Emergent Fractal Attractor Corresponds with Foundational Quantum Problems

Blair D. Macdonald
fractalnomics@gmail.com

Blair D. Macdonald © 2021

Abstract

The field of foundational quantum mechanics originated nearly one hundred years ago yet remains one of the greatest mysteries to physicists today. The experiment in this study tests whether the geometry of fractals, according to a simple isolated iterating fractal (the Koch Snowflake), correspond to the accepted description of 1) electromagnetic wave-particles (light) and 2) quantum enigmas. In this investigation an experiment was conducted on an isolated iterating Koch Snowflake fractal. The propagation of changes to triangle ‘bits’ was observed and measured quantitively and the implications of these changes described and discussed. It was found the fractal, when in isolation, behaves as a quantum entity. The fractal has, 1) wave-particle duality, 2) an oscillating, exponential, sinusoidal wave of discrete ‘bits’ of information and 3) in superposition. Constant light speed ‘c’ was reasoned to be a property of the growth behaviour of the fractal. It was discussed that a concept and a direction of time would be experienced by an observer within the fractal set, and it was reasoned, corresponding to special relativity, this perception of time would slow to a stop when travelling at the frontier of the set and speed of propagation bits. The quantum ‘measurement problem’, ‘uncertainty principle’, and ‘entanglement’ were all addressed as also being a problem of isolated fractals within fractal landscapes or fields where ‘position’ is only ‘known’ by the addition of information or markers. The quantum-classical interface is a problem of the fractal and is scale invariant. From this experiment the opportunity arises to model and analyse what is viewed behind the observer as the fractal iterates. This dual retrospective perspective may offer a unification between quantum mechanics and cosmological mathematics, observations, and conjectures; in so doing possibly explaining the vacuum catastrophe. All these problems may all be different, dual and complementary aspects of the one fractal geometry.
Keywords: Measurement Problem, Entanglement, Light, EMS

Background to this paper

This has been a very difficult undertaking. How to get my findings down on paper. This paper is a working paper, a draft. It marks the end of the line of editing under a ‘inductive’ type paper. Frustrated with the progress and on good advice I am currently writing a deductive type paper. In time I hope to publish.
1 Introduction

Inside half the time of quantum mechanics existence another area of mathematics has developed, it is chaos theory and its related fractal geometry [2], [5]. Both quantum mechanics, chaos and fractals independently share direct similarities: complex numbers, bifurcation [3], infinity, and the potential of all possible events at all times, and indeterminacy — where they both counter the deterministic physics of the classical ‘clockwork universe’. Mathematician Ian Stewart in his popular book: Does God play dice? A New Mathematics of Chaos [4] — remarked: “chaos was unknown in Einstein’s day...”. To mathematicians today, we are surrounded by fractals; there are “Fractals Everywhere” [6] and they are claimed to be an important description of reality. To date, as far as the author is aware, no direct study has been made to test a simple fractal for quantum properties.

The foundational fractal, the Mandelbrot set (Figure 1A), is derived from an infinite series on the complex plain by the iteration of a simple rule revealing a scale-invariant complex structure. A simple fractal, the Koch Snowflake fractal [7], shares the same principles of emergent pattern and infinity without the complexity of the Mandelbrot. All fractals are synonymous with and inextricable to spiral patterns.
**Figure 1. (Classical) Fractals.** (A) The Mandelbrot set; (B) the Koch Snowflake fractal from iteration 0 to 3; (C) Spiral propagation of points to selected triangles; (D) A spiral curve (in red) is produced by a method of scribing circular arc from respective triangle centre points.

The emergent ‘snowflake’ structure is produced through the ‘infinite’ iteration of discrete and identical — but diminishing by one third (triangle) sized — ‘bits’. Figure 1B shows the first three of a potential infinity iterations. Development of shape is a function of an arbitrary iteration rate, tying it to a concept of time. Without ‘zooming’ or magnifying into the fractal set. The (snowflake) shape of the fractal is set to an observer observing inside (or outside) the fractal in approximately $7 \pm 2$ iterations. To ‘zoom’ into the infinite snowflake fractal resembles view into a tunnel. From this, the diminishing triangle bit size with each iteration may correspond to a *spatial* property of the fractal where the difference in bit size is the relative distance between each bit.

In this paper the Koch snowflake was analysed for its property of shape emergence by the iteration of identical discrete triangle bits. A spiral was produced (Figure 1D) by the propagation of highlighted a red dot bits with a (Figure 1C) and the problems of scale, speed and position were questioned with the context of the standard understanding of light and its quantum properties.

Five areas and questions were of focus:

1. **Electromagnetic spectrum (EMS)**
   
   Does the spiralling of iterating triangle bits of the Koch fractal correspond to the pattern of the osculating wave action akin to Young’s wave theory of light [10], propagating with a constant speed ($c$) as deduced the Maxwell equations [11],[12] of the EMS and observation?

2. **Superposition/ wave-particle duality**
   
   If the fractal is assumed to be iterated infinitely in isolation, does it demonstrate a superposition of identical/discrete bits and simultaneously sharing the wave properties?

3. **The measurement problem**
   
   Is the *measurement problem* demonstrated when a marker is placed on a single bit in the infinite isolated set, revealing the position in, and the scale of the fractal, and so ‘collapsing the wave-function’?

4. **Uncertainty Principle**
Does the placing of a marker on the infinite fractal trade-off the ability to know speed and history of wave propagation with position, and so demonstrating the Heisenberg Uncertainty Principle?

5. Entanglement

Do changes to the superposition set demonstrate the instantaneous ‘spooky action at a distance’ behaviour of (EPR) entanglement [13]?

It was hypothesised that if the (five) different questions are asked of the isolated emergent iterating fractal model, it will correspond with problems associated with the quantum properties of light and matter.

The aims of the paper are to expose possibilities and promote future exploration and discussion.

2 Methods

While the fractal can be seen as a simple but tangible object, modelling it also invokes concepts of infinity and complexity. It is for this reason, and keeping with the aims and questions the paper, the following experiments— while classical and empirical by nature— were conducted by imaginary Gedanken thought-experiments.

For the purpose of this paper the fractal model I have chosen is the Koch snowflake for its simple fractal regular-regularity properties and its ease of analysis as outlined in the introduction (Figure 1B, C, and D).

The model utilizes the Koch snowflake fractal and its production is. Schematics of the snowflake development from the 0th the first 6th iteration of the fractal set.

2.1 EMS

The wave propagation properties of the (Figure 1 C) arbitrary ‘red dot’ position-marker placed at the apex of every new pristine triangle bit with each iteration. This marker was traced in both plan and front elevation views with respect to iteration-time to measure the pattern of propagation as the emergent fractal iterated and ‘snowflake’ shape emerged. By standard wave mechanics the pattern was tested following: wave period (T), sinusoidal frequency (f), and wavelength (λ) behaviour; exponentially
increasing frequency coupled inversely decreasing wavelength, oscillation (wave) behaviour, and a universal constant speed of propagation, \( c \).

2.1.1 Time
The unit of time was assumed to be equal to the period of iteration. This time, the iteration-time, denoted \( (i) \), was ‘set’ to an arbitrary 1 beat per second; however, this could be raised to, in correspondence to light speed, the Planck time.

2.1.2 The spatial distance between bits.
The triangle bits were assumed to be identical in shape and size and the difference in size of the bits was due to the spatial distance between the bits and a fixed observation location, as if viewing into a tunnel property when ‘zooming’ as explained in the introduction. The smaller the bit, the further away the bit, when viewing to infinity. This apparent spatial distance between triangle bits was measured (Figure 2) by first, holding at an arbitrary 1 metre from the eye, an iteration 0 bit-sized triangle to the iteration 0 bit-size triangle. Then repeat for the iteration 1bit size measuring the distance between the iteration 1 and iteration 0 in metres where both triangles eclipse each other to the observer. The process was repeated for iteration bit sizes 2, 3, and 4 and so on.

![Figure 2. Fractal Spatial Distance Measurement.](image)

Figure 2. Fractal Spatial Distance Measurement. The distance (d) of eclipse between the (red) iteration (i) sizes (1 and 2) and the (black) i0 size. An arbitrary reach between the observer (eye symbol) the shape was set to 1 metre.

2.1.3 Constant Speed \( c \) Measurement
Testing for constant wave propagation speed $c$ (no matter the speed of the observer) consisted of three thought-experiments on the fractal, wave speed, iteration-beat, and frontier perspective:

1. *Wave speed*: multiply the frequency of oscillations by the wavelength of oscillations ($v = f \lambda$) throughout the set. The experiment also included knowledge of the *spatial distance* of the fractal. Tested for was a different or same *phase velocity* of the wave throughout the set; the latter resulting in a constant *group velocity* constant.

2. *Iteration-beat*: describe the effect the constant iteration-beat has on observations by an observer within the set.

3. *Perspective from the Set-Frontier*: describe what an observer would observe at the frontier of the fractal set, moving at the speed of iteration (the propagation speed), where new bits are introduced into existence.

### 2.2 Particle Superposition, and Wave-particle Duality

To test the fractal for the quantum properties of particle superposition and wave-particle duality properties, specific questions about the fractal were asked in the form of ‘thought-experiments’. These questions were framed as 3 possible states or ‘configurations’ A, B, and C, (below):

A.  : A *Pristine*, isolated, (coherent) set, where all bits are identical or coherent at all places and all iteration-times within the infinite set.

B. *Instantaneous Change*: An arbitrary change is made to the pristine triangle bit (as described in configuration A) that changes the set instantaneously. In this case, an arbitrarily ‘red-dot’ is added to the apex of the pristine bit. This change would be found to be coherent (the same instantaneously) throughout the set — at all places and all iteration-times. This was to demonstrate coherence after an arbitrary change in the set.

C. *Propagated Change*: Converse or contrary to ‘configuration B’, the arbitrary change is propagated and is not instantaneous. The arbitrary addition of the red dot to the apex of the triangle was propagated by iteration at the ‘production (or iteration) speed’ of the fractal. The arbitrary changing of the
set is assumed to be from, or inferred as, ‘a measurement’ or ‘observation’ of the set from a random position within the set.

*Particle Superposition* was tested for by describing *configuration A* from the perspective of an observer outside, not observing, the fractal on a setting of the fractal.

*Wave-particle duality.* The question of simultaneous wave-particle (wave-particle) behaviour by *configuration A* was tested for by describing whether the questioned exists: given the emergence of a coherent superposition ‘snowflake’ fractal shape by the propagation of bits.

### 2.3 The Measurement Problem

The ‘measurement problem’ was tested for by describing the effect a *configuration B* or *C* change has to the *configuration A* fractal system. From an initial condition of a fractal superposition — configuration *A* — an arbitrary change from a specific location or position within the fractal set was made. Analysed was what would an observer would observe from this position concerning configuration *C* wave properties of the fractal set.

### 2.4 Uncertainty Principle

From a configuration *A* fractal, a marker was added to a bit at a random location within the set. The effect on the perception of wave speed and position and whether there is a trade-off was described.

### 2.5 EPR Entanglement

The following describes the test conducted for the EPR entanglement paradox:

1. The fractal was initially set to configuration *A* — a state of fractal superposition and fractal supersymmetry.
2. Two locations (location 1 and location 2) were positioned within the set and located at an arbitrarily distance greater than one iteration-time from each other. These locations are places of observation. Before observation, the set remains in configuration *A*.
3. An arbitrary change to the set — under configuration *B* — was made (endogenously) by the observer in location 1 and the effect recorded by the
observer in location 2. The change could be, a change in the colour of the bits — to the colour yellow, for example — or the symmetric pattern of the fractal.

4. Same as 3 above, only configuration B change was made external — exogenous — to both observers before observation.

5. A change was made while both locations were observed (configuration C) and affects recorded by both observers.

3 Results
The following results are presented in the same order as the methods.

3.1 EMS
The apparent fractal spatial distance between differing iteration bit sizes use found to increase by a factor of 3 as the bit size decreased.

The sequence of propagation of a red marker on new triangles from iteration time \(i_0\) to \(i_6\) is shown in Figure 3A produced a logarithmic sinusoidal spiral pattern. The infinite position of propagation is also shown at \(i = \infty\). The red spiral curve Figure 3A \(\infty\) produced a spiral shown

![Figure 3. Fractal Logarithmic Sinusoidal Spiral.](image)

‘A’ shows the transverse wave propagation of a ‘red dot’ on a fractal Koch Snowflake to iteration \(i_6\), and to superposition, infinity \((\infty)\). ‘B’ shows real (inside) and normalised triangle bits rotating clockwise through \(360^\circ\). ‘C’ shows a normalised Sin wave produced at each iteration-time: the real is a logarithmic sinusoidal.
in more detail Error! Reference source not found.. The spiral was produced by the rotation of discrete triangle bits that diminished in size relative to the original.

The spiral in Figure 1D was produced by a method of scribing cycles from the centre points of respective triangle bits. Note, the red curve appears to be continuous; however, as it runs through discrete points, these discrete points are the only points possible and therefore the curve is ‘imaginary’. Triangle bits rotated through 360 degrees — shown in Figure 3B — in 6 iterations: 60 degrees per iteration. The last, the 6th iteration bit is very difficult to discern and any bit size beyond this iteration was from the assumed fixed observation position, and without 'zooming' into the set, unable to be discerned.

In Figure 3C a geometrical ‘plan view’ schematic using constant or normalised bit sizes with iteration-time wave shows how the logarithmic sinusoidal wave was produced. In reality, the fractal bits propagated such that the wave produces logarithmically increasing frequency while simultaneously producing an amplitude and wavelength logarithmically decreasing. The red marker propagated as a sinusoidal logarithmic wave. The wave period (T) is equal to 6 iterations; the frequency (f) = 1/6; the wavelength (λ) was reasoned to decrease exponentially, inverse to f.

3.1.1 Constant Speed

1. Wave speed: Initially, without any adjustment for spatial distance, the exponential sinusoidal wave property after propagation suggests the frequency increases and the wavelength decreases at increasing iteration-times, not satisfying a group velocity constant speed c. However, if this decreasing distance between points is adjusted for the fractal spatial-distance (measured separately and shown to for the Koch snowflake increase by a factor of 3 between bits) this problem may be relieved and a constant group velocity prevails.

2. Iteration-beat: No matter the position of an observer in the fractal, the iteration beat is constant and the fractal will continue to emerge in front of the observer — in the form of Error! Reference source not found. — corresponding to the iteration beat. This suggests the fractal may transfer information at a constant speed throughout the propagation range. This beat speed; however, cannot be reasoned to be constant throughout the fractal propagation range for reasons described in 1.
3. *On the Frontier:* here, a constant speed may be observed with a trade-off of all other sense of motion or iteration-time to the observer. It may, conversely, be argued or interpreted that an observer at this frontier position, with constant iteration beat, there will always be a new bit ahead forming a fractal geometry in front of the observer.

3.2 **Particle Superposition; Wave-Particle Duality**

*Particle Superposition:* When in perfect isolation the fractal (Figure 3 A) demonstrated a superposition of identical bits. There is perfect coherence of identical bits throughout the infinite set. The ‘triangle bits that make up the fractal shape are discrete: there are no positions between the iteration positions. There are no ‘half’ iterations and no half bits. The red curve (Figure 3) traces the path of the discrete bits, but is not real; there are no positions on this curve other than the said or shown apexes of the triangle bits. Positions on the line can be calculated by the use of complex ($i$) numbers — as done by quantum and light calculations.

Isolated identical triangle bits are in a ‘coherent’ state of all (rotational) symmetries at one time; and the rotations are in both directions at one time. In this case, supersymmetry relates to super rotational symmetry, before observation, of the triangle bits. Without observation they propagate in all directions, clockwise and anticlockwise; with observation, their propagation direction is set — either clockwise or anticlockwise. Supersymmetry may also include all the possibilities of the fractal shape. A state of shape supersymmetry — or topography ‘super-topography’ — is also possible, where all topographies are possible, discussions.

*Wave:* With the wave propagation (described above); the experiment showed — in Figure 3 and **Error! Reference source not found.** — that the isolated iterating fractal, with its identical bits, rotates in a propagating sinusoidal spiral motion. This motion is by a translational wave and the fractal forms by bits of information rotating perpendicular to this motion. The wave, composed of identical discrete bits or ‘particles’, oscillated by nonlinear propagation towards the superposition fractal state (Figure 3 A).

*Wave-Particle Duality:* An observer from the outside may interpret the fractal in three ways. By bits or particle, where the triangle bits that form the (snowflake) fractal —
when ‘measured’ or observed — may be interpreted as being independent; by wave, where the same bits — in the process of forming the fractal — may be interpreted as a part of wave propagation; and by dual wave particle, where bits are interpreted as simultaneous wave and particle (wave-particle) phenomenon.

3.3 The Measurement Problem
The measurement problem is a continuation of the (above) wave-particle duality. Under configuration A; the snowflake fractal is isolated, in superposition and in a state of scale-invariance. Bits are of undefined scale and location. Scale and position are only revealed the addition of another object, (preferably of known scale) or a ‘marker’ is positioned on the fractal. When the addition of a marker is made to the bit, the superposition propagation-wave history — of the bit to produce the fractal structure — is ended. From the new observation position of the observer, without any technology to magnify, can view a finite $7 \pm 2$ iterations ahead into the fractal, and behind from its history.

3.4 Uncertainty Principle
The transition from a superposition — configuration A — fractal with a defined wave speed to a ‘measured’ marked location of a single bit within the set was distinct. Superposition wave-propagation properties, including wave-speed, were completely traded-off for a position within the set. From the marked ‘measured' position, speed hand history of propagation is not available.

3.5 EPR Entanglement
Whether the change — from configuration A to configuration B with no observation — was made endogenously or exogenously, both observers at the different locations observed the same fractal pattern after observation. Any change made while both observers were observing the fractal was not instantaneously observed by each location and instead propagated.

4 Discussions
It was found the isolated iterating fractal independently demonstrates and shares properties of light and quantum with wave-particle and other quantum behaviour that corresponds to how light photons and the electromagnetic spectrum is described by
physicists the quantum problem. By this basic or elementary demonstration, the geometry of the fractal offers a direct solution to the problem of ‘the quantum’ and reduces its behaviour to a known modern geometry that was conceived after the development of quantum mechanics. The following discussions will follow the same structure as the methods and results.

4.1 EMS

The process of fractal development by iteration and propagation of bits of information corresponds to and is consistent with how light behaves and how light theory and the EMS is described. The fractal process is not a linear propagation, but is a spiral wave that oscillates, changes in frequency and size (wavelength) logarithmically, and propagates, so as a wave — a wave composed of bits just as the EMS, first described by Maxwell [11],[12]. From this fractal observation, it may be that the structural geometry of light and the mathematics surrounding light is the mathematics and geometry of the fractal; that light is a fractal by nature. When we do this, the problems associated with light’s behaviour and properties are addressed.

4.1.1 Constant light speed c

All the tests put together — wave-speed, iteration-beat, and on the frontier — it is plausible the fractal can demonstrate an analogy to Einstein’s universal constant speed [14] — no matter the speed of the observer — possibilities for further modelling were identified.

That the information, at the iteration beat, will propagate ahead of an observer, may also give direct insight to the 2nd Law’s ‘arrow of time’. Fractal propagation is also in one direction. This ‘arrow’ may also have direct insight into the perception of time itself to the observer. If an observer is assumed to be moving at the frontier of the fractal set — where the first bit comes into existence — this observer would observe no emergent fractal shape ahead of them, and a concept or perception of time will be absent. If this is so, then this insight also corresponds with Einstein’s special relativity: the fractal is consistent with our current understanding of light and time.

4.2 Fractal Demonstrating Quantum Properties

Notwithstanding fractals and chaos already share similar properties of unpredictably and the infinite potential of possible events, here in this investigation, the isolated
fractal is shown to be independently parallel as to correspond to the quantum. It appears they — the quantum and the fractal — are the same as they have the equivalent — no more and no less — interesting problems associated with them. To describe one is to describe the other: indeed, one — the fractal — would predict the other. The many properties to the fractal — problems of the quantum — are addressed here including superposition, wave-particle duality, the small-scale (quantum)/large-scale (reality) interface; the measurement problem; and finally, quantum entanglement.

4.2.1 Demonstrating Discrete ‘Particle’
The discrete bits that make up the fractal shape act as or may be akin to how discrete photons, electrons or other quantum entities are described by quantum theorists. Bits are discrete: there are no positions between the iteration positions just as Planck’s [15] and Einstein’s [14] first conjectures is described. This demonstration shows no ‘half’ iterations and no half-sized bits; this is consistent and corresponds with quantum mechanics. Predictions of positions between the discrete bits may be calculated using complex numbers just as with quantum mathematics. It may well be possible to interpret the particle as being the complete emergent fractal — the snowflake — and that many snowflakes make up a larger superstructure. Again, this is akin to how are particles are often described; that they also are waves.

4.2.2 Quantum Wave Propagation and Wavefunction.
The scale-invariant properties of fractal objects in reality, evident by fractal landscapes (see below 4.2.5), may directly pertain to reality the predictions and claims of the quantum theory’s de Broglie ‘pilot wave’ [16], the Schrödinger wavefunction equation [17] and positions within the fractal set by the references is described by the Born probably function. That reality is currently paradoxically described by quantum wavefunctions and is equally described by fractal geometry and chaos theory; it may be that through this (fractal) model these are all aspects of the same greater fractal wave function.

As the fractal also develops by decreasing wavelength and increasing frequency with iteration-time (Figure 3) the Fast Fourier Transform may be used to describe this fractal propagation as it currently does with quantum wavefunctions. This would suggest the (Koch snowflake) fractal is a compressed summary of all the wave activity in the (fractal) system. If so, this discovery may offer insights into the Fast Fourier
Transform and all its applications — including with atomic physics (see below). The emergence and evolution of the (Koch snowflake) fractal also invoke osculation and Pi ($\pi$). The bit's spiral rotation in cycles as they propagate is akin to how quantum mechanics 'light' is described. Through the fractal, we have a direct window into electromagnetism and the quantum world: where bits (particles) and waves of different frequency are in an (unobserved) superposition, with non-location until 'observed'. As with the quantum, this sinusoidal wave behaviour from emergence is best described by the same equation, the Euler Formula, (equation 2).

$$e^{i\theta} = \cos \theta + i\sin \theta$$  \hspace{1cm} (2)

Just as with quantum theory; as scribed point positions — during the emergence of the fractal spiral — are discrete, complex numbers $i$ may be invoked to describe positions between these discrete points. Coupled with this, the fractal may also give practical credence to Euler’s Identity (equation 3), as the fractal invokes oscillation and thus Pi ($\pi$) and is a convergent series of diminishing sized bits, invoking $e$.

$$e^{i\pi} = -1$$  \hspace{1cm} (3)

It must be noted that the propagation of a change in the iterating set is not in one (spiral) direction as demonstrated in this work but, is 'radiating' in all directions as each knew bit behaves as its parent and propagates in the direction it is imitated with. This insight corresponds to emission and electromagnetism theory.

### 4.2.3 Demonstrating Complementarity: ‘Wave and Particle Duality’ and the Uncertainty Principle

Just as the ‘point’ positions of electrons on an atom are ('weirdly') described as being — both at the same time a particle and ‘a smeared out’ wave; here, with the fractal, we see a corresponding model. For the fractal, in isolation, this demonstration has shown it is not so 'weird' and is possible. The isolated fractal comprised of identical — wave propagated — bits demonstrates that all of reality can potentially be described as a wave and as point particles as posited by quantum mechanics. And just as with quantum mechanics, the fractal can demonstrate entities are both wave and particle at the same time until reference or observation is made. More to this, the fractal directly demonstrates quantum Bohr’s complementary principle if a property of reality through the fractal: everything seems to come in duality.
4.2.4 The Heisenberg uncertainty principle

The Heisenberg uncertainty principle [18] was demonstrated by the fractal: both position and wave velocity cannot be known at the same time. When the fractal is in superposition or supersymmetry position, scale, and the direction, speed — or ‘the momentum’ — of the fractal propagation of the wave propagation is not known; however, when reference points are added, ‘observation’ made, position and scale are known, and simultaneously all qualitative knowledge, is given up. The converse of this is true; before the reference or measurement is made, the position is not known.

4.2.5 Addressing ‘The Measurement Problem’ by Fractal Landscapes and Reference Points

The addition of a. The addition of a marker or other object is a measurement new marker gives reference and locks in the scale relative to the marker. Before this ‘measurement’ the fractal bits are all sizes and all positions and this demonstration corresponds with the quantum observation or measurement problem. It also corresponds to the phrase associated with quantum mechanics measurement ‘collapse of the wavefunction’. When the marker is applied or an ‘observation’ or ‘measurement’ is made, there is a collapse in the infinite superposition of bits, again corresponding to quantum theory.

As fractals are an ever-present property of the macro ‘classical’ world, the question is does this fractal ‘measurement’ ‘collapse’ property reveal itself in the classical reality too? The answer is yes. To see it, one has to find instances where there is only one repeating pattern, where no scale can be discerned. Instances termed ‘fractal-landscapes’. Obvious examples of these fractal-landscapes are the commonly used examples of fractals: clouds, trees and forests, waves on water, and sand dunes, and snow and snowdrifts. In such places, one can only discern position when a reference point is given or made — or when a measurement is made, to use the language of quantum mechanics. If one — a conscious observer — finds themselves in a total fractal landscape with no reference points they will be what is termed, ‘lost’. When a reference point is added to the fractal landscape, all these (invariant) problems of scale and time disappear and position is known.

In the context of an isolated fractal model such as the Koch snowflake or the Mandelbrot set, this term ‘fractal landscapes’ may be substituted for fractal-fields, from the concept of quantum fields.
4.2.6 Quantum-Classical Interface

Continuing from the measurement problem, the fractal reveals an important insight into the ‘quantum-classical interface’; the line where quantum becomes classical reality. The isolated fractal suggests — in agreement with quantum theory — that this transition is not a problem of the ‘micro’ quantum world vs. the ‘macro’ classical reality; but is an ever-present problem of isolated systems, and this is best demonstrated and understood by examining the isolated fractal systems as done so in this investigation.

However, this been said, there is an insight from the fractal that this quantum state is prevalent also in macro reality and can occur under the same (coherent) conditions as the micro. An explanation of this insight follows. Fractals can be described as being objects that feature the following property: they are the same, but different. This is the principle behind the claim: ‘there is no one (real) snowflake the same’. They are many snowflakes, but they are all snowflakes, and each is infinity complex in detail. This same-different duality property poses the same problem as the quantum poses when these objects are in isolation. Even if there are differences between the objects, scale and location will be lost until reference is made as demonstrated by this investigation. In instances of total isolation monotonic fractal-landscapes, no distinction between the macro and micro can be made. The problem is a universal property of fractality.

4.2.7 Fractal Demonstrating Entanglement

The fractal has demonstrated and corresponds to a parallel problem known as the EPR entanglement paradox[13]. The change was instantaneous, and thus non-local. The initial property assumptions of configuration A and B align with the quantum entanglement postulate that photons are first 'loaded' or 'entangled' before observation. There were no local 'hidden' or 'spooky' variables that involved; it was demonstrated property of an isolated superposition fractal. The demonstrated is not an obvious feature of the fractal and this solution would not have come about unless it had already been claimed as a problem associated with quantum mechanics. If the assumptions of fractal isolation were broken, the consequential slow propagation speed of iteration is akin to the ‘slow’ and not instantaneous speed of light that Einstein highlighted and his 'spooky action at a distance' argument. This demonstration of the fractal entanglement shows it is feasible to demonstrate entanglement in a warm
setting, as opposed to current absolute zero Kelvin environments, and may open an opportunity to warm quantum computing research.

4.2.8 Insights into the Nature of Time
The fractal may help distinguish between concepts of relative and absolute time and may offer direct insight into the foundation question, ‘what is time? On the fractal set, iteration is the only measure of time in the model. When iteration rate is 0, there is no — absolute — time, with respect to the model. If time — the passing of it — is assumed to be tied to the change or addition of reference points or observations, then the model demonstrates relative time; and conversely, a fractal with no reference points or observation demonstrates no-time or time that is zero. The arrow of time was addressed by an observer in the fractal set assumed to be travelling at the speed of the iteration bits are produced. This is — akin to how the speed of light is explained — there will be no reference points and no-time. By this definition, time stops at the speed of propagation.

4.2.9 Opportunities
There are many questions, issues and opportunities arising from this finding — all of which, at this point, is beyond the scope of this investigation, but not beyond the scope of reason.

It is important to note that while what is discovered and discussed in this work shows light may share aspects or properties of fractals, it does not mean to say that the true nature of light and the atom are exact to the fractal experimented upon; and so, there is opportunity to further research this. The opportunity also arises to investigate the fractals opposite — ‘retrospective’ — perspective, the view observed from an observer within the set ‘looking back’ rather than forward. This is expected this will return exponential behaviour where the original bit will grow exponentially from an arbitrarily small size, and if so, this may shed insight on cosmological observations and conjectures and problems such as the Vacuum Catastrophe and even the emptiness of the atom. It may be that the two ‘problems’ — the exponential and the osculating of this work — are different aspects of the same geometry and that this geometry may be able to be described mathematically, in a form of complementarity, by the mathematics behind general relativity and quantum mechanics combined. As the geometries of the past — from Copernicus’s concentric-circles to Kepler’s ellipses and even Einstein’s
curved spacetime — fractal geometry, the geometry of our time, offers a solution to foundational quantum mechanics, and may unlock and offer insight to ‘unification’.

4.3 Conclusions
Incomplete

It was found that the fractal, a current mathematical description of reality behaves as electro-magnetic — light — and the quantum are described. The problems of the quantum are also problems of the fractal and are best addressed by an understanding of the fractal. The fractal demonstrated — and was able to address — the many enigmas of the quantum, from the ‘measurement problem’ to entanglement.

5 Acknowledgements
I would like to thank my wife and children for their patience and support. Without the guiding words, support and supervision of Homayoun Tabeshnia, this work may never have come to be. Thank you for editing Kim Westmoquette; still not done, but we are getting there. I would also like to thank my many colleague’s and student’s over the years that helped me develop this work.
References


