The Physics of Mathematical Philosophy

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Preliminaries

In 1931, Kurt Gödel proved his incompleteness theorems of mathematics [1], the first of which can be stated as follows:

"Any effectively generated theory capable of expressing elementary arithmetic cannot be both consistent and complete"

In this paper, the 'effectively generated theory capable of expressing elementary arithmetic' will be henceforth referred to as a 'formal system' (in the rest of this paper, any mention of 'system' or 'formal system' refers to the type of theory described in the statement above.

These formal systems are sets of mathematical axioms from which theories can be derived and proved. A consistent system is one in which there are no statements that can be made in the language of the axioms (i.e. derivable from the axioms) that are both provably true and false within the system. Likewise, an inconsistent system can prove that some such statements are provably true and false within the system. A complete system is one in which no statements can be made that are neither provably true nor false (i.e. every statement is provably inclusively true or false). An incomplete system is one in which statements exist taht are neither provably true nor false (i.e. some statements are undecidable within the system).

It is important to emphasize here that the terms 'inconsistent' and 'incomplete' as they apply to formal mathematical systems do not imply that the system is somehow flawed or incorrect. The terms are simply used to classify the logical characteristics of the system in question and it is only an unfortunate fact that these terms imply some kind of deficiency when used in common language.

The laws of physics as they are currently expressed are not mathematical axioms. Rather, they appear to be theorems that might be derived from a deeper, universal set of mathematical axioms. Therefore, the fundamental assumption made in this paper is that the two logical branches of physics (classical mechanics and quantum mechanics) are each derivable from different sets of mathematical axioms that constitute formal systems satisfying the requirements of such systems in the Incompleteness theorems. This means that we are assuming that at the deepest level, physics is purely mathematical and the axioms underpinning our physical laws are capable of expressing elementary arithmetic.

We will first examine this assumption by looking at classical physics. Intuitively, classical mechanics appears to be a consistent system. This is because the laws of classical mechanics are deterministic and in principle, given the *exact* initial conditions and the correct equations of motion, one can unambiguously describe the complete evolution of the system. This suggests that any 'statements' of classical mechanics are exclusively true or false. But if the formal system underlying classical mechanics is consistent, then it must be incomplete, meaning that there are statements that can be made in the language of classical mechanics which can be neither true nor false. It is proposed here that these undecidable statements arise as a consequence of relativity. Consider the statement 'Events A and B are simultaneous". This statement is neither true nor false in classical mechanics because there is no absolute notion of simultaneity in modern classical mechanics [2]. It is a valid statement in that *in a particular reference frame* events A and B are exclusively true or false, but the general statement 'Events A and B are simultaneous' is neither true nor false. The same applies to lengths and durations because any length or duration is frame dependent and therefore globally undecidable. Only relative statements such as 'Events A and B are simultaneous relative to C" are exclusively true or false in classical mechanics. Therefore, we can say that the incompleteness in the formal system of classical mechanics is expressed physically as the experience of relativity. Therefore, it is proposed here that the underlying formal system of classical mechanics is consistent and incomplete and that the relative nature of classical mechanics is the manifestation of the system's incompleteness.

Before moving on to quantum mechanics, let us first consider what constitutes the 'domains' of classical and quantum physics. The easiest way to picture the difference in domains is to imagine the Universe is filled with an infinite number of 'boxes'. Each one of these boxes is known as a reference frame. Classical physics describes the relationships between these reference frames, while quantum mechanics describes the microscopic behavior inside the reference frames.

So, are the microscopic behaviors governed by an underlying consistent or inconsistent system? The answer to this is readily apparent in the wave/particle duality. It is important to note that when we say something is a particle, it is not a wave, and vice versa (the two descriptions are mutually exclusive). Therefore, in quantum mechanics, statements like 'X is a particle' or 'X is a wave' are both true *and* false and therefore the underlying formal system of quantum mechanics is inconsistent. The wave/particle duality differs from the classical statement 'Events A and B are simultaneous' because if an observer performs the double slit experiment (the quintessential proof of the wave/particle duality), he will observe the duality and any observer moving relative to the experiment will observe the same duality. The two observers may only disagree on *when* the particle/wave hit the screen.

We therefore conclude from the above arguments that relativity in classical mechanics is evidence of its formal system's incompleteness and the wave/particle

duality in quantum mechanics is evidence of its formal system's inconsistency. Whether or not classical mechanics is consistent and quantum mechanics is complete is not derivable from the laws of physics. It is only our physical observations that can *imply* that classical mechanics is consistent and quantum mechanics is complete (as we will see in this paper, it is the provable incompleteness and inconsistency of these systems that are of primary interest anyhow).

On the Cardinality of Quantum and Classical Infinities

In the late 19th century, Georg Cantor proved that the cardinality of the infinite set of rational numbers was less than the cardinality of the set of real numbers [3]. In this section, we will investigate what the cardinality of classical and quantum infinities are in modern physics.

We begin with the quantum infinities. In the mid 20th century, Richard Feynman developed a method in order to calculate the probabilities of quantum interactions in order to provide quantitative predictions for quantities of interest in Quantum Electrodynamics [4]. For instance, if one whishes to calculate the probability amplitude of electron-electron scattering, one can draw a diagram in which two electrons approach each other, exchange a photon, and then move apart. Using certain rules, one can calculate the probability amplitude for this interaction from this diagram. The result of this calculation, however, gives only an *approximation* of the true amplitude. This is because, according to the rules of quantum mechanics, the probability amplitude of an interaction is a function of all possible intermediate interactions that can occur during the interaction in question. Therefore, to get a more precise result, one must draw additional diagrams (for instance, a diagram that is the same as the first, except the exchanged photon decays into a positron/electron pair that recombines into a photon in transit between electrons) and add the amplitudes from those diagrams to the original. In fact, the precise probability amplitude for a given interaction is the sum of an infinite number of Feynman diagrams. But one can see that even if one were to draw an infinite number of such diagrams, there would still be another diagram that could be added to the set. In other words, the number of diagrams needed to describe an interaction with perfect accuracy, one needs an inexhaustible, or 'uncountable' number of diagrams because each diagram one adds to the set can itself be broken up into an infinite number of diagrams and so on. This is analogous to Cantor's diagonal argument, which is used to prove that the cardinality (size) of the infinite set of real numbers is greater than the cardinality of the infinite set of natural/whole/integer/rational numbers [3] (the cardinality of each of these sets is equal, i.e. the size of the infinite set of natural numbers is equal to the size of the infinite set of rational numbers, and this size is smaller than the size of the infinite set of real numbers). From this we see that the infinities of quantum mechanics are *uncountably infinite*, or the cardinality of quantum infinity is equal to the cardinality of the set of real numbers.

In classical mechanics, we are interested in the infinities of space and time. Particularly, we would like to know if the number of points in the time and spatial dimensions are countably or uncountably infinite. The time dimension is pretty straightforward since the basic definition of time suggests that the dimension must have a discrete nature. This is because time is the measure of a cyclic process. It can be measured from the swing of a pendulum or the oscillation of a cesium atom, but an interval of time is, by definition, an integer multiple of a cyclic process. Our clock could have an infinitely small period, but it is still periodic nonetheless, and so we can assign a unique natural number to each period, which means that the points along the time dimension of classical mechanics are countably infinite. The spatial dimensions are also countably infinite because we must use clocks in order to accurately measure space. If we want to measure a large distance, we could use a mechanical ruler as long as we do not require extreme precision. But if we wish to measure very small distances, we cannot use a mechanical ruler because we will eventually reach the quantum scale where distances become uncertain. Therefore, to measure precise distance, we can send a photon between two points and measure its travel time with a clock. The speed of light has a known value and so the only variable in the measurement of distance is the travel time. This variable has countably infinite many values, and therefore, the possible distances it can reveal are countably infinite as well. Again, it is important to stress that the smallest possible distance can be infinitely small, but the infinitesimal has a discrete nature.

So it has been shown that the points in the classical space-time continuum are countably infinite. Mass and energy are the other fundamental quantities that define classical mechanics. We can easily conclude that mass is countably infinite since the mass of a body is simply the aggregate of all the energies of the quantum particles that make up that body, and the laws of quantum mechanics tell us that those energies can only have discrete values, and thus mass is countably infinite. Finally, kinetic energy is based on the velocity of objects, and since velocity is a ratio of space and time, each of which are countably infinite, we could conclude that velocity is a countably infinite quantity (a velocity expressed in natural units can have a countably infinite number of values between 0 and 1). But we will explore velocity and its relationship to space-time more closely by examining it with the aid of an ancient Greek conundrum: Zeno's Paradox.

 Zeno's paradox is a llogical argument implying that motion is an impossible illusion. Essentially it says that in order to move a distance X, one has to first travel X/2. But to get to X/2, one must travel X/4. To get to X/4 one must travel X/8 and so on such that it can never actually move because it must travel an infinite number of intervals in order to travel any particular interval. This should be familiar to the reader as it is analogous to the Feynman diagram picture given previously. It essentially presumes that space is uncountably infinite. But this problem was solved mathematically by proving that the infinite sum ½+1/4+1/8+1/16… = 1. The difference in the two interpretations is that the set of rational numbers in the summation is countably infinite. But this scenario can give us even more insight into the underlying physics.

One can imagine that if one travelled at a constant speed between two points, one would get from point A to point B in a finite time determined by this velocity. But suppose one moves with a constant velocity and 'stops' instantaneously at each of the points in Zeno's paradox (i.e move half way, stop for an instant, then move half the distance that is left, stop instantaneously, then move half the distance, stop...ad infinitum). In this case, you would get closer and closer to the endpoint without ever reaching it. In modern terms, this could be described as leaving the origin with initial velocity V and decelerating to V=0 as you approach the end of the interval. The traveller is moving with the same speed V between each of the intermediate points, but each instantaneous 'stop' reduces the average velocity by an infinitesimal amount. As the traveller approaches the end of the interval, the number of 'stops' goes to infinity, reducing the average value of V to 0. So the traveller has an absolute velocity, say V=c, between any two 'stops' but it has a relative velocity that is lower than V=c by an amount determined by the frequency of the number of 'stops' in the interval. As Zeno's traveller traverses the interval, the frequency of the number of stops increases and therefore his velocity relative to someone watching from the sidelines approaches 0 the closer he gets to the end.

From the above example, we can describe classical velocity in a new way. First we will discuss the velocity within the framework of Special Relativity (i.e. inertial reference frames in flat space-time). Consider Figure 1 below.
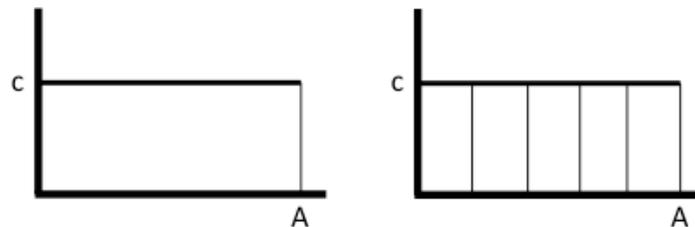

Figure 1 – Constant Relative Velocity

In the diagrams above, the vertical axes show relative velocity (relative to an observer at rest at the origin) and the horizontal axis is distance from the origin. On the left, we see a photon travelling to A at the speed of light (c). On the right, we see a massive particle moving with a constant relative velocity less than the speed of light. The particle velocity is given by the frequency of the stopping points, where the frequency is expressed by any natural number from 1 (speed of light) to infinity (relative speed of 0). Thus, we can relate the number of points in the diagrams above to unique values of relative velocity. Our next task is to determine the precise relationship between the number of 'stops' and relative velocity. If we interpret the stopping points as 'a relative amount of space' observed, we can appeal to the length contraction equation of Special Relativity in order to properly express the relationship. An object at rest relative to an inertial observer has a measured length L_0 (rest length). The same object moving at light speed relative to the observer has an observed length of 0 (in the direction of motion). We also know from the arguments above that if the object is moving at the speed of light, it has 1 'point' (left

diagram). If the object is at rest, it has an (countably) infinite number of points. According to Special Relativity, the difference in length of object (in the direction of motion) with a speed V relative to its measured rest length is given by:

$$L_0 - L = L_0\left[1 - \sqrt{1 - V^2}\right] \qquad\qquad \text{(Eq. 1)}$$

We can use the relationships discussed above together with the bracketed term in Equation 1 to give us the following expression relating the number of points (n) to the relative velocity:

$$n = \frac{1}{1 - \sqrt{1 - V_n^2}} \qquad\qquad \text{(Eq. 2)}$$

From this, we can solve for the quantity V_n in terms of n:

$$V_n = \frac{\sqrt{2n-1}}{n} \qquad\qquad \text{(Eq. 3)}$$

Where n is any natural number. This first important thing to note here is that the quantity V_n is not a measured velocity. Rather, each V_n is an object in a countably infinite set of algebraic numbers (defined by Equation 3), each of which corresponds to a real, measurable relative velocity. So V_1 corresponds to a relative speed of c. V_2 corresponds to a speed infinitesimally smaller than c. V_3 corresponds to a speed infinitesimally smaller than V_2, etc. This suggests that all the space-time properties and their transformations as described by Einstein's Special Relativity are 'encoded' in the distribution of a countably infinite ordered set of algebraic numbers. This set of numbers determines how the dimensions of flat space-time 'scale' as a result of relative motion. As an object's relative velocity approaches the speed of light, the number of points defining that object approaches 1, so that the length of the object (as seen by the observer at rest) is related to the number of these points (when the number of points is 1, the length of the object is 0 because there is only one point describing it). Similarly, the number of intervals defined by the points describes how much slower the moving object's clock runs relative to him (if there are an infinite number of intervals (V=0), the clocks tick at the same rate. As the number of points decreases, the number of ticks of the object's clock relative to the observer's clock decreases, resulting in the time dilation described by Special Relativity).

We should now ask how General Relativity, Einstein's theory of gravity [5], fits into this picture. General Relativity is commonly expressed by saying that the presence of energy causes the coordinates of space-time to curve. But there is a curious consequence of General Relativity: the quantity c (which is a constant, 1 in natural units, in Special Relativity) becomes variable in space (we will consider only static energy distributions here, but the same logic can be applied to dynamic systems). For a spherically symmetric energy distribution (for simplicity, let's assume a Schwarzschild black hole) the value of c is zero at the event horizon and approaches 1 at an infinite distance. If we interpret this fact, not as a consequence, but a

fundamental property, of General Relativity, we can say that the Universe is filled with a scalar field such that at every point in space the field is represented by a number between 0 and 1 (we will call it the c-field). The value of the field is 1 in empty space and is reduced in the presence of an energy source (such as the aforementioned black hole). Consider Figure 2 below.
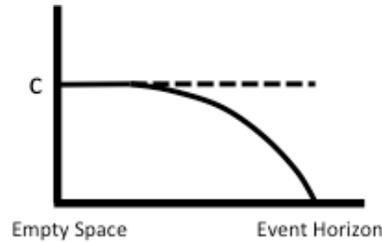

Figure 2 – c-Field Distribution

Figure 2 shows the value of the c-field on the vertical axis and distance between an inertial observer in empty space (far from the black hole) and the event horizon of a Schwarzchild black hole. The solid, curved line shows the c-field distribution from the perspective of the distant inertial observer. Suppose the observer, who we will assume is 'immune' from gravity, watches a particle free-fall toward the black hole. We know that this observer will see the particle accelerate toward the black hole, even though that particle 'feels' no force (that particle is in an inertial reference frame). It is proposed here that this gravitational acceleration seen by the stationary observer is caused by the variation in the c-field. As the observer watches the particle fall toward the black hole, the value of the c-field drops below 1 at a certain rate. But the observer is in an inertial frame of reference, and therefore, the speed of light is 1 in his frame. Therefore, the difference between 1 and the value of the c-field at the particle's position results in a perceived relative velocity between the observer and the particle. And, as was discussed previously, the relative velocity warps space-time. Therefore, it is proposed that the presence of energy modifies the spatial distribution of the c-field, and observers at locations with different values of the c-field will experience relative accelerations, and these accelerations are manifest by the warping of space-time coordinates. So the effects of General Relativity can be seen as a 'scaling' of the set of algebraic numbers given in Equation 3 as follows:

$$V_n = f\big(c(x,y,z,t)\big)\frac{\sqrt{2n-1}}{n} \tag{Eq. 4}$$

When we are at rest in a gravitational field (say, standing on the earth), we experience a force (i.e. we sense an acceleration). Looking at Figure 2, we can see that in order to remain at a fixed distance from the event horizon, we must apply a constant acceleration, the value of which is given by the negative slope of the c-field at that point. So (from the perspective of the black hole) a body in free fall will always accelerate in a direction with a lower c-field value. This body feels no acceleration until it is forced into an accelerated reference frame (i.e. it lands on earth for example). The force experienced by the free-falling body when it lands is

proportional to the difference between the initial and final *c*-field values of the body (assuming a zero initial relative velocity).

There are three interesting points to note before closing this section. First, the model of the *c*-field given above suggests that even the 'curvature of space-time' is relative. The consequences of this are explored in an as of yet unpublished paper. Second, the only known scalar field in quantum mechanics is the Higgs field [6], which is known to impart mass to quantum particles such as electrons and quarks, the building blocks of atoms. But in this context it is better to restate the effect by saying that the Higgs field causes certain quantum particles to travel at less than the speed of light. Finally, it appears from the above analysis that the laws of classical motion, at their deepest level, are contained in an infinite set of ordered algebraic numbers (this seems a lot like Gödel numbering) that are scaled by gradients of a scalar field that may itself be a set of numbers whose distribution reflects the energy gradients of the Universe.

On the Truth of Absolute Statements

Suppose we would like to determine the truth of the statement "*X* exists", where the statement is meant to apply in all reference frames (i.e., "*X* exists" applies to the entire Universe). Such a statement is therefore an expression in the language of classical mechanics. We will also assume a priori that the following are true:

- Basic mathematical logic is correct
- The laws of classical physics are theorems derived from fundamental mathematical axioms that constitute a consistent formal system satisfying the requirements pertaining to Gödel's incompleteness theorem.
- The statement "*X* exists" is neither provably true nor provably false in this formal system.

If the two assumptions above are true, then the statement "*X* exists" is equivalent to the statement "Events A and B are simultaneous" discussed earlier. Therefore, the statement "*X* exists" is not true in all reference frames, but can be true for a subset of reference frames. We can, however, extend the formal system by adding an axiom from which the truth of the statement "*X* exists" follows directly. Therefore, in this extended system, the statement is provably true. However, by adding this axiom, we have made the combined system inconsistent because the statement is now provably true *and* not provably true (as per the second assumption above). As a result of this, the statement "*X* exists" becomes provably false. This means that, if one accepts the three bullet points given above, then assuming a priori that the statement is true because of some underlying, self-evident truth about existence that is outside the laws of physics, mathematical logic tells us that the statement becomes provably false. However, we might choose to add yet another axiom in order to correct for this by assuming that the total set of axioms (those of physics

plus these extras) constitutes a consistent formal system (i.e. we add an axiom to the system from which the consistency of the total set of axioms is provably true). We have been using Gödel's *first* incompleteness theorem up to this point in our examination to the laws of physics. But Gödel also proved a second incompleteness theorem that requires that "any consistent formal system cannot prove its own consistency". Therefore, adding the final axiom still leaves the system inconsistent since that axiom results in a proof of the consistency of the system, violating the second incompleteness theorem.

This exercise demonstrates that any global property of the Universe whose truth must be presumed as a fundamental property of existence (i.e. can not be expressed in the 'language' of physics and therefore requires it's own axioms), the assumption of truth makes the property logically provably false. The only way around this is to show that the statement is provable by the laws of physics, or that the assumption that the laws of physics are derived from a formal mathematical system is incorrect. But assuming that physics is not fundamentally mathematical (or that mathematical logic is some kind of illusion) would require ignoring all the evidence of the unparalleled predictive power of the laws of physics.

So the statement "*X* exists" is widely applicable, one just needs to replace *X* with things like 'absolute simultaneity", "absolute length", "absolute time interval", or even more abstract concepts such as "God" or "karma". In the case of God, we must acknowledge that even if there is a God external to the Universe, he/she/it must act via the laws of physics in order to affect nature (we would sense God through his actions in the physical world). And if God has supernatural capacities, this interaction must take the form of a change in mechanical quantities that would not be describable by the laws of physics. Thus, the arguments in this section show that if God exists outside the Universe, it is provable that he cannot interact with the Universe.

On Rational, Irrational, and Relative Statements

In the previous sections, the truth or falsehood of statements made in the 'language' of physics has been discussed. It was proposed that the system of classical physics is consistent and incomplete meaning that any statement provable by the system is either true, false, or neither true nor false. In quantum mechanics, we've assumed that the system is complete and inconsistent meaning that any statement provable by the system is both true and false. It has been suggested in this paper thus far that statements such as 'Events A and B are simultaneous" in classical mechanics is neither provably true nor false by the laws of classical mechanics, making it incomplete. In common language, we might say that the statement "Events A and B are simultaneous" is 'relative' because of the principles of relativity (one cannot make an absolute statement about simultaneity).

At this point, we must make some logical definitions to simplify the analysis of the consistency or completeness of nature's formal mathematical systems. The requisite definitions are given below:

- If X is exclusively true or false, X is a 'rational' statement
- If X is both true and false, X is an 'irrational' statement
- If X is neither true nor false, X is a 'relative' statement

Given these definitions, we can classify the following self-referential statements:

- "This statement is true" == Irrational
- "This statement is false" == Relative

Regarding the second statement above, this is an example of what is commonly referred to as the Liar's Paradox. It is relative because the truth or falsehood of the statement is not absolute: if the statement is true then it is false, and if the statement is false, then it is true (but it is not absolutely true or false). Going further, we can see that if a statement is not true, then it is exclusively false or relative. If a statement is not false, then it is exclusively true or relative. If a statement is not irrational, then it is neither true nor false (i.e. it is relative) or rational. If a statement is not relative, then it is inclusively true or false (i.e. it is rational or irrational).

So, in the system of classical mechanics, which we are assuming to be consistent and incomplete, all statements are exclusively rational or relative. In quantum mechanics, which we assume to be inconsistent and complete, every statement is exclusively rational or irrational. Thus, we see that the two systems are, in a sense, logical opposites (Classical mechanics == NOT Quantum mechanics)

Classical mechanics is said to be 'deterministic' because any prediction it makes must be rational or relative. More importantly, if the system is deterministic, it is *not* probabilistic. We can express the deterministic nature of classical mechanics as follows:

$$\text{Classical Mechanics: } P(X)=1 \text{ or } P(X)=0$$

Where $P(X)$ represents the degree to which the statement X is probabilistic. X will be called maximally probabilistic if $P(X)=0.5$ and non-probabilistic of $P(X)=0$ or $P(X)=1$. So $P(X)=1$ means a given statement X is exclusively true or false (rational) and $P(X)=0$ means the statement is neither true nor false (relative).

Conversely, quantum mechanics is claimed (in the current paper) to be inconsistent, which means that it can prove statements that are inclusively true *or* false (exclusively rational or irrational). This can be expressed as follows:

$$\text{Quantum Mechanics: } P(X)=1 \text{ or } 1>P(X)>0$$

P(X) cannot be zero in this case if the assumption that the formal system of quantum mechanics is complete is correct, because this means that there are no relative statements in quantum mechanics. As was discussed at the beginning of the paper, the term 'inconsistent' is merely a word describing a mathematical property. It does not mean a physical system with this property is flawed in any way, it simply means, as is being proposed here, that the system is inherently probabilistic (rather than stating that something is either true *or* false, it says that something is only probably true or probably false).

On Information Transfer Between Classical and Quantum Systems

It has been proposed in the current paper that the laws of classical mechanics and quantum mechanics are mathematically opposed to one another. Classical mechanics appears to be derived from a set of axioms that constitute a consistent and incomplete formal system while quantum mechanics follows from axioms that constitute an inconsistent and complete formal system. Furthermore, it has been shown that classical infinities are countable while quantum infinities are uncountable. All this suggests that the systems are incompatible with one another at a very fundamental level, but it also suggests that both systems are accurate descriptions of the branch of reality to which they apply. We must now ask how these separate systems can communicate with one another. How is information transferred between them?

In our experience, all classical interactions, forces, are electromechanical in nature. All our direct experience of change is determined either through the measurement of light or chemical reactions involving electrons, and these are described by electromagnetism. Electromagnetism seems to be the fundamental description of information transfer in the Universe. It is unlikely a mere coincidence that the theory of electromagnetism has been successfully described both classically and quantum mechanically with great success. In the late 19th century, James Clerk Maxwell, inspired by the work of Michael Faraday, derived a set of equations describing the electric and magnetic forces as two aspects of a single theorem [7]. In the mid 20th century, physicists were able to successfully quantize these equations, yielding a quantum mechanical description of electromagnetism known as Quantum Electrodynamics. But given the evidence presented in this paper, there is no reason to assume that one description is any more fundamental than the other (it is often thought that Maxwell's equations are an approximation to Quantum Electrodynamics). It is proposed here that because it can be expressed in both 'languages', electromagnetism is the force of information transfer between the quantum and classical worlds. When combined, the classical and quantum descriptions of electromagnetism are a kind of Rosetta Stone for the Universe, translating classical information into quantum information and vice versa.

If this is the case, we should expect the formal system from which electromagnetism is derived is both inconsistent and incomplete. Its inconsistency is manifest in the

wave/particle duality of photons and electrons (discussed in the first section). Its incompleteness should suggest that it also has a relative nature to it. This is found when combining Maxwell's equations with Special Relativity. If an observer performs an experiment in electromagnetism in which he observes a purely electrical force, then there exists a reference frame in which a different observer will see the same force as being purely magnetic. This 'electric/magnetic duality' is what gives electromagnetism its classical, relative nature. Therefore, we see that the mathematical nature of the underlying formal system of electromagnetism is indeed inconsistent and incomplete (irrational and relative).

Therefore, we can summarize the proposed axiomatic structure of nature by looking at Figure 3 below.
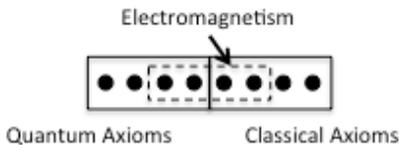

Figure 3 – Axiomatic Structure of Nature

In Figure 3, the fundamental axioms of nature are represented by a row of dots. The dots on the left side represent the axioms from which the laws of quantum mechanics follow, and the dots on the right are the axioms of classical mechanics. These axioms only overlap in the case of electromagnetism, which borrows some axioms from each (shown by the dotted box), allowing it to act as a mediator between the two systems. Thus, as a whole, the Universe is neither mathematically consistent nor complete (recall it was previously suggested that Classical Mechanics == NOT Quantum Mechanics, so if they are both true, the Universe's formal system must be inconsistent), but the axioms are such that we can understand the Universe as a combination of one consistent system and one inconsistent system (i.e. distinct, incompatible theorems are derived from each set of axioms). Certain axioms from each system then together are able to derive a theorem that is neither purely quantum mechanical, nor purely classical, allowing these fundamentally different logical systems to communicate with one another.

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