempt to *apply* mathematics to a pre-existent reality. It is only the dullest of philosophical pedants that maintain doubt regarding such a reality.

12.5 Pauling's Spherons

In Unity theory, protons are formed of four orthogonal four-helical waves resonating in the S^3 component of the inner dimensions. Neutrons are the same, with the addition of a beta boson, a negatively charged shear wave sharing properties with both the electron and the photon. There is, it turns out, only one nucleon: the proton. However, despite this conceptual priority, the neutron remains a modelling concept with value. Since beta bosons do bind tightly to protons, free neutrons do exist, to exactly the same extent as hydrogen atoms exist. It is beyond question that the word "neutron" refers to some repeatable and repeated configuration of substance.

But, according to Unity theory, the usefulness of a word such as "neutron" in one context does not imply its usefulness in every context. The universe is flexible, and what is true here is not necessarily true there. In fact, it turns out that, while a free neutron does deserve the name, the "neutrons" that are hypothesised to sit alongside protons within the nuclei of heavy atoms do not. Unsurprisingly, the nucleus, as modelled in Unity theory, is not a region of space packed with nucleonic ball-bearings labelled "proton" and "neutron". In this appendix, we consider the alternative.

To address the structure of the nucleus, we must first model the interactions between nucleons. We must consider the *nuclear force*. Now, according to the Standard Model, this is denoted the "residual strong force". However this, like many other concepts of twentieth century physics, turns out to be something of a misnomer. The strong interaction, as modelled by quantum chromodynamics, involves rotations in baryonic inner space. But there is little sense in which the nuclear force, such as holds a heavy nucleus together, is a "residual" of this interaction. Rather, there is one nuclear force, for stable matter, and the strong interaction, for unstable matter. QCD is an element of Unity theory, yes, but the proton, being stable, is beyond its domain of validity; proton structure involves no rotation in inner space. The unity quarks of a proton do not require holding together at distance, since they are dimensional components of a single wave configuration, sharing an identical location. They are bound together by a potential well, yes, but that well is nothing to do with QCD. For a free proton, Newton's first law is enough.

Heavy nuclei, however, are different; they have physical size in space. They need a *reason* to stay together. Why and how do nucleons bind in this fashion? The answer, according to Unity theory, is, as ever, straightforward. They bind strongly for the same reason that they bind gravitationally, weakly and electromagnetically: the energetic favourability of resonance in a larger inner dimension. The most likely explanation for the physical nature of the nuclear force is that it involves expansion of baryonic inner space at the expense of the leptonic dimension. Such a trade decreases the energy of protons and increases that of electrons; however, since there is far more baryonic than leptonic mass in an atom, overall, the trade must be energetically favourable.[5]

[5] We are unlikely to see such asymmetrical exchanges in single fermion waves, but there seems no theoretic reason why $R_8 = 0$ should not provide such opportunities for expansion and contraction of complete inner components.

There is also another effect at play. In the spatial paradigm, two bound protons must sit side by side in space. In the old view, this is theoretically necessary, because, despite the claims of the nuclear shell model, there is no physical mechanism by which two protons, each apparently consisting of a soup of sea and valence quarks, can possibly exist in coherent superposition. However, the quark model, in the old paradigm, is *incorrect* when applied to protons: protons are not made of up and down quarks. And the Unity model of protons does allow for such coherent superposition. This adds a new theoretic element.

> In the Unity model, proton waves can superpose *coherently*, at a single location.

The electron's stability is passive: it has no lower level to fall to. The proton's stability, on the other hand, is active: it generates its own stability by means of a potential well. This means that, while a superposition of two free electrons must decay immediately, a superposition of two free protons isn't necessarily forced to. The likeliest physical mechanism by which this occurs is simply a doubling of the frequency of the proton resonance: the result is effectively "two protons", though it is, in fact, more appropriately thought of as a single proton resonance of doubled mass: a proton at a higher harmonic.

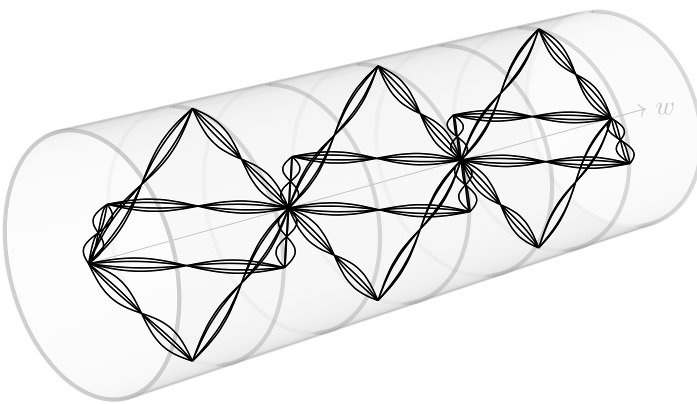
So, in the Unity model, two nucleons may superpose, pairing to fill a spinless 1s orbital. And the process doesn't stop there. It only stops beyond *four* superposed protons. Beyond that point, the 2p orbitals have spatial asymmetry, which, given that the protons themselves are generating the well that holds them together, is clearly ruled out. If the well itself is oscillating in space, then the whole thing must fall apart. But before we get to that, we have scenarios with two, three and four protons superposed around a single location in space, with varying numbers of beta bosons tightly bound to them. Beyond that point, the potential well is unstable, and proton waves can no longer be locally superposed: they must instead sit side by side in space. This is the reason why there are no stable nuclei containing five nucleons. A five-nucleon nucleus, unlike a four-nucleon nucleus, must occupy *two* locations in space, and, with only that much mass present, the nuclear force is not yet strong enough to maintain a bond. The single isolated nucleon goes on its merry way.

The situation described above—up to a maximum of four nucleons occupying precisely the same location in space—is precisely the basis of Linus Pauling's theory of *close-packed spherons* [42]. Pauling, while less widely known than some others, is recognised within the community as having been a scientist of the highest calibre. His output can only be described as prodigious. And Pauling himself thought that his spheron theory, on which he worked for much of the second half of his life, was greatly underrated. This wasn't ego speaking. He knew that the close-packed spheron theory was basically correct. It was thoroughly ignored, however, in favour of the nuclear shell and liquid drop models, neither of which are at all satisfactory. But there was a very good, if flawed, reason for that, within the old paradigm: the quark model of nucleons permits no local superposition; in other words, it permits no *spherons*.

Now, this appendix isn't the place for a full analysis of the spheron theory. Mostly, we wish simply to note that Unity theory generates and justifies it, and that there is a huge body of Pauling's work lying ready to be absorbed into mainstream nuclear physics, as soon as the up/down quark model, which has hampered progress so grievously, is deprecated. Pauling wrote copiously on the close-packed spherons, and his notebooks are readily available to all [43]. In this appendix, we get the ball rolling by giving an explanation, arrived at independently of Pauling's work but repeated, not far from identically, in it, for the origin of the *magic numbers* of stable nucleons. Here, we combine the two explanations/languages, so as to bring out the relevant links.[6]

⦿ Definition: *Spheron.* A coherent superposition of proton waves at a single location in (W, x, y, z) space-plus, forming a single particle.

A word on *charge.* In Unity theory, the electromagnetic charge of a proton is not quantised, and a baryonic wave structure may, in isolation, have any leptonic charge. In measurement by and combination with electrons, a proton's charge is quantised, yes, but, deep within a nucleus, we cannot presume that every protonic wave has exactly the charge of the standard proton. As such, in the following discussion, the word *proton* is taken to refer to the baryonic *mass* of a proton, rather than the isolated particle with unit charge.



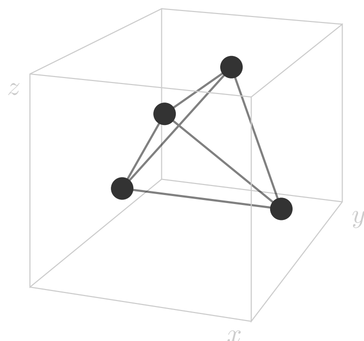
Deuteron at a single location in (x, y, z, W)

So, an alpha particle, for example, consists of four protons, and those protons, most likely, have zero charge. However, "neutron" is the wrong word for them, as neutrons necessarily contain beta bosons. It is not fully clear, as yet, whether an alpha particle contains beta bosons or not. Given its total stability, the likelihood is not. But whether the proton wave has charge +4 and is bound to a beta wave of charge -2, or whether the proton wave simply has charge +2 is, for present purposes, moot. We note that the latter is the likelier and simpler to work with.

[6]It was reassuring to find, at a very late stage of the construction of this work, full agreement, contra the mainstream, with a well-developed theory by a figure such as Pauling. Such agreement provides yet further corroboration for Unity theory.

So, a spheron consists of a single, double, triple or quadruple proton resonance, with some charge. The most stable nucleus is an alpha particle, which is the nucleus of the helium atom. Pauling termed this the *helion*. The helion is the largest nucleus with total spherical symmetry, and corresponds to the magic number 2. Five nucleons is then unstable, as already discussed. Beryllium-8 is also notably unstable, as its nucleus consists of two helions, separated in space. The nuclear force isn't yet strong enough to hold these together, and they fly apart. Beryllium-8 is the only light element that undergoes fission, and is also the only light element that undergoes alpha decay. Its behaviour is clear evidence for the spheron theory.

For heavy matter, then, colocation in the outer dimensions is no longer a possibility. The next obvious type of stability is that of oxygen-16, in whose nucleus four helions sit the vertices of a tetrahedron. Tetrahedral symmetry is next best thing to full spherical symmetry. Oxygen-16, as depicted below, duly corresponds to the magic number 8.



Other multiples of the helion are also notably stable, such as carbon-12, the main constituent of organic matter, neon-20, magnesium-24 and silicon-28. The upper end of this type of stability is at calcium-40, which consists of ten helions. This, it would seem, is the largest number of helions that can bind together without forming what Pauling sensibly termed a nuclear *core*. Ten is the next tetrahedral number above four, hence it looks likely that calcium-40 is the heaviest element in which fermionic exclusion can stop a single spheron from falling into the very centre. Calcium-40 occupies a unique position in nuclear physics, as it is the last stable nucleus with, in the old language, equal numbers of protons and neutrons. In the new language, it is the last stable nucleus with full symmetry between its constituent spherons.

Beyond calcium-40, the structure of the nucleus changes, forming a core and a *mantle*. The would-be space at the centre of a symmetrical configuration is too large, and a spheron fills it. This breaks the symmetry between the spherons, as one location in space (the core) is now marked out as different from the others (the mantle). Closest packing is icosahedral, and, around a single sphere, 12 spheres means a full mantle. We should expect this to correspond to the next magic number. As Pauling was aware, this should have been at $13 \times 2 = 26$, but is observed to be at $14 \times 2 = 28$. This poses an apparent problem. Unity theory offers a solution not available to Pauling.

In the spatial paradigm, a "location in space" offers no degrees of freedom: it is a zero-dimensional point. However, as we now know, that is a modelling assumption. In fact, every point in the outer dimensions corresponds to a copy of the inner group U_X. In particular, a spheron, as a *baryonic* resonance, doesn't occupy the W dimension. In the (comparatively) large leptonic inner dimension, a proton or protonic spheron is already a classical particle, located at a particular place. A proton has no symmetry in W. Hence, unlike in the spatial paradigm, such as Pauling was bound to work with, the spherons in Unity theory have an extra degree of freedom.

Now, we may be sure that this degree of freedom—stacking spherons in W—offers no stability in isolation. While *perfect* colocation in space would generate no lateral force, such an equilibrium is analogous to that of a vertical stack of two marbles. Hence, this extra degree of freedom makes no difference to light elements. However, beyond calcium-40 there is a nuclear *core*, a nucleus within a nucleus. And a nuclear core is then protected from the outside world by a nuclear mantle. Clearly, the stability of any group of spherons must be far higher if that group is located in the core rather than in isolation. While marbles may not be stacked vertically alone, they may certainly be stacked so in a box.

So, we have good reason to believe that, if a nucleus is large enough to sustain a core, then the core is capable of holding *more than one spheron per spatial location.* Protons, and therefore spherons more generally, aren't limited to (x, y, z) space. Two spherons must have matching *W-momenta*, yes, so as not to clash, but that still leaves the entire leptonic circle—some 137 times the size of the resonant space—in which two helions can be positioned.

Conjecture. *Magic number 28.* 28, rather than 26, is magic because a close-packed mantle of twelve spherons permits a protected central core, which can then host *two* spherons.

To proceed, we refer to Pauling's work. He produced an approximate formula regarding the mathematics of closest packing [42], which relates the number of spherons in the nuclear core to the total number of spherons. It is

$$n_t = \left(n_i^{\frac{1}{3}} + 1.30\right)^3,$$

where n_t is the total number of spheres, and n_i is the number of internal spheres, i.e. the number excluding the mantle. The only tuning of this formula, whose indices are dictated by the three-dimensionality of space, is in the empirically determined number 1.30, which, he wrote, represents "the effective thickness of the outer layer". Note that this matching has nothing to do with nuclear data, and is a piece of pure (albeit approximate) mathematics. It allows us, to some extent, to analyse larger nuclei.

The next stable configuration, beyond a single-location core, is when the core itself moves to a tetrahedral structure. This is the same transition as from magic number 2 (helium) to magic number 8 (oxygen), now enacted in the core rather than the nucleus as a whole. With a tetrahedral core, we must suppose that direct stacking in the leptonic dimension is impossible, as there is no longer a spherically symmetrical central location at which it can occur. But it would seem a reasonable notion that the core might shift to a pentatopic (5-cell) configuration in (x, y, z, W) space-plus, occupying the equivalent (x, y, z) space as would house a tetrahedron (4-cell). In this scenario, according to Pauling's formula, there are 24 locations in total. With five replacing four in the core, this gives $25 \times 2 = 50$, which is the next magic number.

With distinct caution as to the details, we might then suppose that the next full mantle consists of a core of $n_i = 10$ spherons (magic number 20), giving a total of $n_t = 41.2$ spherons, i.e. the observed magic number 82. And with even more caution—we are certainly hitting the realms of fiction now—we might suppose that the largest magic number 126 corresponds to e.g. an inner core of one location, containing three W-stacked spherons, surrounded by an outer core of twelve locations, each containing two W-stacked spherons, surrounded by a mantle of $n_t - n_i = 36$ locations, each containing a single spheron. It is, of course, highly unlikely that the numbers are as clear cut as that. Nevertheless, this assignment, which, in broad brush strokes, seems reasonable, gives $1 \times 3 + 12 \times 2 + 36 \times 1 = 63$, corresponding to magic number 126.

Needless to say, these latter ideas are much fine-tuned, post hoc, to explain the magic numbers as they already exist. As such, they should not be taken as anything more than suggestions. The point, however, in this appendix, is not to lay out the structures of the nuclei in the Unity model—as yet no such detailed theory has been constructed—but rather to show that the close-packed spheron theory of Pauling is certainly viable and most likely correct. Given the current lack of consensus regarding the basic structure of the atomic nucleus, this qualitative fact is important.

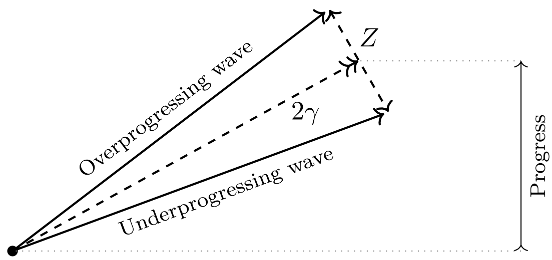
> The nuclei of heavy atoms are permanent, close-packed, crystalline structures.

This fact stands in direct contradiction of the nuclear shell model, at least as it extends beyond the spherically symmetrical 2s orbital, and also of the liquid drop model, which claims that a nucleus is a swimming sea. According to Unity theory, both of these models contain elements of truth—the existence of physical shells and spherical structure—but that is as far as it goes. Beyond that, their successes are, it seems likely, down to fine-tuning.

Pauling's theory has hitherto been rejected because it has lacked a theoretical basis. While Pauling suspected that the spheron idea was phenomenologically correct, he was bound to explain it in the language of the shell model, and, more importantly, in the language of neutrons. The relevant explanations, in his work, are thus somewhat vague. This was no fault of his: it was an impossible task. In particular, he had to claim that, in any given spheron, the protons *and neutrons* occupy localised 1s orbitals. It is easy to see why this idea was not assimilated; there is no clear image as to how two different particles, the proton and the neutron, could coexist with each other in this fashion. But a new version of the spheron theory emerges within the Unity paradigm, and it is to be hoped that it may shed some future light on the mysteries of the heavy atom.

12.6 Bound States of the Weak Interaction

We have observed that, since a photon is a magnetic wave which coprogresses, a Z wave is necessarily a magnetic wave that *doesn't* coprogress. More specifically, for observability, a Z wave is a pair of magnetic waves that over and underprogress. This is easiest to visualise if we consider two identical photons superposed. While preserving overall w-momentum, let us direct one of these photons slightly forward of the angle of progress, and one of them slightly behind. The photons have now picked up what appears to be a *longitudinal polarisation*: some of their energy is now stored in a form other than in kinetic energy. That component, by definition of the mathematics of electroweak theory, is now independent of the γ field. The combined effect of the two components over- and under-progressing is seen as a Z wave: energy symmetrically distributed around spatial coprogress x, in the orthogonal w dimension.



Pair of magnetic waves viewed as 2γ and Z

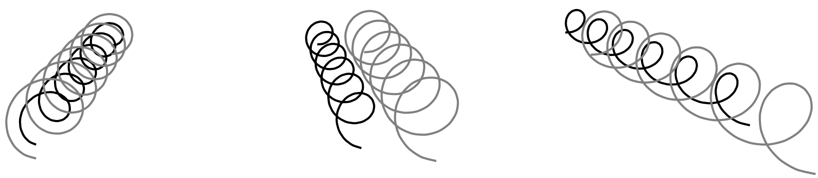
Consider the part of this wave that moves slightly ahead of progress. What reins it in? Well, we know that something does. If there was nothing pulling such errant waves back towards coprogression, then the entire wave of the present would fall apart, spreading out forwards and backwards like wavepackets do. Clearly, this doesn't happen, or at least it hasn't done for some billions of years. So, a nonlinear effect must be at play, that is to say, a macroscopic curvature of substance.

In other words, there must be a *force* holding the present together, front-to-back. Now, the electromagnetic and strong forces, whose symmetries derive from the inner dimensions of the present, are both independent of the dimension of progress, so we can say firmly that they are not responsible. Only the Z force and gravity remain. Just as both gravity and electromagnetism hold atoms together in space x; so must both gravity and the Z force be involved in holding the present together in w.

> The stability of the (x, y, z) cosmos requires the presence of forces acting in w.

Consider an atom of hydrogen. Its constituent proton and electron waves are held together by electromagnetic attraction, generated by the energetic favourability of the superposition of opposite charge. But this "held together" means "held together *in space*". And it is equally vital, for the stability of an atom of hydrogen, that its constituent proton and electron hold together in w; that they coprogress, in other words. Now, the proton's progress is dictated by its structure. Simply by dint of its four orthogonal wavevectors resonating in inner space, it *must* travel at the same angle of progress as all other protons. But the electron doesn't have to. An electron can sit in full stasis, at rest with respect to all four outer dimensions. So what's to stop a proton and an electron drifting apart from each other in the direction of progress? Clearly, the equivalent of electromagnetism in w, which is the weak *force*.

So, we must consider a hydrogen atom as not only an electromagnetically bound state, but also as a *weakly* bound state. Electromagnetism stops the atom falling apart in x; the weak force stops the atom falling apart in w. The two scenarios are essentially symmetrical, but for the fact that a resting proton and a resting electron have significant wavetrain length in w. They share the present's thickness. Hence, the two forces have different character, and different *strengths*. The weak force is much weaker, because, while a separation in x involves an immediate departure from the relevant electromagnetic potential well, the same degree of separation in w leaves a great deal of the relevant waves superposed.



Ground state Electromagnetic separation Weak separation

We can visualise this in the pair of long corkscrews depicted above. Superposed, we have a proton and an electron at rest, coprogressing into the page in an electromagnetic and weak ground state. Pulling the corkscrews apart in space x creates electromagnetic separation, and much attraction is felt. The force is strong, because the waves now have no common ground. But, if we separate them in w, i.e. longitudinally, it's a different matter. The waves separate at the ends, but much overlaps, as in the ground state. The force generated, therefore, is weaker. Fortunately, the force *required* for stability is also much smaller, as there is little reason, given prior coprogression, for atoms to separate in such a fashion.[7] Unlike in space, where stability must cope with all sorts of chaos, the present is very coherent in w.

As yet, this isn't a well-developed aspect of the theory. To describe the wave profile of the present is a formidable task, one which may not succumb to experimental analysis for centuries. This short nod to the bound states of the weak interaction represents a way into a new area of physics, in which particles are considered not only as having a significant and measurable thickness in w, such as quantises them as per the Planck constant, but in which, beyond that zeroth-order quantum approximation, they have higher-order structure in w. As we will see in the last appendix, this idea has significant ramifications for the mathematics of quantum field theoretic renormalisation.

[7] This is not true in high-energy colliders.

12.7 The Higgs Field

There has been a great deal written about the Higgs field, and much importance attributed to it. Too much, indeed. In Unity theory, that importance is diminished somewhat, to sensible proportions. The Higgs boson, together with its associated theoretic mechanism, is, it turns out, just another bit of physics: certainly interesting and of considerable value, but of no really deep significance. For example, in electroweak theory, the weak mixing angle, which is independent of the Higgs, is of far greater physical relevance: it contains the most interesting data of the weak interaction, namely the progress of the wave of the present. A not insignificant portion of the mystique of the Higgs boson has come, it seems, from the opacity of the theoretic fog surrounding it.

The Higgs mechanism is a complicated quantum field theoretic explanation for the existence, most surprising in the old paradigm, of weak boson mass. In Unity theory, however, we need no such "mechanism", because we can see that, from the perspective of the wave of the present, the weak interaction is fundamentally different from the electromagnetic and strong interactions. In those two interactions, the gauge bosons have good reason to be massless: the photon because it has no variation in the inner dimensions, and the gluon because it is a name for a mathematical entity—a rotation in inner space—not a physical configuration of matter. Neither a photon nor a gluon can store energy as mass, as opposed to shifting it from one place to another. This is the meaning of the word "massless".

But a weak boson *can* store energy. While a W boson does transfer energy from one dimension to another, effecting an energy rotation in a (W, x) plane, the SU(2) symmetry so generated doesn't preclude resonance. A photon cannot resonate, as it is defined by its travel in an open dimension of space; a gluon cannot resonate, as it is defined to rotate S^3 while being electromagnetically neutral; the weak bosons, however, whether polarised in the (w, x) or (W, x) plane, *can* resonate, in X, as discussed earlier in this book. Hence, their mass ceilings are to be expected. There is no mystery when it comes to weak boson mass, and no elaborate explanation is required.

> In Unity theory, the weak bosons, as physical configurations, are naturally massive.

What, then, is the Higgs field, supposed to "create" weak boson mass? What is its physical nature? Well, as is always the case when something is used extensively before its theoretical foundations are understood, the nomenclature currently describes a collection of related ideas. This theory is at the forefront of physics, far from fixed even in the old paradigm. It will take time, therefore, in the new paradigm, to unpick the contents of the Higgs theory, and to determine the precise physical meaning of its various aspects. Such an analysis is beyond the scope of this book; indeed, it is beyond the current scope of Unity theory. That said, the *essence* of the Higgs idea is nevertheless well understood: we have seen that the Higgs field describes second-order, planar expansions of substance.

Conjecture. *The Higgs field.* The mathematics of the Higgs field describes second-order expansions/contractions of substance.

We also suggest that the following physical phenomena, some of which we have already discussed in this book, are pertinent to any theory addressing such second-order expansions/contractions. In particular, we observe that any such theory, since it must address the weak interaction, is bound to consider the w dimension of progress. This demands the modelling of a number of hitherto undescribed aspects of physical reality, regarding the wave of the present. The Higgs theory already models at least some of these aspects, and new versions of it will need to model others. For physical understanding, it is the *correspondence* between mathematical and physical elements which is important. Here, we list a number of these:

1. The local SU(2) symmetries of the weak (w, x) and (W, x) planes, broken, respectively, by progress in w and the S^1 topology of the W dimension.

2. The non-zero vacuum energy stored in the wave of the present, both in its structural integrity, i.e. in weak binding energy, and in its progress across substance.

3. The geometric torsion, especially in the (w, W) torus, of the universe arising from global fourth-order expansion/contraction, and its effect, transmitted via geodesic curvature, on the symmetries of the wave of the present.

4. Presumed asymmetry in the wave profile of the present itself, including the fact that transmutations, as governed by the charged-current weak interaction, must presumably begin at the leading edge and subsequently filter through to the back.

5. The variable chirality, in the sense of helical handedness, of waves marginally over and underprogressing in w, and the consequent non-constancy of this chirality through the δw extent of a particle.

6. The scalar (from the perspective of the outer dimensions) exchange of gauge symmetric expansion and contraction between the baryonic and leptonic components of the inner dimensions.

These ideas are complex and difficult to imagine; to visualise eight-dimensional reality in any global sense is close to impossible. Intuition is key. But intuition, while it may hint at a path, rarely shows it clearly. Thus, the above are listed in deliberately imprecise terms, so as not to prejudice future study. The hope is that they may open up possible links between quantum field theoretic mathematics and the physical scenarios described by Unity theory. Let us get the ball rolling with a brief description, in the language of Unity theory, of the Higgs boson itself.

As the quantum field theoretic story goes, in the Higgs mechanism, three components of the Higgs field are absorbed by the weak bosons, which become massive in the process. These components or degrees of freedom of the Higgs field are the resonances associated with second-order planar expansions of the space spanned by (w, x, W, X).

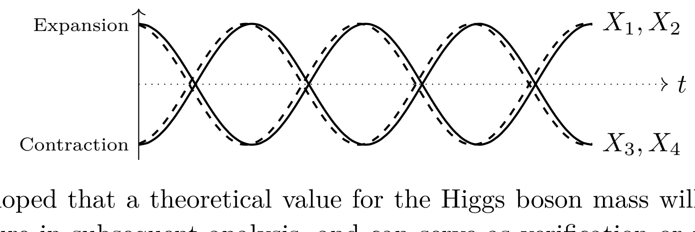
One of these planar waves, i.e one degree of freedom, has orthogonal wavevectors $\hat{W}$ and $\hat{x}$. Reversing the charge offers another degree of freedom. These two are the charged $W^{\pm}$ bosons, whose mass ceiling is then dictated by the second-order resonant space of the baryonic inner dimensions. The Z^0 wave, on the other hand, has only one degree of freedom: its wavevectors, in the w dimension, must be symmetrical around progress. Its mass ceiling is dictated by the same resonant space.

Now, the Higgs field describes *all* second-order expansions/contractions of substance. When a particle is described, in the language of quantum field theory, as interacting with the Higgs field, what is meant is that the resonance of said particle involves second-order expansions of substance. The electron, the proton and the photon all have negligible second-order expansion, a fact which has hitherto been described, in abstract terms, as their not interacting with the Higgs field. The weak bosons and the third-gen hadrons, on the other hand, owe most of their existence to second-order exchange. That is precisely why they are so heavy.

So, what is a Higgs boson? Well, it isn't nearly as world-changing as some folk have made out. Certainly the nickname the "God particle" is entirely undeserved, as there are many particles, including all of the most important ones, that would get along perfectly well without any reference to it: the proton and the electron, for instance. The Higgs boson is rather mundane, in the end: it is simply the last remaining degree of freedom among second-order exchanges of expansion/contraction of substance.

The Higgs boson doesn't store energy in x and W, as those components are absorbed, in the language of QFT, into the $W^{\pm}$ bosons. It doesn't store energy in w, as that component is absorbed into the Z^0. So where does it store energy? There is precisely one solution that fits all the requirements. Since the inner group consists of four dimensions, there must be solutions to $R_8 = 0$ involving second-order exchanges *within* U_X. Such a trade between all four inner dimensions must manifest itself as a second-order, scalar boson: second-order because such a resonance must involve some (X_1, X_2) expanding at the expense of some (X_3, X_4), and scalar because such a resonance has no outer-dimensional components of polarisation. It is a pure store of mass-energy, directionless and chargeless.

Conjecture. *The Higgs Boson.* The Higgs boson is a second-order, gauge symmetric resonance of the inner dimensions themselves, with polarisation in (X_1, X_2, X_3, X_4).



It is to be hoped that a theoretical value for the Higgs boson mass will emerge from this conjecture in subsequent analysis, and can serve as verification or falsification of it. Such a theoretical value must partake of the second-order mass unit, and is likely to require a consideration of the hypervolume of the inner group.[8]

[8] It is possible that this hypervolume accounts for the factors of α and π in the Fermi constant.

12.8 Renormalisation

Renormalisation, the process by which infinities are eliminated from quantum field theoretic calculations, sticks out as one of the most unsatisfactory aspects of modern physics. Despite many attempts to render it palatable, those who truly understood their own understanding of such things—most notably Dirac and Feynman—were adamant that renormalisation is bogus. With QED well established, Dirac said [44]:

> "I must say that I am very dissatisfied with the situation because this so-called 'good theory' does involve neglecting infinities which appear in its equations, ignoring them in an arbitrary way. This is just not sensible mathematics. Sensible mathematics involves disregarding a quantity when it is small – not neglecting it just because it is infinitely great and you do not want it!"

Feynman took up the thread [15]:

> "The shell game that we play is technically called 'renormalization'. But no matter how clever the word, it is still what I would call a dippy process! Having to resort to such hocus-pocus has prevented us from proving that the theory of quantum electrodynamics is mathematically self-consistent. It's surprising that the theory still hasn't been proved self-consistent one way or the other by now; I suspect that renormalization is not mathematically legitimate."

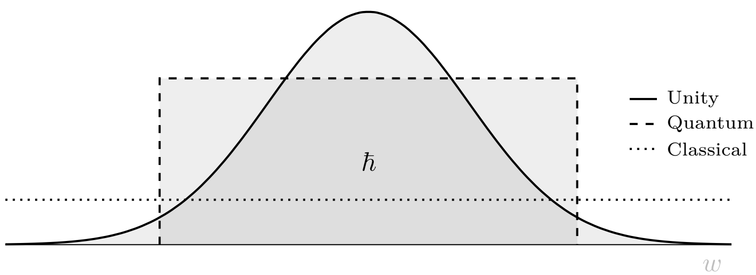
In Unity theory, it becomes clear that they were correct. It also becomes clear why the process does, nevertheless, yield sensible results. The necessary theoretic ingredient is, unsurprisingly, *the wave of the present.*

In QED, to use the simplest example, probabilities are calculated by summing across all possible Feynman diagrams, corresponding to all of the possible ways in which the initial state could become the final state. This approach has been borne out in incredibly accurate prediction of, for example, the anomalous magnetic moment of the electron. Now, an electron can, in QED, emit and reabsorb a virtual photon of any energy. So, we must sum over all possible paths, including ones involving photons of potentially unlimited frequency. But this generates an ultraviolet divergence: the path integral, over all possible energies, is undefined. Of course it is: it must include photons of potentially unlimited energy. The situation is then remedied by *renormalisation*: the process of cancelling one set of infinities with another to yield a finite result.

This has never been understood in the the old paradigm, because there has never been any real physical understanding of what it means for an electron to "emit and reabsorb a virtual photon". The topological Feynman diagram shows a point particle, the electron, releasing another point particle, the photon, which subsequently curves around to rejoin it. This violates every rule of physics. Now, the process isn't taken literally; a Feynman diagram isn't a route map. But the question still stands. What is actually happening, physically speaking, when an electron emits and reabsorbs a virtual photon? Without an answer to this question, we are fumbling in the dark.

The answer lies in the modelling. “Particles” such as the electron and the photon are not, in reality, physical points. According to Continuity, there is no such thing. A “particle” is a useful mathematical fiction. In fact, an electron is a name for a coherent wave, resonating in the inner W dimension, coprogressing with the wave of the present. Its quantum nature comes from its length δl, dictated by the macroscopic structure of the present itself. An electron is a wavepacket, not a point particle. And a photon likewise. The photon’s quantum nature comes from its finite extent in w, a dimension orthogonal to space. According to the axiom of Unity, *no* particle is quantised: every configuration of substance rises continuously out of its surroundings.

Now, the classical model simply ignores the w dimension altogether. Implicitly, therefore, the classical model has the w dimension as featureless and constant: nothing changes in w, so w can be ignored. This is a mathematically consistent procedure, but oversimplified: it rules out all quantum behaviour. That was fine, until quantum behaviour began to emerge at the end of the nineteenth century, first recognised by Planck. It was he who imposed the first cutoff, effectively truncating the classical model in w, thus imposing a finite action $\hbar$, given by the rectangular area below.



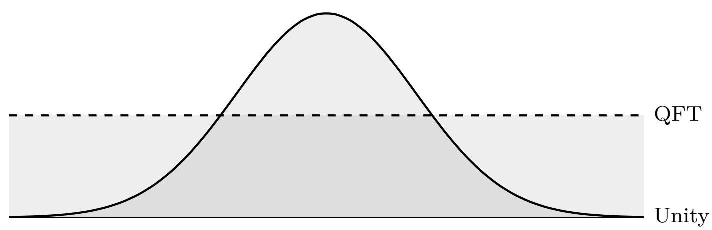
But, according to Continuity, step functions such as the one above don’t belong in physics: *natura non facit saltus*. Instead, Unity theory has the present as a wavepacket. The same action emerges as an integral—the curved and rectangular areas are both $\hbar$—but there is now no discontinuity. The present, held together nonlinearly by the weak force, rises continuously out of the blank substance of the universe, exactly like a swell does from the ocean. The phenomena of quantum physics then emerge, now without logical contradiction, in the curved area above, since every configuration of substance within the present partakes of the same macroscopic structure.

This nontrivial profile in w has deep implications for quantum field theory. An electron, for example, considered as a wavepacket, must, according to the uncertainty principle, have a spectrum of local progress momenta. Now, for a free particle, those w-momenta, reined in by the weak force, may safely be neglected. But, in *interaction*, the same cannot be true. Below a certain level, an electron cannot be considered as a point particle, because... it isn’t one. While a quantum-mechanical electron has a well-defined eigenvalue of mass, that eigenvalue *cannot* be truly constant through the w-extent of the electron. According to Riemannian geometry, in which nothing in fixed, there is simply no reason why it should be.

However, since all electrons partake of the same macroscopic wave structure—the structure of the wave of the present—all electrons must have, in a probabilistic sense, the same small distribution of local mass values around the observed 0.511 MeV. According to Unity theory, 0.511 MeV is an *average*. Since energy is defined locally, its every value is an approximation. And the same is true of the mass of protons, the kinetic energy of photons, the second-order mass of weak bosons, *all energies*, indeed.

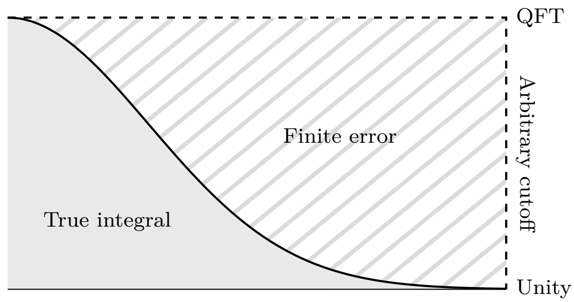
Every constant of physics is a definite integral over the imperceptible dimensions.

Now, consider the effect of this ubiquitous spread of mass values on an electron struck by a photon. In such an interaction, the electron cannot be considered as a point particle of specific mass, but rather must be seen as a diffuse entity with a specific distribution of mass values, centred around m_e. The classical model stated that the electron simply *is* a point particle with mass m_e, but QED can't do that. It must take into account the variation in the electron and all possible interactions with all aspects of the electron wave, including its higher- and lower-mass components. One of these interactions is, for example, the exchange of energy between one part of the electron and another, in x; this is modelled with the exchange of a virtual photon. In actual fact, the virtual photon isn't emitted from the electron and subsequently reabsorbed, as is stylistically suggested by a Feynman diagram; rather, the virtual photon models the internal fluctuations of the electron wavepacket, the transmission of energy from one part of it to another. But here's the rub. In QED, which has no notion of the profile of the wave of the present, we are forced to sum over *all* such photons, regardless of their energy. Unsurprisingly, this generates an infinite integral.



Integrating over all frequencies, as denoted "QFT" above, is essentially a nonsense idea, as Dirac and Feynman knew. An electron doesn't generate photons of arbitrary, potentially unlimited energy. Why not? Because an electron has a specific distribution of mass eigenvalues: continuous, yes, but also limited by integral convergence. While things do vary through the electron, leading to transmissions of energy within its bounds, those transmissions follow probabilistically standardised distributions, as modelled in the curve above. You simply don't get huge imbalances of energy within an electron. Why would you? While an electron's internal structure is more complicated than the particle model claims, it is nevertheless a coherent configuration, not a swarming sea of arbitrarily energetic virtual particles.

So, how come field theory *works*? How can these infinities be subtracted away to give sensible answers? Well, since all electrons partake of the same structure, the error in one divergent integral is the same error as in other calculations of the same sort. The error in calculating the dressed electron mass, say, is, in appropriate units, the same as the error in calculating the dressed interaction with that mass. So, if we impose an arbitrary cutoff to tame the integral, subtract the large but identical errors from two different calculations, and then subsequently remove the cutoff by sending it away to infinity, we get the right result. This "dippy process" is *renormalisation.*



The wave of the present has a macroscopic structure independent of the observable energy that moves against said structure. Hence, the above diagram could be drawn, at various scales and in various units, *throughout* quantum field theory. Underlying the disturbing infinite integrals are sensible finite integrals dictated by, among other things, the wave profile of the present. The reason those finite integrals have not yet been modelled in a mathematically consistent fashion is that they *sum* to the quantum of action. Hence, any discipline, such as QFT in the old paradigm, that takes particles at their spatial face value, seeing $\hbar$ as fundamental, is bound to deal in inconsistency.

Quantum field theory, it turns out, was a first bold, yet also tentative, step in modelling the energy profile of the wave of the present, in modelling the cosmos from outside it. Following Planck, the pioneers of QFT took our perceived reality to be a block of finite w-thickness, and the resulting step function—the quantum as a brick—duly generated infinities. But the days of the quantum, as a piece of truly fundamental physics, are done. Planck's constant is a summary, nothing more. The time has come for us to look beyond, then, to look *within* the "fundamental" particles of the old school.

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