Quirk Theory: Notes on “The Equation of Natural State”

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Abstract

Thought experiments are used to demonstrate that the natural principles of quantisation and relativity are inconsistent with the axioms underpinning field theories based on differential geometry. In particular the calculus of variations is used to highlight an inconsistency that is almost certainly responsible for a lack of progress towards a unified field theory in physics.

A deep connection is shown between principles of least action and the principle of scale invariance in physical theories, and further that field theories cannot ever achieve scale invariance without breaking the limit theorem of calculus. If principles of least action are in fact important to natural law, the unavoidable conclusion is that the unification problem in physics lies not in the theories of quantum mechanics and general relativity, but in the language they are written in. It also then follows that scale dependence is a requirement of field theories but may not be necessary as a principle of natural law.

Fortunately, this axiomatic inconsistency may be resolved by reformulating the principles of quantisation and relativity using “Leibnizian geometry” rather than Cartesian geometry. Leibnizian geometry (called so here to honour the ideas of Leibniz) arises out of graph theory and the name is used to distinguish it from the more familiar Cartesian geometry that underpins calculus and field theory.

This reformulation requires another “natural” principle, conformity of distance, to consistently map the logical connectivity of a network graph on to coordinate space. In Leibnizian geometry the three natural axioms of quantisation, relativity, and conformity result in an algebraic Equation of Natural State (ENS), $(\Delta\psi) = 0$ that defines all the valid states (co-ordinate locations) of that space. The ENS acts on all pairs of connected vertices (points) in the Leibnizian graph: Any such a pair with a coordinate vector difference that satisfies the ENS is called a quirk (a mash-up of quantised relative co-ordinate).

The ENS in turn guarantees scale invariance to any Leibnizian geometric manifold it is applied to. In this geometry, the ENS also guarantees Nature cannot help but follow a path of least action, which is arguably a more satisfactory result than a “many paths” interpretation that Nature considers paths not of least action and then chooses not to follow them.

A new complex vector definition of length $(\Delta\psi)$ is required to replace the standard Euclidean definition of length so non-congruent solutions become possible in this Leibnizian framework. This new metric remains rotation invariant in any co-ordinate system, and allows both congruent and non-congruent solutions to the coordinate space to be treated in a seamless and consistent manner.

If Quirk theory has relevance to our universe, the allowable trajectories of points in the geometry should form emergent solutions expressible as probability density functions in coordinate space with the recognizable quantum numbers and mass ratios of the standard particle model. The known physical constants should arise as emergent calculable properties of such a geometric manifold, much as Pi arises as a calculable property of Cartesian geometry. A methodology for such calculations is given at the end of the paper.

Background

The paper is divided into three sections. The first section does not deal directly with physical law but presents useful derivations and insights from geometry, algebra and set theory. The second section applies these insights to the problem of the unification of Quantum Mechanics (QM) (1) and General Relativity (GR) (2). The final section explores a new alternative but comprehensive approach to the unification problem.

To use an analogy, the approaches to a bridge are constructed, one end being the fundamental axioms that underpin geometry, algebra and set theory, the other being the empirical and axiomatic underpinnings of GR and QM. The required design of the unification "bridge" becomes apparent from these approach structures. This process tempers enthusiasm for overly abstract mathematical theories with a strong dose of empirical rationalism and adherence to the tried and true philosophy of minimal sufficiency: Nature is surely just one tiny grain of sand in the Imaginarium of mathematics but hopefully it at least has Dirac's initials carved on it.

Modern physics is predicated on the axioms of relativity and quantisation: The natural world seems to consist only of discrete objects moving relative to each other. Einstein's field equations (3) of General Relativity and Schrödinger's equation (4) of Quantum Mechanics have been developed to explore in detail how this happens.

And yet while no observation has been found to refute these theories, there remain observations and inferences which are difficult to address using these theories. Further, there are theoretical inconsistencies between the two theories relating to the smoothness of space at very small scales which implies they might never be reconciled in a unified framework.

This paper explores exactly why this unification problem arose from two theories that otherwise embody the most complete and accurate knowledge to date of how the universe works. First, some philosophical arguments concerning unification are used to uncover what such a unification principle might look like. Then the notions of quantisation and relativity are explored from a perspective of geometry and graph theory. Finally an argument is made that unification using field theories is not likely even in principle.

Remarkably, all three apparently separate trains of thought in the last paragraph lead to the same unifying principle. The final part of the paper defines a new approach that explores this unification principle in detail: The application of natural law principles to Leibnizian geometry, herein known as Quirk theory.

Occam's Razor and the Quest for a Unified Theory of Physics

An overview of the history of inductive reasoning applied to physical observations has resulted in an observation known as Occam's razor (5): A simpler explanation is more likely to be correct than a complicated one. Over time new physical principles have been found to describe more and more observations in nature with fewer and fewer parameters. In short, complexity in physical systems appears to arise as emergent behaviour from simple principles and rules.

If Occam's razor is wrong or incomplete (as any inductive reasoning can ultimately prove to be) the unification attempt will fail and the universe will remain mysterious in a quite complicated manner. Perhaps current theory simply reflects Gödel's incompleteness theorem (6) that a complete theory based on non-trivial axioms must contain internal inconsistencies.

But if Occam's razor is right we may well succeed in unification attempts; According to Gödel the theory will be incomplete but consistent. Hopefully the incompleteness will not prove debilitating to the usefulness of the result. If unification succeeds, the universe then may well remain mysterious for other reasons (mechanism of expression, numerical resolution, emergent behaviour etc.), but at least the universe will be mysterious in a more understandable way. We will know the how and the what, if only by mathematical analogy. The why of it may well remain ineffable and simply reflect the unknowable incompleteness of a unified result.

As a thought experiment, Occam's razor, while not a scientific theory, can be given scientific relevance by proposing it as an axiomatic principle. It may then be deduced that a unified law of physics must not only exist and it must not just be simple, it must indeed be the simplest possible law. If this were not so, the axiom would be discarded as logically flawed.

Given the fact of our existence in an observable universe, this law may now be deduced: The fundamental property of space is shape, and the fundamental measure of shape is relative distance (Δs), and the simplest possible equation involving relative distance is:

Equation 1

$$\Delta s = 0$$

If Occam's razor is correct this admittedly very strange conclusion is unavoidable. Either we give up our belief in Occam's razor and therefore any great hope of succeeding in unification theory or we accept this equation and try to make sense of what seems to be an absurd conclusion. If correct, our everyday sense of distance and extent in the universe must be a profound and undeniable illusion.

Before completely giving up on this crazy conclusion, it should be noted in passing that this equation is not without precedent: in the theory of general relativity it describes the space-time interval path of the photon. (7). It is rather curious that the photon also happens to be the only quantum object dealt with in any detail by this theory.

The Mathematical Description of Structure in Space

Space is describable by the language of geometry which begins with the mathematical notion of a geometric point. A geometric point is possibly best defined as a zero dimensional object and is the simplest concept in geometry that is not nothing. But “Nothing” is not an absolute concept, being commonly defined (8) as “not any thing”. In geometry, the “thing” is the geometric point: The point and nothing are co-dependent concepts that mutually define each other.

One can imagine a finite or infinite set of points co-existing with nothing. But nothing can be done with this structure until some mathematical notion to navigate from point to point is upheld; else every point is maintained in a state of complete isolation from all else and no compound shape or spatial structure can be envisaged because the very notion of location is not inherent in a zero dimensional point object. Once the points are connected by some means, the total structure is termed a geometric manifold.

It turns out that there are (at least) two different ways of embodying this notion of location to the points, resulting in two very different approaches to geometry. For convenience these two classes of geometry are called here Cartesian and Leibnizian.

1) The Cartesian geometry derives from defining a number of independent co-ordinate axes (orthogonal dimensions), each axis being an ordered list drawn from the complete set of real numbers. A geometric point is immutably affixed to every unique combination (tuple (9)) of co-ordinate value. It is abbreviated here as C geometry because it was made popular by René Descartes (10). C geometry underpins calculus and differential geometry of which the field theories of quantum mechanics and general relativity are relevant examples.

2) Leibnizian geometry is derived by adding points via logical connections to create a network according to a general connectivity rule. It originates from Euler’s Graph Theory (11). Geometric points are fixed immutably to the graph vertices. Only after the connected graph is established are co-ordinate tuples (drawn from the set of real numbers) assigned to each point in the manifold. In this paper it is abbreviated as L geometry because of the distinct similarity to the Monads espoused by Leibniz (12). This geometry, while simple to understand, is not commonly taught in any detail at high school level.

Roughly speaking, L manifolds are built from the bottom up (nothing to everything), whereas the C manifolds are built from the top down (from everything down to nothing). It is more than just a matter of semantics and philosophical viewpoint; it turns out there are very significant identifiable differences between the two types of geometry and great care must be taken when comparing the structural notion of shape and space in both frameworks.

While the description here is given in terms of coordinates derived from the set of real numbers, this is purely to simplify the explanation: It is to be understood that both these geometries can be generalised to include coordinates derived from the set of complex numbers.

Cartesian Geometry

The ideas of René Descartes popularised the notion of co-ordinate systems and analytic geometry. In practical terms this meant creating a group of independent axes (orthogonal co-ordinates) each representing an ordered set of real numbers. The C manifold is created by affixing a mathematical point to each unique combination of coordinates and this is very poorly illustrated in Figure 1. It is poorly illustrated because it is almost impossible to visualise such an infinitely fine grained fabric of points.

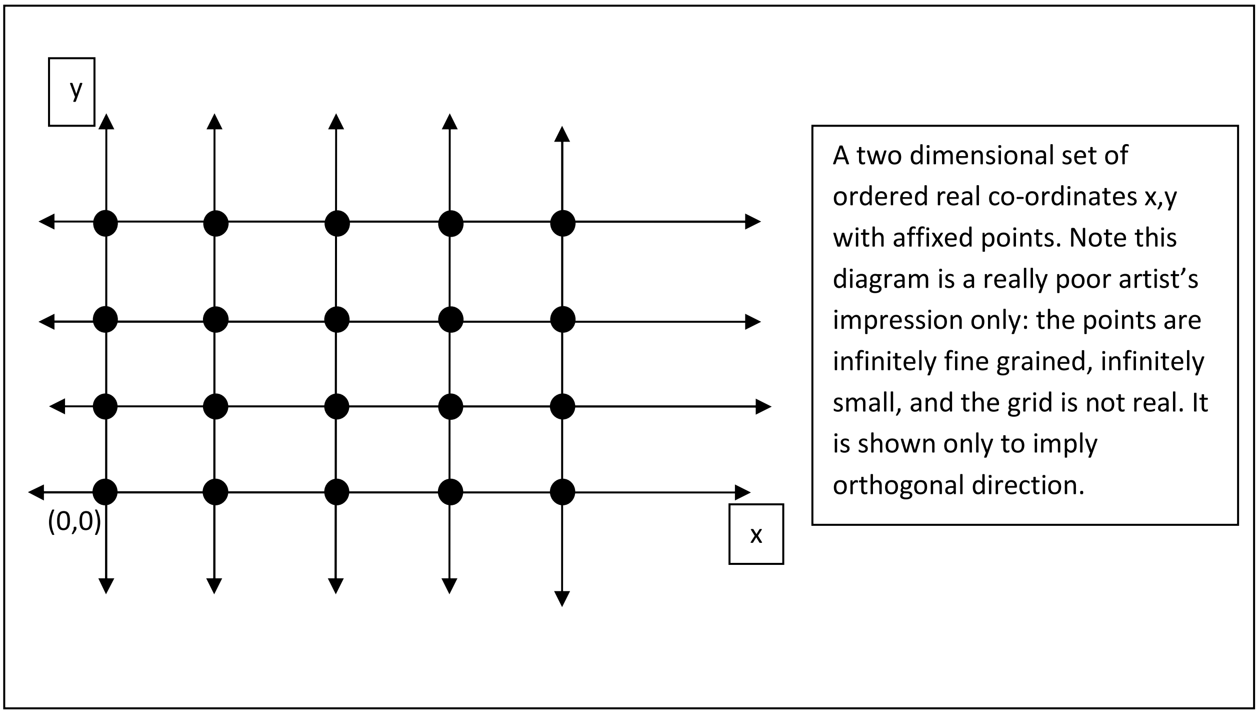


Figure 1: The Cartesian geometry.

A number of features of this type of geometry are apparent:

- A C manifold contains an infinite number of points countable on the set of real numbers.
- The geometry forms a spatial continuum because it is infinitely divisible. It is simply not possible even in principle to magnify the manifold to a stage where individual points may be shown.
- The points form a fixed "background". Any point in a C manifold is by definition fixed in place to its co-ordinate and it cannot be moved.
- Discrete objects and shapes like a circle or parabola in this geometry are defined by the notion of a function (13) which is an algebraic relationship between co-ordinates used to select an infinite subset of the points in this background space where the functional relationship is found to hold true. It is normal practice to "colour" this set to visually distinguish it from the "transparent" background super-set of the Cartesian manifold.
- In order to apply calculus to functions in this geometry, the functional subsets must be continuous (14). Since field theories rely on derivative theorems from calculus, this continuity is required by all functional field theories.
- The connectivity of the points in the manifold is implicit rather than explicit. The notion of a "nearest neighbour" is only ever by implication of the ordering of the real coordinate values. The notion of where one point is compared to another is conveyed by the Euclidean Vector (15).

Objects may be placed and moved around in C manifolds using a functional form. For example, selecting the infinite sub-set of points in a two axis Cartesian manifold where y= $ax^2 + \mathrm{bx} + \mathrm{c}$ for a given 'a', 'b', and 'c' results in the shape of a parabola which may be moved around in this space and made to change size by choosing different values of 'a', 'b', and 'c'.

It must be recognised though that this appearance of movement or animation itself is an illusion; the points making up the parabola are not moving in co-ordinate space, different values of 'a', 'b' and 'c' cause different infinite subsets of points to be selected from the geometry, even though it is still the 'same' parabola in algebraic notation.

A very good analogy can be made to our own bodies. In ten years time very few of the atoms that make up our bodies will still be present; they come and go, but nobody denies we are still in a very real sense the same person. In the same sense, though the set of points that make up the parabola may change, it is still the same functional object (the algebraic equation representing the parabola)

This notion of shape, change of shape, and movement of shapes in C geometry requires that there is a fundamental link between the function, its parameters, and the consequent properties and capabilities of that functional shape in the C-manifold.

It is also possible to warp any Cartesian axes relative to another by application of a function (such as general relativity does with tensor calculus). This can be a very convenient way of doing a variable transform of a function expressed in a flat Cartesian Geometry but in fact it adds nothing to the fundamentally functional nature of C geometry.

What it is not possible to do because it breaks the calculus requirement of functional continuity is to warp one axis to be in any way congruent or overlap or cross another or to use a discontinuous equation as a function. If you attempt to do this, you cannot then use the undeniably useful theorems of calculus to deduce provable outcomes from the resulting structure.

Leibnizian Geometry

Leibnizian or “L” Geometry derives from how an L manifold is constructed from a set of mathematical points. Figure 2 illustrates the basic concepts required to create a manifold with structure (shape) and distance (measure of shape) in this type of geometry. It starts from graph theory (11) where the geometric points in L geometry are immutably affixed to the vertices of the graph.

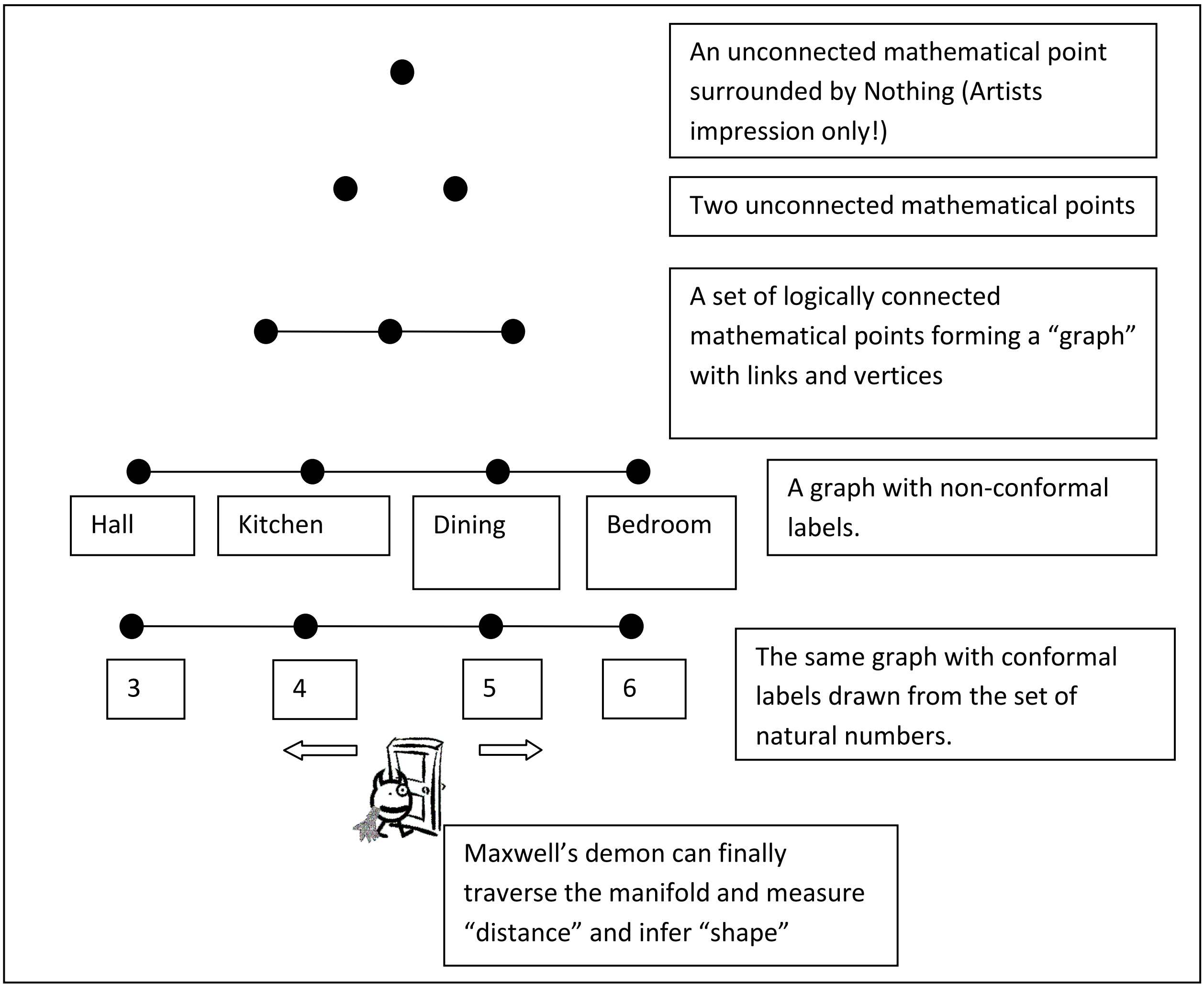


Figure 2: Method of construction of a Leibnizian (L) Graph

The dimension of a manifold is determined by this logical connectivity. In the case of a point only being connected to at most two other points only a one-dimensional graph is achieved, but additional connections allow the construction of higher dimensional graphs as shown in Figure 3.

It is most important to note that the notion of co-ordinate has yet to be introduced. The dimension of a graph is not related at all to the concept of dimension in C geometry (Dimension in C geometry being intimately tied up to the notion of an orthogonal Cartesian axis being an independent ordered set of values from the real set of numbers.)

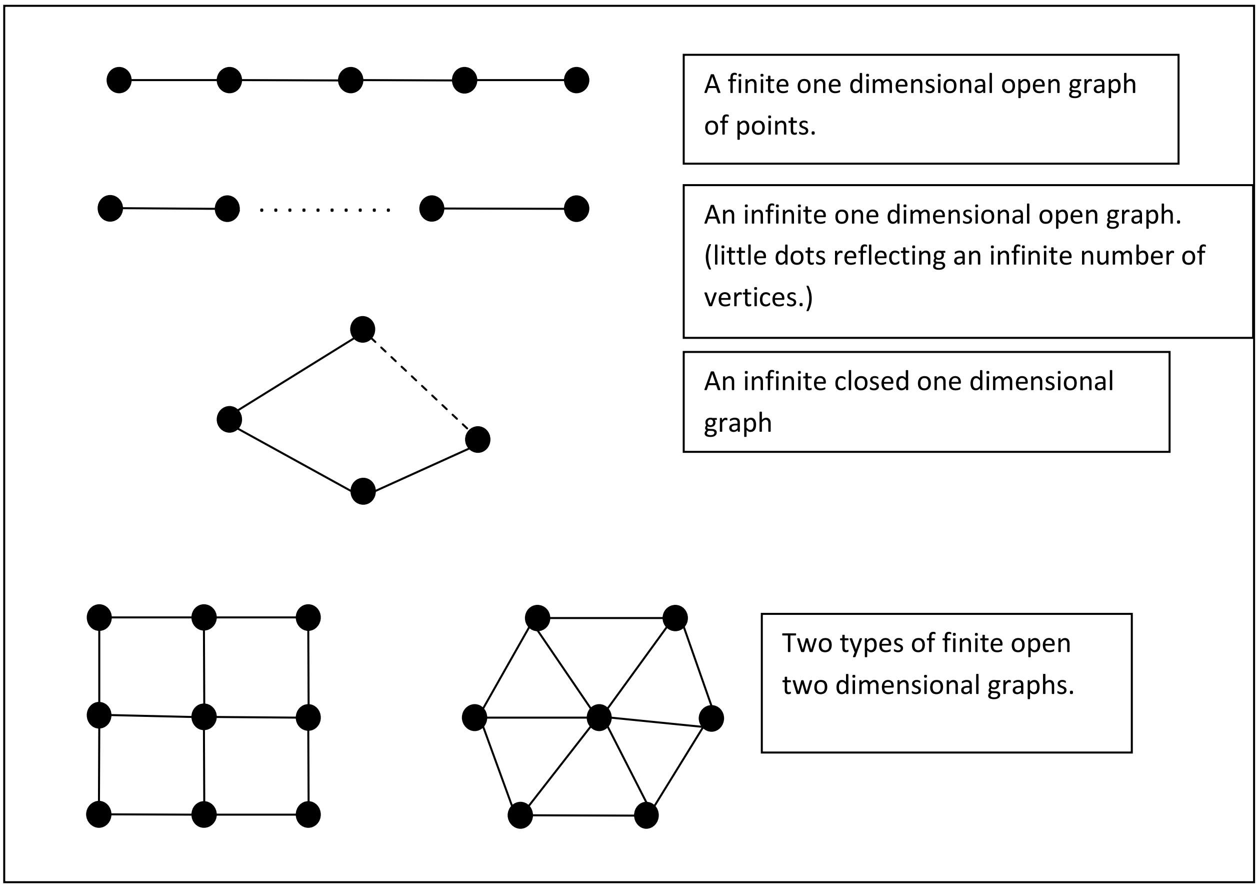
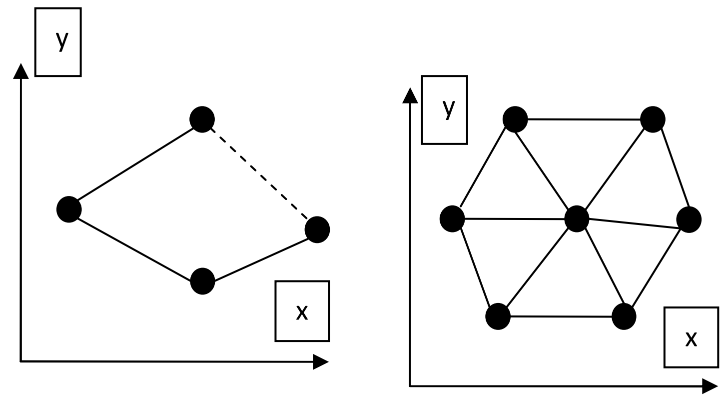


Figure 3: Notions of dimension, finite, infinite open and closed in L Graphs

In generalised L geometry it is allowable to link any individual point to any number of other points. A general connectivity rule may be used to construct geometries of various dimensionalities (even fractional ones). Maxwell's demon can explore the geometry by counting hops between vertices on the graph, and to use these "hop" numbers to explore connectedness and distance in the manifold.

Points are discrete objects, and the L manifolds are created by adding points via a connection rule. As a result, the number of points in any L-type manifold is always countable on the set of natural numbers, and this count may be finite or infinite in number.

The description to date of this L geometry is no different from standard graph theory. The L graphs explored above are now extended as shown in Figure 4 to introduce the concept of co-ordinates to graphs.



An infinite closed one dimensional, and a finite open two dimensional manifold, each graph vertex assigned a pair of orthogonal ordinates (x,y). The graph links are for visualisation only; they do not form part of the co-ordinate space and must not be thought of as line segments connecting points.

Figure 4: Various topologies and the notion of dimension and co-ordinate space in L-type geometry.

Each point in the L graph is decorated with a co-ordinate in the form of a value tuple drawn from the set of real numbers. Any number of co-ordinate dimensions may be assigned to the points.

What distinguishes these co-ordinates in L geometry from C geometry is that each point does not have a fixed co-ordinate value. In L geometry, the coordinate of a point can be independently chosen to be of any value (from the set of real numbers). Points can be made to move along algebraic trajectories in co-ordinate space simply by changing the co-ordinate value associated with that point; it is the underlying graph that remains fixed and immutable, because the points are fixed immutably to the graph vertices.

Different shapes can be made in such a space simply by changing the co-ordinates to suit the desired shape. This notion of shape, change of shape, and movement of shapes in L geometry requires only that a set of co-ordinates be assigned to the points in the graph that reflect the desired shape.

Maxwell's demon can navigate these different L manifolds by the connectedness of the underlying graph. But it is now also possible to infer distance from the coordinate structure associated with the graph vertices. The notion of a "conformal" co-ordinate map is now apparent. A conformal distance map is one where the integer "hopping" count of the underlying graph network bears a logically consistent relationship with the numerical "distance" measure calculated between the co-ordinates assigned to those points.

Comparison of Leibniz and Cartesian Geometry

Here we face the dilemma which lies at the heart of reconciling the Leibniz and Descartes world views of geometry; the differences are not in fact only philosophical in nature:

1) The Cartesian view defines infinite manifolds whose points are countable infinite on the set of real numbers. The Leibnizian view defines finite or infinite manifolds whose points are countable finite or infinite on the set of natural numbers.
2) The Cartesian view proposes that a mathematical point is immutably affixed to every unique co-ordinate. The Leibniz view proposes points are immutably fixed to underlying graph vertices: the co-ordinate remains an independent variable added to decorate each point.
3) Shapes in C manifolds are expressed by defining functional subsets of points in the C manifold. Shapes in L geometries are described simply by changing the value of the co-ordinates assigned to each point to reflect the desired geometric shape.
4) Co-ordinate distance conformity of nearest neighbour points is implicit in C manifolds by the ordering of Cartesian axis whereas it must be explicitly imposed as an axiom on L manifolds.

There is one important point of similarity; coordinate space is continuous on the real set of numbers in both types of geometry with no in built notion of scale.

In L geometry it is quite possible to make the whole manifold a congruent singularity by assigning an identical co-ordinate to every point. It is impossible to make two points congruent in a C geometry; they are fixed in place; but it is possible to make two functions congruent to each other in a C manifold.

The two classes of geometry explored above are not mathematically identically equivalent to each other. There is no generic exact transformation that will translate a C manifold to an L manifold or vice versa. However a C manifold and an L manifold may be compared to each other via their respective point co-ordinate space, and in most instances (with some notable exceptions like congruent solutions!) a C manifold can be made to a very close approximation of an L manifold and vice versa.

It is possible to at least partially visualise the L manifold on a C geometry because the set of point co-ordinates assigned to any L manifold are always a subset of a C manifold. So the spatial coordinate state of the L manifold may be compared directly if you are prepared to hide away the graph that underlies the L manifold. This technique is important when it comes to comparing algebraic theories derived in L geometry to field theories derived in C geometry using functional calculus.

A function based “C shape” can only ever approximate an “L shape” because L shapes can and do have discontinuous curvature differentials, while C shape functions cannot be discontinuous if you actually want to benefit from using differential calculus on such a structure. Similarly, shapes in L geometry can only approximate shapes in C geometry because there is only a limited number of points in the L manifold (countable infinite on the set of natural numbers) to draw a C shape which comprises a functional subset of points countable infinite on the real number set.

It is most important to realise in L geometry that the point coordinates create the space out of nothing. One point can be “here” and another “over there”, simply by assigning appropriate co-ordinate values. Distance can then be calculated, but it must be realised that there may well be no other points between “here” and “there” on the underlying graph, just nothing. In C geometry by contrast there is always an infinite fabric of points between the two points we choose to call “here” and “there” because of the way C geometry is defined.

Geometric Interpretation of Quantisation

Important differences between L and C-type geometry become evident when we wish to establish the principle of quantisation for these geometries. If we examine any geometric manifold for a natural object to quantise, the geometric point would surely be the obvious choice since it is the only object available in the manifold that is discrete of and by its very nature.

In L geometry the choice of the geometric point as the object of quantisation is then very simple; assignment of independent co-ordinates values post-facto to the construction of the underlying graph means these point objects of quantisation are by definition free to move anywhere in the co-ordinate space created for such a structure. Making such a movement simply involves assigning a different co-ordinate value to the point.

Even if some more complex emergent compound shape in the L-type manifold was designated as the object of quantisation, it would always be possible to break this object down to the individual points as quantisation objects but no further since by definition nothing exists between the points in L geometry but the connectivity rule of the underlying graph. The geometric point is therefore the natural object of quantisation in L geometry.

But if the attempt to use the point as the object of quantisation is made for C geometry, problems immediately arise. Each point has a fixed co-ordinate value by definition so it is simply not possible to move it relative to other points in the manifold. Any universe constructed on such a basis must be both static (have only one state) and smooth. This is completely at odds with even the most cursory observation of our universe at any scale. So if the point cannot be the natural object of quantisation in a C geometry what is?

To introduce the principle of quantisation in Cartesian geometries, the object of quantisation must be the function (1). The function naturally describes a subset of the Cartesian geometry (i.e. a shape in space in the form of a curve or surface). By changing the function parameters, functional objects can change shape and move in relation to other functions. The mathematical function then is the natural object of quantisation in Cartesian geometries, and it moves over the background continuum of the points in the C geometry: It is not at all surprising the name originally chosen for the discrete object that carries the quantum numbers in quantum mechanics is the wave-function.

While this is an entirely valid view to take of the quantisation principle it is a derivative one in the sense that any non-trivial function must have a-priori parameters that allow it to “move” and “change” in such a space. The function parameters and functional form do not arise out of the C geometry but must be imposed upon it so that results reflect observations of the natural world.

In this regard the use of “wave function” as the quantisation object in C geometry does not derive from any philosophical reasoning other than it being the simplest available thing in C geometry capable of doing the intended job. By contrast in L geometry the point as the object of quantisation is already present and available for intended use from the very definition of the geometry.

Necessity is of course exactly how Schrödinger’s equation came to have the parameterised form that it has involving Planck’s constant and particle mass and the values thereof; There is no a-priori requirement or indeed expectation that the parameters have any meaning except to match the functional theoretical model to observations of the natural world.

Geometric Interpretation of Relativity

The distinction between C and L geometry also allows us to consider the axiom of relativity in both types of manifold.

In L geometry, the only connection between points is the logical one derived from the underlying graph and this connectivity is completely independent of co-ordinate value. This is an explicitly relative and local view: the only concrete notion of where another point is derives entirely from the sequence of local graph connections relative to the one you are observing from.

But relativity goes even deeper than that in L geometry: Provided all points in the manifold are added using the same connectivity rule for the graph, no point can ever be judged to be uniquely identifiable so as to give an absolute notion of location within the manifold.

C geometry on the other hand has the notion of absolute co-ordinate built in to it, both in terms of location (the origin being an absolute unique point), and in terms of direction (the orthogonal co-ordinate Eigenvectors being unique directions by which orientation of a function may be gauged.

Because absolute orthogonal co-ordinate axes underpin the very definition of C geometry, it follows that any theory based on functions will generally have built in to them the notion of absolute position and orientation. In order to make progress in achieving a C manifold embodying the principle of relativity it follows that the functional form chosen for a theory of relativity must be carefully restricted so that the notion of absolute position and direction is explicitly eliminated. This requirement is the extraordinary insight that Einstein brought to his development of special relativity (16).

This is also exactly why the field equations of general relativity take on the form they must have: they are an explicitly limited functional form of co-ordinate transforms chosen to be invariant under translation and rotation. Remarkably (and a mark of true genius), Einstein then worked out (2) how the geometry could be functionally "bent" or curved in response to any general distribution of a mass function spread over that geometry and still maintain this invariance. This is after all why the theory is called "general" relativity.

However, just as with quantum theory, there need be no a-priori reason for parameter values in this functional field theory (such as large G, the gravitational constant) beyond the fact that any such parameters of necessity will take on a value required to match what is observed. This is because the functional form of general relativity was imposed from without on a Cartesian geometry with the express purpose of matching observation.

By contrast, the notion of relativity in L geometry is already in place because the abstraction of the connectivity graph from the co-ordinate system may be used to guarantee a relative structure from the very definition of the geometry.

Reconciling Geometry with the Axioms of Relativity and Quantisation

This section is intended only as a general overview and for speculation on the need for a scale limit or not in natural law.

Natural law seems to be predicated on the axioms of quantisation and relativity. These principles must be separately imposed and parameterised for Cartesian geometry, but they are both shown to arise from the very definition of Leibnizian geometry.

In C geometry, the functions of general relativity obey the principle of relativity, and the functions of quantum mechanics obey the principle of quantisation, but nobody seems yet to have come up with a functional form that generally obeys both principles simultaneously. Dirac's work (17) arguably comes closest to achieving this in a limited way.

These issues of difference between L and C geometry all come to a head when we consider how nature acts at very small scales. Because a C manifold by definition cannot be squeezed into a state of congruency (a singularity) it follows that any functional theory derived from it that tries to squeeze itself into a singularity will generate an infinite result that makes nonsense of the function, presuming there is some integral property of the function (like mass) that must be conserved regardless of scale.

This is a quite familiar concept in looking at general relativity applied to black holes where an infinite mass density is possible in theory but generally considered un-desirable in practice. A very similar problem occurs in quantum mechanics if you try to squeeze a quantum wave function into a singularity space. In principle the wave function could collapse to a point (after all what is the logical mathematical end-point of a complete collapse), but practicing quantum physicists seem to want to avoid this in practice. The rules defining calculus and C geometry simply do not allow this to be done without making nonsense of the functional form of the theory.

The solution at present seems to be to impose a lower limit on the scale to which functions can be squeezed; that is, the Planck length. While it is certainly plausible that the scale dependence of current theories of quantum mechanics and general relativity reflect some very deep and real property of space, it is quite curious indeed that the need for such a scale cannot be deduced directly from the principles of quantisation and relativity. It is perhaps even more worrying that the value of Planck's constant is intimately tied up in consideration of black body radiation integrated over a wavelength scale that is not limited either at the lower or upper end by any such length restriction.

The need for a Planck length in fact seems to be a separate axiom imposed on these theories, and further this axiom was imposed post-facto to improve theoretical out-comes. This is quite unlike the axioms of quantisation and relativity which actually preceded the development of quantum mechanics and general relativity.

Perhaps then it is just as likely that this scale dependence is a mathematical artefact imposed out of necessity to accurately express the theories of quantum mechanics and general relativity as field theories in C geometry. At present there is no definitive answer either way to this quandary.

Exploring Quantised Relative Systems in L and C Geometry

The benefits and problems of using either class of geometry in solving problems in physics may be explored by a mathematical understanding of the relationship between Cartesian co-ordinate systems and Leibnizian manifold point connectivity graphs. In order to achieve this outcome the co-ordinate values in the Leibnitz view should be a conformal map to the connectivity graph otherwise it is all but impossible to find a useful means of comparison. This simply means that distance measures in the Cartesian view should at least be logically consistent with similar measures in the Leibniz graph it is being compared to.

This concept is explored below in Figure 5 which explores the notion of a piece-wise chain expressed in both Leibniz geometry and Cartesian geometry form.

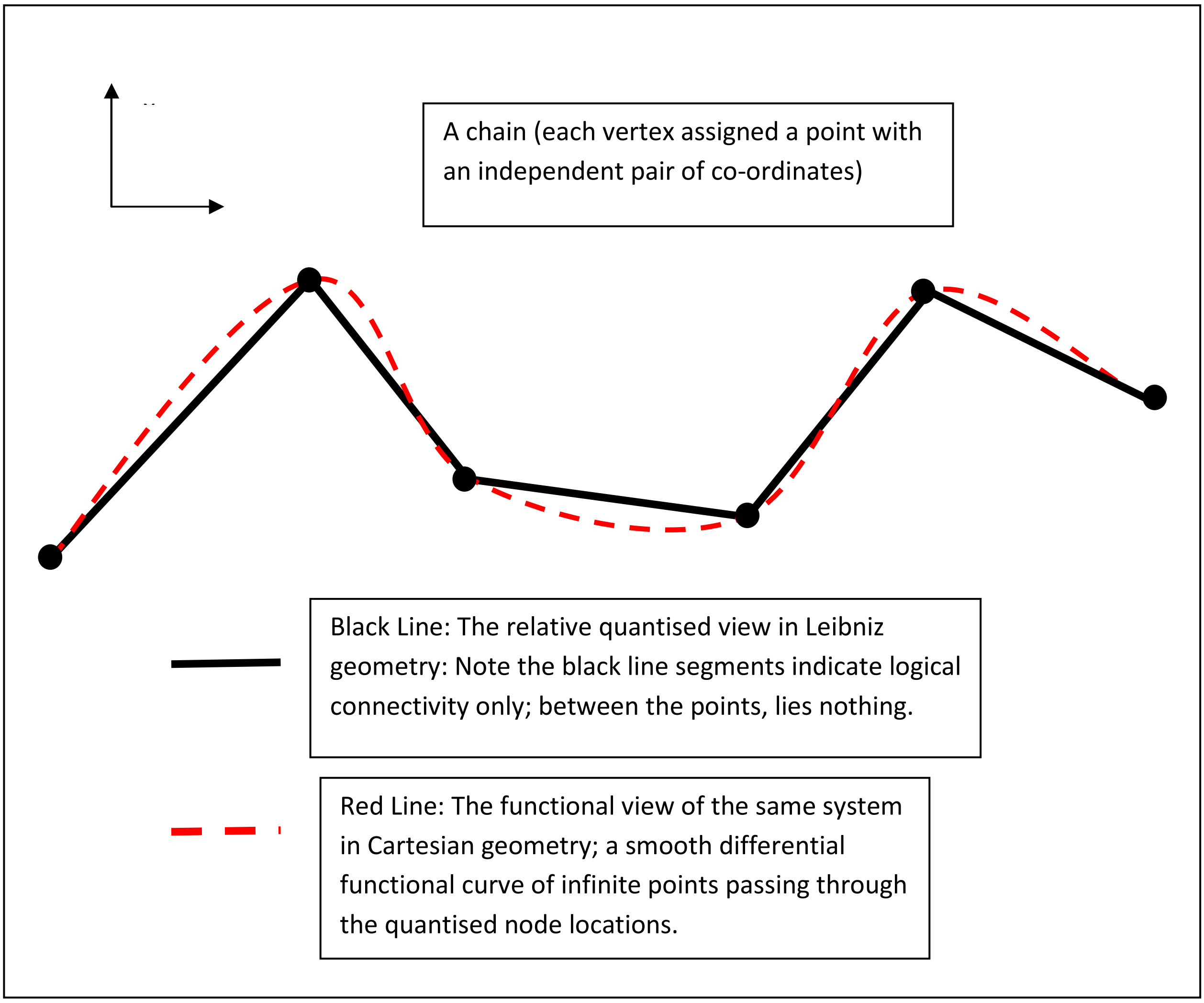


Figure 5: The perils of applying calculus to quantised geometry

The solid black line in this figure is simply a finite open one dimensional L manifold. The shape of such a chain can be varied simply by assigning new co-ordinate values to the nodes in a completely independent manner. The length of such a chain is simply a sum of the piece-wise Euclidian distances between point co-ordinates.

The dashed red line expresses the same structure in a functional form from an overlaid C geometry. Calculus requires a continuous co-ordinate curvature derivative in the limit and the length of the curve is now a path integral. But this continuous derivative requirement is generally not possible at the nodes of a chain where discontinuities naturally occur in the L geometry. The best that may be attempted in C geometry is some smooth “functional” curve approximation.

This simple view explains how calculus might be so successful at exploring a quantised world, even though the nature of the discontinuities between quantised objects might yet prove to be incompatible with calculus. A Cartesian view of the natural world can be made to work exactly down to the scale of quantisation because a functional form (Red line in figure 5) can always be found to approximate the quantised view (black line) to any requisite degree of accuracy. But any attempt to use calculus to describe what is going on “between” quantum objects is certain to degenerate into an exploration of mathematical artefacts.

Figure 6 shows how difficult it is to manipulate C geometry to eliminate absolute concepts of location and direction, while the same system expressed in L geometry lends itself readily to these concepts.

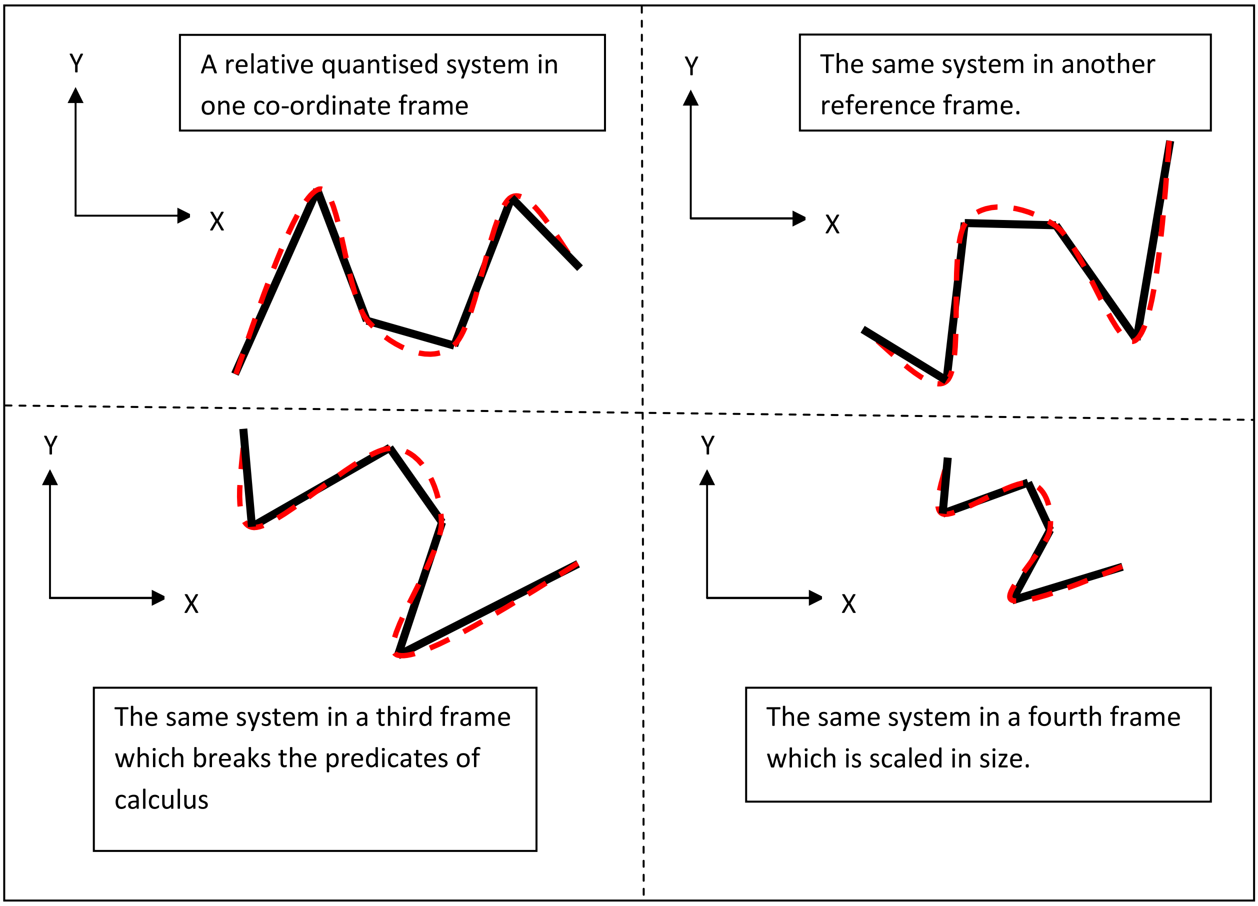


Figure 6: Different C-Type views of the same underlying L-Type geometry

As shown in Figure 6, the very act of trying to assign a co-ordinate system can produce four different Cartesian views (red lines) of the same quantised relative system (black lines.) All four systems are identical and invariant from an L geometry perspective (black lines): The underlying L manifold graph is completely unchanged. To come to the same conclusion in C geometry you must first rotate and translate and scale the frames of reference. Figure 6 would also tend to indicate that relativity of scale should perhaps also be included under the relativity axiom.

The Leibniz View of Geometry: A path towards unification

The arguments above imply that Leibnizian geometry may allow a more natural expression of the natural principles of quantisation and relativity than Cartesian geometry. At the very least it might provide an alternative mathematical view of natural law that allows some new insight into natural law to be discovered. One such theory in L geometry is now presented.

The first step on this path is to propose a principle which restricts the coordinate system of an L manifold to some logical relationship with the underlying graph connectivity rule. If this is not done, there is no basis for restricting shape in L manifold coordinate space, and any desired result can be obtained, even ones that have nothing to do with the natural world.

The principle proposed here is that of conformity of distance. Such a conformal principle simply means any point in the L manifold cannot be simultaneously nearer to a reference point by graph hopping count, and at greater distance in co-ordinate space by a distance metric, than any another point. It is understood that such a one to one conformal map requirement will impose restrictions on the co-ordinates based on the connectivity of the underlying graph.

Applying this restriction is straightforward in practice. Each point in the L manifold has an independent co-ordinate system assigned with that point at the origin. The distance to each nearest neighbour point in the underlying graph is then by definition relative to that observer point. Provided the equation used for distance as a function of co-ordinate is invariant under rotation, then no special direction can exist in the co-ordinate space and a fully relative quantised system is thus maintained in the L geometry.

The only remaining feature to be calculated is what actual distance should be assigned between the coordinates of neighbouring points in the L graph to make it conform to the L graph hopping count? This distance may be found by logical deduction.

If we propose a non-zero co-ordinate distance between two nearest neighbours in an L graph, then because the set of real numbers is infinitely larger than the set of natural numbers, we can always find another point with a distance measure that is smaller than this nearest neighbour but which is not in fact a nearest neighbour. This outcome is logically inconsistent with the principle of conformity we wish to impose. It follows by deduction that the co-ordinate distance of a point from its nearest neighbour in a L graph must be zero in order to maintain a principle of conformity.

$$\Delta s = 0$$

This is exactly the same result found in Equation 1 gained by the rather more philosophical argument from Occam's razor at the start of this paper! This is quite encouraging; we now have additional confirmation of this absolutely absurd outcome as a possible unification principle. The same argument applies generally to any non trivial L manifold regardless of the underlying graph.

This result also happens to neatly extend the relativity principle to include relativity of scale or scale invariance, since we can scale zero by any value and the distance formula for Δs whatever we choose it to be remains the same. Conformity of distance and scale invariance are then both expressions of the same basic principle in any L manifold.

Calculus of Variations: A Crack in the Armour of Field Theories?

A particular branch of calculus always seems relevant to physics. In every empirical outcome some principle of least action is somehow involved both in GR and QM problems. Not only does it seem that every empirical outcome follows some such least action principle, but that every conceivable variation on the experiment also follows in a similar vein. Importantly while outcomes that are not least action can easily be found mathematically in functional C geometry, it seems nature never chooses to take them.

The natural world always seems to require some principle of least action to be at work. Referring to Figure 5, in the Cartesian view there are an infinite number of functional curves that can pass through the quantised relative nodes, of which only one path integral is of minimal length. What better way to impose least action in a path integral than to presume nature acts more like the chain than the smooth curve. Provided the link length of the chain is constrained to be constant, every conceivable co-ordinate state (shape) of the chain results in the same minimum chain length (black line) and this is entirely consistent with observation that a chain always follows a path of least action, regardless of the individual motion of the nodes. The links impose the least action principle on a chain.

A chain in this instance need not be just an analogy; a real bicycle chain exists in the real quantised relative universe around us. You can pick it up and move it and bend it and throw it. And lo and behold, try as you might you can only move it according to a principle of least action in a relative quantised manner: The length remains invariantly minimal. This chain is a real physics experiment in action, not just an esoteric metaphor.

By contrast any change in state in the Cartesian geometry view of Figure 5 creates new functional parameters whose path integral must be re-minimised to find the red line that closest approximates the black. This many path method implies that maybe Nature tries out all the possible paths (red curves through black nodes) and then settles on the one with least action. If this were really so, Nature would surely be free to choose a path that is not least action; this path would after all have been computed by Nature in order for it to be rejected, and if it can be computed, it can be acted on by a functional theory.

It seems more satisfying to work from the view that Nature has no choice but to follow a path of least action, rather than consider many paths that are not least action and then not follow them! One dilemma in C geometry concerns the fact that different functional expressions of least action are required for GR and QED. How is it that Nature knows which type of least action to follow under which circumstance? This is resolved now by performing a thought experiment on the L and C geometries outlined in Figure 5.

The calculus of variations (18) and the resulting minimal action is predicated on finding parameters (p) of a function f(p,s) such that Action is a minimum where:

$$\text{Action} = \int f(p,s)ds$$

Under what conditions can a minimal answer for Action on parameters ‘p’ be the only available solution for a non-trivial definition of f(s)? The answer of course is that there are no conditions under which this is possible. If s is a path integral on a C geometry continuum it is always possible to find a valid value for p which is not minimal Action. A minimal action solution cannot be a-priori guaranteed.

Consider now the equivalent Action function expressed in L geometry. The integral is no longer over an infinite continuum, but instead over a number of points in the graph, which may be finite or countable infinite on the set of natural numbers. In this situation the calculus of variations reduces from a path integral form in Cartesian space to a summation form in Leibnizian space as apparent from figure 5:

$$Action = \sum f(p,s) \cdot \Delta s$$

It now becomes apparent that there is actually now one way and one way only to guarantee a minimum Action for any non-trivial function f(p,s), and that is:

$\Delta s = 0$

This result is identically equivalent to Equation 1.

The principle that nature must only ever follow a path of least action (and it does not matter which one, as long as there is one) is shown here to be identically equivalent to the principle of conformity on an L manifold which has already been shown to be identically equivalent to the principle of scale invariance.

The fact that such a result is attainable only in L geometry and not to any field theory available in C geometry means that current field theories can never impose least action principles in natural law. Why then do least action results constantly appear in empirical observations? By deduction it follows that if nature does actually always follow some path of least action, any unification attempt in the form of a field theory in Cartesian geometry will fail, because the only way to guarantee such a result is not compatible with C geometry, only L geometry.

Quite remarkably, we now have three quite different derivations (compelling arguments albeit perhaps not rigorous proofs) of a possible unification principle (Equation 1), all leading to this same absurd result. The implication at first glance is that we live in a congruent universe incapable of expressing extent and shape. A quick trip to the local pub is sufficient empirical evidence that this is not so.

Perhaps it is worth spending some time to understand why this hypothesis for a unifying principle seems so absurd before it is discounted out of hand: After all, the arguments behind such an approach are quite compelling. This understanding and its relationship to existing natural laws is now explored in the final part of this paper using L geometry concepts presented above.

Summary of Unifying Concepts and their Application to Leibnizian Geometry

A number of conclusions can be drawn from the thought experiments presented above:

1) If the axiom of conformity is introduced along with those of quantisation and relativity as a basis for natural law, then the unification law $\Delta s = 0$ arises as a deducible expression from these three axioms and is generally applicable to any L manifold.
2) In addition, two separate arguments by induction (Occam's razor) and deduction (principles of least action) have also led to the conclusion that the unification equation could be $\Delta s = 0$.
3) The very act of quantising a relative system according to this law includes a scale invariance that makes the equation incompatible with field theory and C geometry at small scales.
4) Leibniz manifolds might empower a much more natural expression of the principles of relativity and quantisation than functional Cartesian manifolds.
5) Only L manifolds that have the same connectivity rule for every vertex point of the underlying L graph fully embody the principle of relativity.

In order to make progress deducing how all this might relate back to the natural world the following must be explained.

a) How do we introduce co-ordinates to quantised points in L geometry without adding the notion of absolute space or direction?
b) How do we observe actual separations between objects in space when the common sense Euclidean interpretation of $\Delta s = 0$ implies complete congruency between all quantum objects?

The assignment of relative distance in a co-ordinate system is established by translating the location of the co-ordinate origin to an arbitrary reference point. All co-ordinate distance measures are then relative to the reference observer. Each point in an L manifold therefore requires its own independent co-ordinate system, and because no point is distinguishable from any other in an L manifold if the graph is constructed from a single connectivity rule, there can be no absolute point of reference. It depends entirely on the chosen point of observation.

The notion of absolute direction is automatically removed from a co-ordinate system provided the equation for Δs when expressed in co-ordinate form remains invariant under rotation about all and any combinations of coordinate axis. This establishes point (a) above for a fully relative coordinate system.

Now to point (b): Unfortunately if we start with the usual Euclidean definition of distance for Δs (distance squared equals sum of squares of orthogonal co-ordinate differences) the rather disturbing conclusion is reached that the only relative co-ordinates that satisfy the equation $\Delta s = 0$ force all the points in an L manifold to have a coordinate separation of zero; i.e. they are all congruent with each other. No structure in space can be built from such a solution.

To make further progress another definition of distance is required that nonetheless still remains invariant under translation, rotation and scaling of the co-ordinate system but which also does not always require points to be congruent with each other. Sound impossible? One such definition now follows.

Introduction of Complex Vector Length

The congruency problem is addressed by defining a complex vector length that reduces to the usual Euclidean scalar value where appropriate.

The usual notion of the length of a complex vector is:

Equation 2

$$(\Delta s)^2 = z \cdot \bar{z} = (a + i \cdot b) \cdot (a - i \cdot b) = a^2 + b^2 + 0 \cdot i$$

This of course is the familiar Euclidian distance metric.

Consider what happens however if the notion of a scalar length Δs is replaced by the notion of a vector length$\Delta\psi$, and further that this vector length is defined as:

Equation 3

$$(\Delta\psi)^2 \stackrel{\text{def}}{=} z \cdot z \stackrel{\text{def}}{=} (a + i \cdot b) \cdot (a + i \cdot b) = (a^2 - b^2) + i \cdot (2 \cdot a \cdot b)$$

A number of important features are apparent in this equation:

1) When the imaginary part (b) is set to zero, the equation reduces to the Euclidean equation of scalar length in the real domain (a^2)
2) The usual scalar length of this complex vector length $\Delta\psi \cdot \overline{\Delta\psi} = a^2 + b^2 = (\Delta s)^2$ is identical in value to the normal Euclidean mathematical definition of the length.

Note that the symbol ψ was not chosen to enrage and provoke practitioners of quantum mechanics. It will become clear later that this definition of ψ most closely approximates in L geometry the notion of a probability wave function in C geometry.

Solving the Problem of Congruency

The complex vector length Equation 3 can now be tested to see if the problem of congruency can be addressed in Equation 1 by replacing our normal Euclidian definition of length (Δs) with a complex vector definition of length ($\Delta\psi$).

The axiom of relativity will be ensured by allowing only co-ordinate differences be used in the equation (Δ), the axiom of quantization will be ensured by allowing the differences only to apply to the separation ψ of discrete objects (the geometric points in an L manifold), and the axiom of conformity (relativity of scale) will be ensured by setting the entire result to equal zero.

Equation 4

$$\Delta\psi = 0$$

The following result is then apparent, by extending the complex vector notion to an arbitrary dimension M of complex co-ordinates attached to each point in the L manifold.

Equation 5

$$(\Delta\psi)^2 \stackrel{\text{def}}{=} \sum_{j=1}^{M} (\Delta z_j)^2 \stackrel{\text{def}}{=} \sum_{j=1}^{M} (\Delta x_j + i \cdot \Delta y_j)^2 = \sum_{j=1}^{M} \left((\Delta x_j)^2 - (\Delta y_j)^2\right) + i \cdot \sum_{i=1}^{M} 2 \cdot \Delta x_j \cdot \Delta y_j = 0$$

Where Δx_j is the relative co-ordinate difference along the real part of dimension j and Δy_j is the relative co-ordinate difference along imaginary part of dimension j. It is quite straightforward to show this equation remains invariant on rotation about any or all of the M dimensions. For this equation to be true, both the real part and imaginary parts of the length vector must be zero so:

$$\sum_{j=1}^{M} (\Delta x_j)^2 - (\Delta y_j)^2 = 0$$

$$\sum_{j=1}^{M} \Delta x_j \cdot \Delta y_j = 0$$

Provided M>= 2 then a remarkable result may be achieved: solutions for x and y become available where the co-ordinates of points in the manifold are not congruent but for which the complex vector length under this new definition of length remains zero.

A simple example for M=2 is sufficient to demonstrate this:

If point 1 in the L manifold has coordinates (4+3i,3+4i)

And point 2 in the L manifold has coordinate (2+6i,6+6i)

Then clearly the points are not congruent to each other because the vector difference from point 1 to point 2 is (-2+3i,3+2i)

And substituting this difference vector into Equation 5 results in a complex length of zero:

$$(\Delta\psi)^2 = ((-2)^2 - (3)^2) + ((3)^2 - (2)^2) + 2 \cdot i \cdot ((-2 \cdot 3) + (3 \cdot 2) = 0 + 0i$$

This is a quite remarkable outcome. There are non-congruent solutions for point coordinate positions that result in a complex vector length difference of zero, and the equivalent Euclidian distance calculated from this complex vector length of zero, is also zero, however calculation of the normal Euclidian length formula from the original coordinates results in a measurable real length and extent in the space of $\sqrt{26}$

Equation 5 can be generally applied to any L manifold, and allow points to become non-congruent while still maintaining a valid solution to our unifying principle Equation 4. It is also clear that congruent solutions are also perfectly valid coordinate states for the points.

It should be noted that any co-ordinate system satisfying this equation defines a particular "state space" of the geometry so this equation is best called an equation of state.

Equation 5 is applicable to each and every pair of neighbouring points in a graph defining an L manifold, so the question arises as to which particular L manifold might represent the universe we inhabit. This means specifying three additional properties: The connectivity rule for the L graph (there must only be one to conform to the relativity principle), the number of points (N) in the manifold and the number of co-ordinate dimensions (M) assigned to the points in the geometry.

The philosophy of minimum sufficiency would suggest that the connectivity rule should specify complete connectivity between any point and every other point in the graph, and that the number of points should be countable infinite on the set of natural numbers. The reason for this is that to choose some other L manifold would require that a particular number or rule be justified against a very similar alternative rule or number. Without additional knowledge about how nature acts, there can be no justification for distinguishing between such rules or numbers. It would have to be justified for example why N=100 instead of say 200 or 1,000,000. Also, common sense observation of the universe around us indicates N must be extraordinarily large indeed given the number of quantum particles in the observable universe. Finally there seems quite a wide held view in the quantum mechanics community that the universe technically should have only one wave function embracing all the particles within it. The complete connection of an L Graph would enforce this QM notion that in a real sense every part of the universe is connected to every other.

Finally the question of the number of complex co-ordinate dimensions M must be satisfied. First we note that $M \geq 2$ is required for non-trivial non-congruent solutions to be obtained (that is solutions for universes that have more than one valid state). We also note from Dirac's equation (17) for a particle that no more than 4 complex fields are required to describe a general relativistic quantised particle. So for a starting point M=4 will be chosen noting that M=2,3 may be a possibility, and M>4 cannot be immediately discounted.

Finally it will be noted that empirical evidence shows that small physical systems can usually be experimentally isolated to a very good approximation from the rest of the universe. It follows that an L manifold solution where N is less than infinity say N<1000 will be computationally much more tractable and may still be of great use in confirming empirical results.

Definition of Quirk Space as a Proposed Unified Theory of Physical Law.

We can now state the formal definition of the complete pure natural geometry, co-ordinate system, and associated equation of state that satisfies the axioms of relativity, quantisation and conformity in an L Manifold as being:

Equation 6: The Equation of Natural State

$$(\Delta\psi)^2_{pq} \stackrel{\text{def}}{=} \sum_{j=1}^{M} \left(\left(\Delta x_{pqj}\right)^2 - \left(\Delta y_{pqj}\right)^2 \right) + 2 \cdot i \cdot \sum_{j=1}^{M} \Delta x_{pqj} \cdot \Delta y_{pqj} = 0 \;\; \forall p, q \in \mathbb{N}; \forall x, y \in \mathbb{R}$$

And that for our universe we start with the likely value of M=4. Because this equation defines all the valid co-ordinate sates of the L manifold it is a state equation, and because it appears to be the simplest non-trivial equation that enforces the natural principles of quantisation, relativity and conformity, it is thus termed “The Equation of Natural State”, hereafter referred to as the ENS.

Equation 6 acts on an L manifold with an infinite number of points (countable on the set of natural numbers) with an underlying connectivity graph that connects every point to every other. The ENS therefore must act at all times between every combinatorial pair of points in the manifold.

Because the vector difference between any 2 points in this construct is so important it is given the special name of “quirk”; a mash-up of quantum relative coordinate. A quirk consists of a pair of points whose vector coordinate difference satisfies the ENS at all times.

Quirk space then is a fully connected L manifold of infinite number of points, every combinatorial pair of points being a quirk, and approximate Quirk spaces may be constructed for N less than infinity.

Equation 6 forms a coupled set of algebraic equations. It is not a field theory. It is scale invariant. It is quantised. It is relative. It guarantees that any structural change in the state of the manifold follows a principle of least action. It contains no unknown parameters (except M=4).

Tracking Change in Quirk Space (Introducing Universal Time)

The ENS defined for Quirk space has no concept of time in it. Indeed the Leibniz manifold expressed in Quirk Space has no memory at all of past or future states.

Given that multiple valid co-ordinate states of this space exist, it must then be considered how the system is permitted to transition from one state to another. In particular, can any state transition directly from any other? Observation indicates otherwise. A system state representing a snapshot of the Universe in the year 1900 clearly is not followed immediately by one in the year 2000, many other states have occurred between the two. What is it that permits the seemingly orderly flow from one state of the universe to the next?

If Quirk space does represent reality, the immediate past and future state, or at least a restricted set of past and future states must somehow be encoded in the instantaneous "snapshot" present state of the space. Julian Barbour et al (19) express and explore this idea conceptually in a number of papers, and indeed the notions of conformity and scale invariance are strong themes in his work as well. His works have inspired this paper in numerous ways.

Because each state is defined by a set of complex co-ordinates each with continuous trajectories, it is valid to use differential calculus on the co-ordinate state of each quirk with respect to a parametric variable used to track change in the manifold. The parametric variable (t) referred to here as universal time should perhaps be more properly defined as a parameter of universal change. It is not a separate dimension; it is purely a mathematical construct used to measure how the Quirk space is allowed to change shape.

In order to move from state S1 at time t1 to state S2 at time t2, the universe must transition through an infinite number of states on the real number interval t1 to t2. Further each and every one of these transition states must also satisfy the equation of state, Equation 6. These transition states can be explored by taking first and second differentials of the ENS (here using Newton's dot notation to save space expressing differential form)

The first differential of the ENS with respect to t is:

Equation 7

$$\sum_{j=1}^{M}\left(\Delta x_{pqj}\cdot\Delta\dot{x}_{pqj}-\Delta y_{pqj}\cdot\Delta\dot{y}_{pqj}\right)+i\cdot\sum_{j=1}^{M}\left(\Delta x_{pqj}\cdot\Delta\dot{y}_{pqj}+\Delta\dot{x}_{pqj}\cdot\Delta y_{pqj}\right)=0$$

And the second differential is:

Equation 8

$$\sum_{j=1}^{M}\left(\Delta\dot{x}_{pqj}^{\;2}-\Delta\dot{y}_{pqj}^{\;2}+\Delta x_{pqj}\cdot\Delta\ddot{x}_{pqj}-\Delta y_{pqj}\cdot\Delta\ddot{y}_{pqj}\right)+i\cdot\sum_{j=1}^{M}\left(2\cdot\Delta\dot{x}_{pqj}\cdot\Delta\dot{y}_{pqj}+\Delta x_{pqj}\cdot\Delta\ddot{y}_{pqj}+\Delta y_{pqj}\cdot\Delta\ddot{x}_{pqj}\right)=0$$

These equations introduce the concept of velocity and acceleration to the manifold which must not yet be confused with the common notion of velocity since we are dealing here with a universal time and not a local time (which ultimately can only be measured by counting the number of changes in a highly repeatable physical process in the same inertial frame as the observer.) Further differentiation is possible ad-infinitum, indicating the overall state transitions will likely follow harmonic solutions. Indeed common terms found in harmonic algebraic solutions are readily apparent in these equations and similarities to the Bessel function so important to QM theory in C geometry are also apparent.

The time differentials of the ENS also indicate that the initial conditions of trajectory velocity and acceleration are NOT independent of state but instead depend on the current shape of the geometry. This outcome is encouraging because as Julian Barbour notes, for a truly relative notion of the universe, the flow of future (and past) states must somehow be embedded in the current shape of the universe. This differential form of the state equation in equations 7 and 8 demonstrates the exact mechanism by which this might be achieved.

The following sections explore ideas that have not been formally proven as yet, relating how to interpret Quirk theory results as observations of our Universe. If Quirk theory is, as intended, a unification theory of physics, then these ideas must relate back to our universe in the ways described in the following sections. Some parts are grossly speculative and will be flagged as such; possible but perhaps not very likely.

The Quirk Space Equivalent of the QM Wave-function

Here the term 'delta' refers to the coordinate difference in one particular dimension of a quirk's co-ordinate system, and is used by context to include some of, or all, the relative coordinates of the quirk. Velocity and acceleration deltas of the quirk are also presumed by context.

In any given solution, the delta of any quirk follows a geodesic trajectory governed only by the ENS and its time derivatives, much like in GR (by analogy only), where a test particle travels through curved space. Once a valid solution is found for initial velocity and acceleration conditions of the quirk's delta according to algebraic Equations 7 and 8, the sequence of state changes of the quirk's delta flows from those conditions by integration of the set of ordinary differential equations 6, 7, 8.

But this is only one solution of many, and there may be many others, or only a few, depending on the entire Quirk space delta state. Quirk theory is not a deterministic model, we know from QM it cannot be. The points in quirk theory should be regarded as a sampling statistic only. So any single trajectory solution to equations 6, 7, 8 for a quirk's delta is only one of the many possible solutions.

All other valid trajectories are found as follows: For any given known state in Equation 6, there is a range of velocities, and accelerations that satisfy equations 7, 8. Trajectories resulting from each and every valid initial condition need first to be solved. A probability density function (PDF) for that quirk at any time is created by plotting it's delta for all valid trajectories, evaluated at that time. The PDF can change shape over time as the quirk delta trajectories change, but each PDF is entirely local to a quirk.

These quirk PDF's may now be plotted in absolute Cartesian space used by Quantum Mechanics, but only by defining one of the quirk points at the origin. The Quirk space solution presented above has quirks within it that relate the chosen reference point to every other point in the space, and this subset may be used to map out all the other point PDF's relative to the origin from the perspective of the "observer" point. There will be N-1 PDF's in this reference space, each adding to probability one. These PDF's will both move and change shape with integration time relative to each other and should directly reflect the action of the QM wave-function. A different observer point in Quirk space will see a different solution, but the procedure followed is the same, since all the data is available in the Quirk space solution trajectories for any chosen reference point.

The Causative Mechanism of Heisenberg's Uncertainty Principle

So if equation 7 can be solved for a variety of velocity deltas for a known position state (Equation 6), then it follows that Equation 7 for a known velocity state, can also be solved for a range of delta positions for Equation 6. So the method of calculating the PDF outlined in the last section can be made to work both ways, velocity to position or vice versa.

In Quirk theory, certainty in position state gives rise to a range of velocity solutions, and certainty in velocity state gives rise to a number of position solutions, which should in turn be the exact mechanism by which Heisenberg's uncertainty principle (20) works in Quirk Space. By extension, equation 8 which contains position, velocity and acceleration states (and further differential equations beyond), will work by a similar logic. Equation 7 then represents the position-momentum uncertainty, and Equation 8 represents the energy-time uncertainty.

Equations 6, 7, 8, carry within them a direct causative mechanism for Heisenberg's uncertainty principle and that the current Quirk space delta state restricts the possible past and future states of Quirk space by the presence of delta state information in equations 7 and 8. The result of this is an orderly flow of state with time, even though the Quirk space itself has no knowledge of past or future states. Quirk theory gives the sampling statistic mechanism by which the uncertainty principle works.

Making and Breaking Gauge Symmetries: The Causative Mechanism

Breaking or making of a gauge symmetry to express a particular force, as it is termed in Cartesian field theories, is related to the degenerate states of the ENS Equation 6. To illustrate, 4C Quirk space will be used where each quirk delta has 8 values (from the 4 complex numbers in the co-ordinate system)

The action of the ENS can result in any one of the eight delta values of a quirk (or any combination thereof) going to zero, causing the two points in that quirk to become congruent in that dimension. When this happens, the symmetries that were available to that quirk increase to the next higher appropriate gauge symmetry and the Quirk which was behaving according to one gauge symmetry, now behaves according to another of higher order.

Conversely when the ENS forces a coordinate delta to be non-zero, the points in the quirk are not congruent in that dimension any more, and that quirk breaks symmetry to the lower order group of the gauge symmetry.

This means when the entire Quirk space starts as a singularity, all coordinates of all points in the quirks are congruent, and all quirks exhibit the entire symmetries available to all 8 coordinates. Because the root vectors of the ENS equation 6, match the root vectors of a quite complicated group. I will call it GENS here until the exact group can be figured out but it has at least 12222237 symmetry and others. The entire GENS gauge symmetry is available to the quirks. A quirk co-ordinate system always aligns along these roots, and its constituent points can thus escape into space.

As the space expands from singularity, quirk deltas must leave congruency in order to make that space, (the delta is no longer zero) and that quirk as a direct causative consequence spontaneously breaks symmetry to a lower order group in the GENS group.

As space continues to expand, more and more of the quirks are forced to break symmetry in order to create that expanding extent of space, and this is why today the broken gauge symmetries representing the forces of nature appear as they do. Quirk theory, not only predicts that gauge symmetry is broken; it is entirely explicit about the exact mechanism of how it happens. It is the expansion of space itself that breaks the symmetry, through the action of the ENS.

It may be that M can be made infinite in the ENS and thus remove the only parameter required in the derivation of the theory. Perhaps when M is infinite, sets of 4C Quirk spaces exist as connected structures that do not ever interact at all with each other due to the unique status in all of maths of the GENS group. This must be viewed as a highly speculative statement.

Quirk Space Starting as a Singularity (The Big Bang)

It is now clear that when the entirety of Quirk space starts as a singularity, not only is its position exactly known (Equation 6), but the velocity and acceleration derivatives (Equations 7 and 8) are degenerate. The initial conditions for velocity and acceleration of the quirks can take on all possible values, just as the uncertainty principle says they should. In essence the singularity is and behaves as a single quantum particle, expressing all the gauge symmetries in the GENS group.

Trajectories progress from singularity by taking all possible velocities and accelerations and integrating the Quirk space forward according to Equations 6, 7, 8. It is noted here that from this point of singularity, it does not matter if the integration follows forward or backward, both solutions will be identical.

Because quirks always align along gauge symmetry root vectors, the points can break free of the singularity and the (GENS) gauge symmetry is immediately broken because the delta of those quirks have become non zero in order to break free of the singularity. As space expands further, the deltas of ever more quirks become non zero, and gauge symmetry is broken further, right up until the present day. One presumes this process can and will continue.

Wave Function Solutions in Classical Mechanics and General Relativity

Quirk space under appropriate assumptions can also be applied at the macro scale, where quantum probability effects are not overly evident. When used at the macro level the initial conditions of velocity and position in equations 7 and 8 are now known with much greater precision. In this case a single quirk point may be placed at the centre of mass of the objects under consideration, and these accurate velocities and positions used exactly as stated in the sections above for equations 6, 7, 8.

It is most important to note that you must only fix coordinates to match the setup for 3 of the 8 coordinates for each point. This is all you can measure in 3 dimensional space, the remaining coordinates go where they will to satisfy the broken gauge couplings for each force when equation 6 is solved. If you try to fix all 8 coordinates, you will quite successfully recreate the big bang in miniature. You have been warned.

It is now only required for a single quirk trajectory to be found in Quirk space, and this is valid provided the situation being simulated does not involve undue sensitivity to initial conditions: There is no need to bundle the trajectories in as PDF's, because they all follow similar paths.

But if such a solution is sensitive to initial conditions, such as the presence of an unstable Lagrange gravitational point (21), then it becomes necessary by circumstance to return to the multiple trajectories

PDF interpretation of Quirk space presented above: A spacecraft for example at rest at such a Lagrange point can go almost anywhere from this point with a little nudge. This is simply the uncertainty principle in action in Equation 7 at the macro level, the difference from the microscopic scale being that the spaceship only can follow one of the trajectories in the bundle, not all at once!

In turn, only one trajectory is taken because while each quirk point in that ship wants to follow all allowed paths, they cannot at the macro scale because they are all coupled together by the electromagnetic force holding matter together: It holds them to account to only take one path. So it is seen that it is this electromagnetic coupling that prevents quantum effects from being expressed at large scales: it is just a numbers game.

It is presumed but has not yet been proven, that because of the relativity principles used in the construction of Quirk Space, that results under GR conditions will also be possible by this method. For example Quirk theory should have point trajectories in three real dimensions of 4C quirk space that will fit empirical data showing the perihelion advance of Mercury (22), using only a few quirk points at the center of mass of the objects under study (which might include a separate observer point). This will require a subtle twisting of the quirk space compared to a low intensity field, and in a full solution this twisting should result in the time dilation and frame dragging effects observed in GR.

However this type of macro simulation is just fitting Quirk space to known empirical outcomes, like a ball thrown in a ballistic trajectory on Earth. It is quite valid to extrapolate this solution (giving due attention to sensitivity to initial conditions), but if you wish to show the application of gravity and electromagnetism in Quirk space, restrained to three dimensions of motion, many more points in a more realistic setup will be needed to constrain the geometry.

It is obvious though that such a simple situation does not demonstrate restriction of freedom of movement in three dimensions, or the action of a force: They simply replicate and extrapolate empirically measured motion in three real dimensions of the 4C Quirk space. Such restrictions are the topic of the next section.

Symmetry Breaking and the Expression of Force and Dimension

It was shown previously that breaking of the gauge symmetries is directly caused by the expansion of space, and because the quirks align along the ENS root vectors in the singularity, space must expand if the quirk deltas have velocity, and because equation 7 is degenerate at the singularity, the uncertainty principle requires the quirk deltas to have velocity. And so space must expand from the singularity, it has no choice, and gauge symmetries must be broken, they have no choice, and so as Leibniz quite correctly said at the time, “this world, is the best of all possible worlds.” (23)

But as space expands, more and more available gauge symmetries are broken. As the solution expands from singularity, the points are free to move in all 8 dimensions, but as each gauge symmetry is broken, the degrees of freedom left available to those points must reduce, so the points are free to move in fewer dimensions, and after a few such gauge symmetry breaks, we are left with Quirk space that only has three remaining degrees of motion left; that is the familiar three we see today.

There is no requirement for Quirk theory to hide away the dimensions. When we see an elementary particle in the standard model, we see it in all its 8 dimensional glory; but it is only free to move around in three dimensions. That is after all why an electron can seem point like, or like a 1s shell, or like a 3p shell, even though at heart it is the same object.

The Interpretation of Rest Mass and Potential Energy

The other property to consider is mass. In quirk theory, this is quite straight-forward to quantify. In GR the field equations show that adding mass (as expressed in the stress energy tensor) curves space around it. However this interpretation can just as easily be reversed without changing the field equations at all: that is, curving space causes mass. It is just a short step in interpretation only to state that in Quirk space, bent space is mass.

It follows then that the rest mass of a particle in Quirk space must be related to the internal bending angles between the quirks that make up that particle, in fact we can generalise this concept to state that potential energy is related to the bending angles between the quirks; within a particle it represents rest mass, and between particles this represents a potential energy that can cause action. This may well be the Quirk space equivalent of gravity in action in field theory, in which case ultimately it might not related to the gauge symmetries at all.

Depending on exactly how the gauge symmetries break in practice as space expands, some of breaks may well mean that orthogonal but identical gauge groups split off in the 4C Quirk space. It is entirely possible that several independent orthogonal electromagnetic gauge couplings break off, resulting in duplicate sets of matter, of which we can only "see" the one properly aligned with the three dimensions we move in. This highly speculative interpretation of dark matter would mean it is just like ordinary matter, with all the same particle masses as the standard model, we just can't see it or influence it by electromagnetic means. But the gravity potential model outlined above would still act on all this matter combined.

Continuing this highly speculative argument, by the symmetry of the 4C space taken in subsets of three degrees of motion, it might be possible for four such fields to contain normal matter, and four such fields to contain antimatter, antimatter which can no longer be "seen" by the electromagnetic force in order to annihilate their counterparts since the gauge symmetry is now broken. This would mean visible matter makes up 12.5% of all matter, and four of the other seven fields contain all the antimatter. However until the full structure of the GENS group associated with the root vectors of Equation 6 is known, this will remain speculative.

The Quantum Vacuum

The nature of the quantum vacuum must be addressed. Quirk theory makes no provision at all for energy to spontaneously emerge and disappear from nowhere; between the points in quirk space lies, literally, nothing. However it is noted that a particle moving in Quirk space is in simultaneous resonance with every other particle in the universe through the action of the ENS (Equation 6). Most of these particles are so far away that there is very little chance of them significantly interacting with this particle by the ENS, but there will indeed be a random background jitter due to the cumulative sum of all these interactions that can cause apparently spontaneous changes in the particle travelling freely through coordinate space.

The "vacuum" energy in QM theory is not interpreted as such in Quirk space: it is background energy due to the presence of mass in the rest of the universe, and it does not break the principle of conservation of energy at any time like it explicitly does in QM theory.

The Interpretation of the Photon and Other Forces

The interpretation of the photon also requires comment. In quirk space, the photon is effectively embodied by the ENS itself and does not exist as a particle in its own right. In Quirk space, any pair of charged particles in the universe is connected by the quirks between the points in the two particles. This connection is instantaneous and always applies at all times. As such the ENS must be directly responsible for the transfer of energy between an electron in a receptive (low energy state) and an electron in a productive (high energy state.)

Indeed, it can already be shown that the ENS Equation 6 is entirely compatible with a numerical difference equation form of Dirac's (17) equation of the photon.

Once the coordinate systems of all the quirks in each particle are oriented to each other by chance in just the right manner, energy can flow spontaneously from one particle to the other along a root vector of the ENS, an action that is interpreted as the transfer of a photon. In practice, the transfer is accomplished by the swapping of positions of the two points in the quirk aligned along the gauge symmetry vector for that force. The same principle applies to all the other forces as well; it is just that different collections of quirks exhibit different gauge symmetries from the GENS subgroups.

No photon of energy can be transferred by the ENS without a charged particle available and ready at each end of the transaction. The conceptual interpretation of a photon emitted from an electron and travelling in space at the speed of light and by chance coming upon another electron in a receptive state is a profound illusion. In Quirk space it just cannot happen.

Entanglement and Perception of Time

Quirk theory means that entanglement is the normal state of matter and not the exception. This is because the ENS acts instantaneously at all times regardless of distance between every pair of points in the Universe.

It is presumed that our local perception of time follows from counting regular changes in things that happen in our local frame of reference (like an atomic clock); but although the ENS in this state acts instantaneously between two particles distant from each other, it also follows that some universal time must elapse in the time differential Equations 7 and 8 to actually stabilise and process the swapping of points in the quirks attaching to these two particles. Thus the transfer of energy from one particle to the other will take time, and this should take longer the further they are apart. Presumably it is the elapse of the universal time required to achieve this transfer which is intimately tied to the calculation of the speed of light.

General Relativity: Frame Dragging and Time Dilation

It is plausible that when a particle travels away from another at high speed, or many particles are in the same place creating a high gravitational field, that the 3 degrees of motion available to the particle, may no longer align exactly along the same three coordinate vectors of the reference point in the 4C Quirk space. This twisting effect would neatly explain the time dilation effects of special relativity, and the time dilation and frame dragging effects in general relativity.

If the misalignment of coordinates really does occur in relativistic circumstances, this might also neatly explain the CP violations in the standard model when relativistic collisions occur; but this is highly speculative.

Does this mean there might be a unique vector in open space with no gravity field where an atomic clock is at rest with respect to the average velocity of the rest of matter in the universe, and that this clock would tick faster than all others? The author is unsure. Presumably if the microwave background really does have an axis, this would be it.

The Double Slit Experiment

A new interpretation can be put on the double slit experiment. The emission electrons are connected directly via the ENS equation 6 to both the reception electrons in the detector, and to the electrons creating the two slits. All other particles on the stage are also connected, but do not significantly have action by the ENS due to their relative location. A state of resonance between the ENS equations connecting electrons around the slits, the detector, and the source electrons means some detector electrons are much more likely to have the ENS transfer energy to them than others, resulting in interference peaks on the detectors.

The energy flows directly from the source electron to the detector electron, mediated by the ENS equations of electrons at the slits. So the "photon" does not go through either of the slits, it goes via the resonance of a complete coupled system where energy disappears at one electron and appears at another. It need not in any sense go through one or both of the slits at all. The mere presence of the slits is sufficient to create the resonant system.

If matter is introduced near one of the slits to intercept such energy to the detector, it too becomes a significant part of the system, and the resonance state is disrupted resulting in a non-interference pattern on the detector. The transfer of energy via the ENS takes time according to the speed of light, but the ENS equation itself acts instantaneously at all times, so it should not matter if an attempt is made to block a slit "after" a photon has left the source or even if it has "gone through the slits". Until it is actually registered on the detector, the process of energy transfer by the ENS may still be disrupted, and the interference pattern lost.

Computations in Quirk Theory

There is a methodology for computing actual results using this theory. Quirk theory in its entirety results in a densely coupled infinite set of ordinary differential equations with respect to a parametric variable of change (universal time) (Equations 6,7,8). This system is computationally intractable; it is quite possible though that pure mathematics may supply some useful analytic deductions from such a structure since it is already expected breaking of gauge symmetries flow directly from this derivation.

Practical simplifications are however possible. We know from long empirical experience that it is generally possible to isolate a physical system to make detailed measurements of interest. In other words, just because the rest of the universe can influence a local physical process, does not mean it usually does, or if it does, only in a very small way and that steps may be taken to isolate a system if required.

It is therefore likely that we do not need to simulate the full Quirk Space. It is probably only necessary to simulate Quirk Space with a limited number of points; just enough to form the standard particles in an empirical setup of interest. Some few dozen points may well be sufficient to identify and confirm that Quirk space can replicate the standard particle model. This is a computationally tractable problem.

The methodology is as follows:

- Choose N points for the reduced form of Quirk space.
- This forms a group of (N/2)*(N-1) quirks, and a coupled set of N/2*(N-1) ENS equations 6,7,8
- Choose initial coordinate conditions for the points approximating the structure of interest.
- Choose quirk velocities and accelerations reasonable for the situation, or define the quirk positions for three separate times, or some combination thereof. Adjust velocity and acceleration to solve for equations 7,8 of the set of ENS equations as a starting point.
- Do not fix more than 3 coordinates of the 8 for each point for calculations in the modern era; that is all we can measure: The other 5 coordinates must go where they will by equation 6,7,8 to satisfy the broken gauge couplings for the forces. Fixing all 8 coordinates simply recreates the original singularity as the only solution.
- Track the trajectories by solving the coupled set of ordinary differential equations 6,7,8 through universal time to find the solution. Repeat for all possible variations of velocity and acceleration in 7,8 to find the range of trajectories.
- Plot the probability density functions of each quirk at any given moment of universal time. Choose a reference point, convert the quirk PDF's to point PDF's in Cartesian space and measure the result and compare with the measured empirical outcome for the standard model or QM or GR experiment.
- For classical simulations simply set a point at each centre of mass of interest connect all the quirks by point pairs, and proceed as above except you only need one trajectory. If the system is sensitive to initial conditions, solve many trajectories and choose one. In relativistic situations, the initial quirk conditions must satisfy what observations would show under relativity conditions. If you want to simulate gravity or another force directly you will need more quirks.

Because Quirk space is scale invariant, the only notion of size is with respect to another standard particle. Enough quirks must therefore also be introduced to the solution to form two such particles, and a stable solution should emerge that maintains the known relative sizes of these particles (say the proton relative to the size of an electron in a 1s shell). Size here is judged on the range of the combined probability density function of all the quirks making up a particle. It may not be possible to create a particle in Quirk space without also creating its anti-particle, or other symmetric particles.

Scale invariance means the equations can be solved at any scale, so the computational methodology above must impose a sense of artificial scale suited to the numerical range used in the computation in order to get an accurate solution in a reduced N Quirk space. The answer may then be easily compared to an empirical result in SI units simply by scaling the entire result by a single factor to suit a particular measurement system. Any scale factor may be applied and the calculated solution remains valid.

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