Relativity and the Dual Nature of Reality

Norman Graves

Abstract

The current received wisdom is that quantum theory is correct but incomplete. However an examination of the history of the development of quantum theory shows that it is based on an unproven assumption. That assumption, that angular momentum is quantized, leads to the absurdity of the quantum leap and so cannot be valid. All subsequent theories which rely on this assumption must therefore be called into question.

If the quantum leap is to be regarded as an absurdity then it follows that the orbital radius of the electron in the hydrogen atom must remain the same for all energy levels. The conditions necessary to bring this about are identified and a model developed for the hydrogen atom. Such a model is only possible if it is assumed that certain velocity terms are affected by relativity.

This idea is combined with a second postulate concerning the nature of gravitational mass and is then used to develop a second model, this time for the photon as a compound particle comprising an electron and a positron locked in mutual orbit. This too relies on relativity affecting orbital velocity.

Special relativity is unique among physical phenomena in that for objects traveling at significant speeds there are two versions of every measurement. In other words relativity is possessed of a natural duality. There are two ways to measure distance, two ways to measure time and two ways to measure mass depending on who is making the measurement; the stationary observer or the moving observer. This idea can be extended to cover frequency, wavelength. However the relationship between the wave characteristics of a particle and its particle characteristics is the same within each of the two domains and is consistent with classical mechanics. This leads to the idea of a wave/wave duality and a particle/particle duality rather than the current wave/particle duality and effectively unifies the quantum and classical worlds. This duality is shown to pervade many aspects of physics and in so doing provide explanations for phenomena that are otherwise unexplained.

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Chapter 1 The Trouble with Quantum Theory

"It should be possible to explain the laws of physics to a barmaid" – Albert Einstein

"Anyone who is not shocked by quantum theory has not understood it." - Niels Bohr.

"Physicists use the wave theory on Mondays, Wednesdays and Fridays and the particle theory on Tuesdays, Thursdays and Saturdays." - William Henry Bragg

"By denying scientific principles, one may maintain any paradox."- Galileo Galilei.

The Scientific Method

Anselm of Aosta (1033 – 1109) was a monk of the Benedictine order in the 11th Century. He rose through the ranks of the church to become Archbishop of Canterbury and was eventually canonized. He is remembered for establishing Canterbury as the principal seat of the English church. Anselm was of the opinion that belief in God was more than just an article of faith but was also rational. He sought to show this by proving the existence of God using logic. His logic was convoluted, but the essence of his argument was that if we postulate that God exists then we can, through a series of logical steps, prove that God exists. Such a circular argument is of course invalid. It is simply not the case that by assuming something to be true you can prove that therefore it must be true. And so belief in God remains an article of faith.

Quantum theory abounds with many similar arguments. A case in point is that of quantum entanglement. Quantum entanglement is said to occur in certain processes when two particles are created at the same time and have related characteristics. The theory asserts that these characteristics are not manifest until the particle is subject to an observing process, in the interim both particles are said to exist in a quantum indeterminate state. However when one of the particle is observed and its characteristics are revealed, the other particle assumes its version of the characteristic, instantly and over any distance. This is in violation of Einstein's theory of relativity which holds that nothing can travel faster than light.

There is however another possible explanation. If particles are not subject to quantum uncertainty and carry with them all of their characteristics in a manner which is deterministic, then no such instant communication need take place. This was Einstein's view and is what he aimed to show with the so called EPR thought experiment.

The matter could easily be resolved if was possible to exploit such instant communication in a way that allowed information to be transmitted. If information could be transmitted at a speed faster than light then there could be no doubt that entanglement was a real phenomenon. Unfortunately the definition of an observing process is such that it precludes such a possibility. In effect a particle is said to have been subject to an observing process if that process would have allowed information to be transmitted, which means that information can never be transmitted based on entangled particles.

Which of these two possible explanations you accept comes down to a matter of belief. If, like Einstein, you believe that action at a distance is impossible, then you accept that particles are objectively real and all of their properties are deterministic. If on the other hand, you agree with Niels Bohr, that particles exist in a state of quantum uncertainty until they are observed then you accept that reality is somehow subjective or at best probabilistic. And so belief in quantum entanglement remains an article of faith.

The debate over objective and probabilistic reality has a knock on effect regarding the Heisenberg uncertainty principle which provides us with a similar dilemma. Heisenberg stumbled into the existence of uncertainty when he tried to manipulate the velocity and momentum of the electrons in the hydrogen atom by tabulating them. In effect he had rediscovered matrix algebra. This had been around for some time, but was mainly confined to mathematicians and not physicists. In matrix arithmetic multiplication is not commutative, in other words A times B is not the same as B times A. In this case the difference represented the uncertainty with which the properties of the particle could be known.

Heisenberg sought a physical explanation and eventually came up with the idea that it was not possible to measure both velocity and momentum to arbitrary accuracy at the same time because the tools available, electrons and photons, were of the same order of magnitude as the electrons being measured and so measuring one of the parameters necessarily altered the other.

Niels Bohr however had a different idea, one which fitted with his ideas about probabilistic reality. He reasoned the particles themselves were possessed of inherent uncertainty; that they existed in some sort of nether state until they were observed. Eventually Heisenberg himself was persuaded to this opinion.

Once again, which of these two explanations you accept comes down to a question of belief. If you believe in probabilistic reality then this provides you with a satisfactory explanation, equally if you believe in objective reality then the explanation involving the size of the measurement tools is equally valid.

What Anselm's failed proof illustrates is that neither position can be proven one way or the other because, just like his own 'proof', they each depend on their respective assumptions.

These ideas are not unconnected with one another, so for example if you accept the idea of intrinsic uncertainty then you have to accept quantum entanglement. Quantum entanglement can be said to depend upon intrinsic uncertainty. There is a lineage of such ideas which we can trace back through the history of the development of quantum theory all of which lead back to an underlying assumption.

An Assumption

The assumption in question was originally proposed by John W Nicholson (1881-1955). He observed that the units of Planck's constant were the same as those for angular momentum. So he reasoned that the orbital angular momentum of electron in the hydrogen atom was related to Planck's constant. He went one step further and argued that the orbital angular momentum could only take on values which were an integer multiple of Planck's constant. He thus "quantized" angular momentum. Niels Bohr then used this assumption to develop his mathematical model for the hydrogen atom.

This idea that angular momentum is quantized is a cornerstone of quantum theory. Not only did Bohr use it to create a mechanical model for the atom, but so did Louis de Broglie and Erwin Schrödinger use it in their wave models. De Broglie argued that the electron could be viewed as a wave, and showed that his waves formed a harmonic series when viewed in the context of the atom. However his waves were the result of assuming that the wavelength is related to Planck's constant, which in turn he assumed to be a quantum of angular momentum in exactly the same way as Bohr. De Broglie's harmonics are therefore pre-ordained since the total orbital angular momentum is said to be an integer multiple of Planck's constant. Schrödinger then developed a set of equations to describe de Broglie's waves and this too incorporates Nicholson's postulate. Indeed the simplest

way to derive Schrödinger's wave equation is to substitute quantized angular momentum into the canonical form of an undamped second order differential equation. The fact that Schrödinger's wave equation contains a potential energy term demonstrates a clear link to Bohr's model and to the quantum leap.

Given that quantum theory rests on the assumption that angular momentum is quantized it seems extraordinary that no-one has ever tried to prove that this is the case. It is true that de Broglie did spend some 40 years trying to find what he described as a "causal link"[i] between his wave mechanics and classical mechanics. He was not able to do so. The best he could ever manage was to conclude that there were two solutions at the same time, but he was not able to convince the likes of Bohr who stuck to their idea of probabilistic reality. However he never let go of this underlying assumption regarding angular momentum, which is perhaps the reason that he failed.

Anselm's 'proof' or rather its failure to prove the existence of God can provide us with some important clues as to how we must go about proving Nicholson's assumption and so validating quantum theory.

The fact that quantum theory rests on the assumption that angular momentum is quantized means that it is not possible validate quantum theory and prove that angular momentum is quantized by consideration of quantum theory itself, since everything that comes after is dependent on the said assumption. This means that there is no way to obtain such a proof by relying on Bohr's model of the atom, on de Broglie's wave particle duality or Schrödinger's wave equation or anything that depends on any of these. Equally no claims about the accuracy of calculations based on any of these ideas can conclusively prove that angular momentum is quantized; there always exists the possibility that some other form of quantization would lead to exactly similar results.

If we cannot prove the validity of the assumption from the perspective of quantum theory then the only alternative is to base such a proof on classical mechanics. A problem arises if we try to do so using classical Newtonian mechanics. While we obtain a stable atom, the resulting atom has only a single energy level. Such an atom would be incapable of absorbing or emitting photons. In order to prove quantum theory, or indeed develop a valid alternative theory, it is necessary that we somehow modify Newtonian mechanics in such a way as to present us with an infinite number of energy levels and in such a way that the differences between energy levels matches those of the empirically derived Rydberg formula.

This is exactly what Niels Bohr tried to do when he derived his eponymous model for the hydrogen atom. He argued that the model presented by Newtonian mechanics was incorrect because it did not take account of the idea that angular momentum was quantized into units of Planck's constant. By modifying classical Newtonian mechanics in this way Bohr was able to derive a model which matched the energy levels of the Rydberg formula.

The problem is that this idea of quantizing angular momentum is simply a conjecture. What is needed is a proof. This can only take the form of a modification of Newtonian dynamics which leads to a mechanism that causes the quantization to take place.

Reductio ad Absurdum

While it is not possible to prove that a postulate is true based on the truth of the assumption, the obverse is not the case. It is possible to disprove postulate by first assuming that it is true and then showing that this leads to a contradiction, a paradox or an absurdity. Such proofs are referred to as *Reductio ad Absurdum* and are commonplace throughout mathematics and date back to ancient times. A good example is Euclid's proof that the square root of two is irrational. Euclid first postulates that the square root of two **is** rational and then shows that this leads to a contradiction

and hence that it cannot be true. Indeed the so called 'scientific method' is itself based on the underlying logic of *reductio ad absurdum*. This requires that we first put forward an assumption or postulate and based on this develop a model. The model is then tested against experimental or empirical data and if it fails the postulate underpinning the model is deemed to be incorrect. In this case the absurdity is the failure of the experiment used to test the model, but otherwise the logic is essentially the same. In short the scientific method is a means for testing the assumption and not just the model.

The assumption that angular momentum is quantized is just such a case where we can apply the logic of *reductio ad absurdum*. Using this assumption we can derive Bohr's model for the hydrogen atom, however the model requires that changes in the energy level of the atom occur when the electron moves from one orbit to another without ever occupying anywhere in between the two orbits. This was quickly dubbed the "quantum leap" and is clearly a physically impossibility. It was recognized that this was sufficient to render the Bohr model invalid, but what was not recognized at the time, nor indeed since, is that it means that not only the model, but the assumption that lies behind it, is also invalid. That is angular momentum cannot be quantized, at least not in the way that Nicholson and Bohr describe.

To get around this slight inconvenience, physicists will often say that the Bohr model is obsolete and that our view of the world has moved on, that reality is not what it seems, that particles do not exist until they are observed etc. However it is a false premise to proceed along these lines when the underlying assumption has already been shown to be false. What all of these circumlocutions amount to is simply another way of trying to describe the quantum leap but without using the words "quantum" or "leap". The electron, for example, is described as a wave function which "collapses" when it is observed to reveal the position or the velocity of the electron itself, which is now viewed as being in its particle form rather that its wave-like form. The process of collapsing is just another way of describing the instantaneous transformation of the electron into a particle which then exists at some point in space by denying that it existed as a particle prior to this transformation. In reality all such descriptions are simply euphemisms for the quantum leap.

The fact that the Bohr model leads to the absurdity of the quantum leap clearly demonstrates that the assumption that angular momentum is quantized is false. To then argue that it is correct to assume that angular momentum is quantized if we change to viewing the electron as a wave rather than as a particle is equally invalid. It is akin to telling Euclid that the square root of two is a rational number if we change the context in which we view it. It is logically inconsistent to accept that the quantum leap is a physical impossibility and to still assert that angular momentum is quantized. Once a postulate is shown to be invalid it remains irredeemably invalid whatever the context.

Quantization and Harmonics

We do however know that something is quantized and that this is connected with the discrete energy levels of the atom. This is because there is a relationship between the various energy levels is linked to a harmonic series. In the case of de Broglie these harmonics are thought to be related to the orbit of the electron as standing waves, existing as multiples of the base orbital frequency but the presence of a harmonic series transcends that limited view.

Wherever we see a harmonic series in nature there must be an accompanying sampling process or quantization taking place. This comes about when we consider the Fourier representation of a harmonic series. The Fourier representation of a harmonic series is unity at the base or fundamental frequency and at every integer multiple of the base frequency and has a value of zero everywhere else on the $j\omega$ axis. For real entities this extends along both positive and negative $j\omega$ axes to infinity. Such a function is commonly referred to as Dirac Comb. The Fourier transform of a

Dirac Comb is itself another Dirac Comb, only this time in either the time domain or the space domain. Such a Dirac comb is a sampling function or, if you prefer, a quantization function.

All of which begs the question that if angular momentum is not quantized but we know that something must be quantized, what exactly is the variable of quantization inherent in the structure of the atom?

A possible clue lies in the timeline of events leading up to Bohr's model. For the better part of 250 years it was assumed that Newton's version of classical mechanics was complete. Then in 1905 Einstein showed that it was not, he showed that time and distance and mass varied according to the relative velocity of the observer and the observed. Bohr's model was first published seven years later in 1912 and even at the time was acknowledged to have problems. Bohr chose to ignore relativity, which at the time was not well understood and even rejected by some physicists. So just at the time when we needed to investigate the idea that Newtonian mechanics were incorrect, the idea that one aspect of them is incorrect emerged. Bohr simply overlooked this and sought to introduce another change to Newtonian mechanics. Given the timing of the discovery of relativity and the attempts to describe the dynamics of the atom, it seems highly likely that relativity lies at the heart of any misconceptions we might have about classical mechanics.

In summary: quantum theory can only be validated from the perspective of classical theory and not from within quantum theory itself. This means that there has to be something wrong in our current understanding of classical (Newtonian) mechanics, since as it is currently understood the mechanics of the atom simply do not work. The presence of a harmonic series in the mechanics of the atom means that something is sampled or quantized. Niels Bohr sought to suggest it is angular momentum that is quantized into units of Planck's constant. However this assumption leads to an absurdity, the quantum leap, and so cannot itself be valid. Despite this the assumption has been carried forward without question into subsequent models of the atom. This means that we must seek an alternative explanation, either some other change to classical mechanics, which supports the idea that angular momentum is quantized or, much more likely, based on quantization of some other variable.

We will ultimately gauge the success of any new postulates and models for the atom based on the scientific method, which requires that whatever we postulate as the deficiency in classical mechanics is tested by experiment. In the meantime we can suggest a few pointers to a successful model. First, of course, it must have an infinite number of stable states whose differences return the correct values for the energy levels of the atom by matching those predicted by the Rydberg formula. The dynamics must be such that the orbital radius of the electron remains the same in all the various energy levels, since anything other than this would require the existence of the quantum leap or its latter day equivalent. It should also address the issues of which Bohr was unaware or chose to ignore; these include an explanation for the existence and the value of the Fine Structure Constant, an explanation for the existence of and value of Zero Point energy, an explanation as to why the orbiting electron does not emit synchrotron radiation and it must be seen to fully take into account the effects of relativity. Finally, since all of the variables involved are continuous, it should provide an explanation as to how exactly such continuous variables can interact with one another so as to only be able to take on certain discrete values. In effect this is the mechanism which underlies quantization and is the causal link that de Broglie was unable to find.

[i] From *Nobel Lectures, Physics 1922-1941*, Elsevier Publishing Company, Amsterdam, 1965

Chapter 2 The Hydrogen Atom

"To understand hydrogen is to understand all of physics" Victor Weisskopf

How far is it around the world?

At first sight it may seem strange to begin a discourse on the hydrogen atom by posing a question about the size of the earth, but all will become clear. So the question I want to pose is how far is it around the world? More precisely, if I was to set off from a fixed point on the surface of the earth and follow a great circle route, how far would I need to travel in order to return to my point of departure?

The circumference of the earth is some 40,000 km, so at first site it would seem that the answer to the question is 40,000 km, but this is only a partial answer. Nobody said that I had to complete the journey in a single orbit and so 80,000 km would be an equally valid answer as would 120,000 km and so on. In general we could write a simple formula to describe all of the possible such distances:

$$d = 40000n \qquad \text{Equation 2-1}$$

Where $n = -\infty \ldots -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, \ldots \infty$

It is important to understand that all of these solutions are correct at any one time. Every time I pass over the departure point it is correct to say that I have travelled 40,000 km, 80,000 km, 120,000 km etc. since I was here before. Furthermore since the starting point and endpoint can be chosen arbitrarily anywhere along the great circle route, it is true for any starting point along the chosen path. So no matter where I am on the great circle it is correct to say that I have travelled 40,000 Km, 80,000 Km, 120,000 Km etc. since I was there before.

This phenomenon, where there are multiple, equally valid, solutions to a mathematical problem, is referred to as 'Aliasing' and is frequently encountered in sampled data systems. Each of the values is an alias for the so called base value. [1]

However even this falls short of a complete answer because in our imaginary orbiter we can travel as fast or as slow as we like. The distances we have measured so far are measured at a low speed where the effects of relativity are negligible. But if we were to travel much faster, at close to the speed of light, then the distance we perceive travelling in the orbiter is reduced or foreshortened.

Special Relativity

It was Einstein who gave us our present understanding of how relativity affects distance. He did so initially for objects travelling at constant speed in what is now called Special Relativity. Later on he was to deal with objects that are accelerating or decelerating in what has come to be known as General Relativity. Here we need only concern ourselves with the special case since our orbiter is assumed to be travelling at constant speed, that is, it has constant tangential velocity.

What Einstein showed was that distances measured in the direction of travel are foreshortened or compressed, those at right angles to the direction of travel are unaffected. The extent of this

[1] Ideas around sampling and aliasing did not emerge until the late 1940's when Claude Shannon and Harry Nyquist published papers on the effects of sampling.

foreshortening is governed by a factor called the Lorentz factor. The Lorentz factor is usually referred to as Gamma (γ) given by a simple formula and tells us the extent of foreshortening for a given speed.

$$\gamma = \sqrt{\frac{c^2}{c^2 - v^2}}$$ Equation 2-2

where *c* is the speed of light and *v* is the velocity of the moving object

For example, if I was to circumnavigate the earth at 86.6% of the speed of light, where Gamma has a value of 2, then I would perceive the distance around the earth for a single orbit as exactly half that seen by a stationary or slow moving observer, that is I would perceive the distance around the world for a single orbit as 20,000 Km. Of course in general the distance around the earth would still be subject to aliasing and have multiple values, in this case of 20,000 Km, 40,000 Km, 60,000 Km and so on.

The dynamic range of Gamma extends from 1, at very low speeds, all the way to infinity at the speed of light. In effect this means that, by suitable choice of the orbital velocity and the number of orbits, we can contrive the distance from point A to point A to be anything we care to make it.

So the correct answer to the question: How far is it around the world? is;

How far do you want it to be?

How far *do* you want it to be?

Suppose we want to choose a particular distance around the world and then to explore all of the possible strategies for achieving that it. If, for example, we want to find all the possible ways of travelling from A to A while covering a distance of 400 Km. One possible strategy would be to complete one orbit of the earth at speed where Gamma has a value of 100. That would be at a speed of 99.995% of the speed of light. The next viable solution would be to complete two orbits at a speed where Gamma equals 200, that is at 99.99875% of the speed of light. The next would be three orbits at Gamma = 300 and so on. In general we can summarize this as

$$\gamma = 100n$$ Equation 2-3

For $n = 1,2,3, \ldots \infty$

There are thus an infinite number of ways in which we could contrive to go around the world while covering a distance of 400 Km. Once again the distances around the world are aliased. For example when $n = 1$ the distances are 400, 800, 1200… km, when $n = 2$ they are 200, 400, 600… km and when $n = 3$ they are 133, 266, 400, 533…km. For each value of *n* all of the respective values are valid, it is just that we are choosing the particular alias where the distance equals 400 km. the situation is summarized in Table 2-1 which shows the possible distances for values of Gamma which are an integer multiplier of 100 and for *n* orbits. The principle diagonal is always equal to 400 km, our chosen distance.

Gamma \ n	1	2	3	4	5	6	7
100	400.00	800.00	1200.00	1600.00	2000.00	2400.00	2800.00
200	200.00	400.00	600.00	800.00	1000.00	1200.00	1400.00
300	133.33	266.67	400.00	533.33	666.67	800.00	933.33
400	100.00	200.00	300.00	400.00	500.00	600.00	700.00
500	80.00	160.00	240.00	320.00	400.00	480.00	560.00
600	66.67	133.33	200.00	266.67	333.33	400.00	466.67
700	57.14	114.29	171.43	228.57	285.71	342.86	400

Table 2-1 Distances under relativity

Orbital frequency

An often overlooked aspect of special relativity is the affect it has on frequency as perceived by the two different observers. This comes about because as well as affecting distance, relativity also affects time with different observers recording different times depending on their respective points of view. In the example above; for a stationary observer the orbital period remains more or less the same no matter which of the various strategies we choose. The orbital circumference is 40.000 Km and the speed of the orbiter varies from 99.995% c when $n = 1$ to approaching 100% c when $n = \infty$. The time taken to complete one orbit is therefore also substantially constant at 133.425 msecs. The orbital frequency as experienced by the stationary observer is simply the reciprocal of the orbital period and so is 7.5Hz.

The situation for the moving observer is somewhat different. At 99.995% c, where Gamma = 100, time is slowed down by a factor of 100, so the orbital period experienced by the moving observer is 1.33425 msecs. The orbital frequency at this particular speed will be seen as 750Hz. When Gamma is equal to 200 time is slowed down even more and the orbital period is 0.667 msecs making the orbital frequency 1500Hz. In general the orbital frequency will be multiplied by Gamma with respect to that seen by the stationary observer and so will form a harmonic series as Gamma takes on successive values in the series Gamma equals 100n.

It is left to the reader to work out the various strategies for circumnavigating the earth while covering a distance of 291.9 km.

Having looked at the effects of relativity on an object orbiting around the earth, it is time to shrink things down to the scale of the atom and consider the electron in orbit around the atomic nucleus.

The Rydberg Formula and Series

During the 18th and 19th century it was discovered that when shining white light through a gas the resulting spectrum contained dark lines. These were located at wavelengths which were specific to the type of gas and later formed the basis of spectroscopy. Work by a Swiss mathematician and numerologist, Jakob Balmer (1825-1898), led to a formula that linked six of the various wavelengths of these dark lines for hydrogen. Using his formula Balmer was able to predict a seventh spectral line, which was subsequently found by the Swedish physicist Anders Ângström (1814-1874). However Balmer's formula did not predict all of the spectral lines of hydrogen. The Swedish physicist Johannes Rydberg (1854-1919) was able to generalize Balmer's formula in such a way that his new formula was able to predict all the spectral lines of hydrogen.

The atom is seen as occupying one of a number of discrete energy states, that energy being carried by the orbiting electron. Transitions between a high energy state and a low energy state result in the release of energy in the form of a photon. Those from a low energy state to a high energy state are

the result of energy being absorbed from an incident photon. The Rydberg formula tells us what the wavelengths of the photons will be for any given transition.

The Rydberg formula is most often quoted as:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad \text{Equation 2-4}$$

It is important to understand that Rydberg's formula is based on the results of experiment and observation. It does not seek to explain the spectral lines, rather it seeks to describe them and it is complete, that is it describes objectively all of the spectral lines for hydrogen. The Rydberg formula deals only with the differences in energy between the various energy states. It has nothing to say about the absolute value of energy carried by the orbiting electron. The Rydberg formula forms a sort of gold standard against which any successful model for the hydrogen atom may be tested.

As quoted above, the Rydberg formula uses the somewhat obscure wave number (1/λ). It can be expressed more usefully in terms of the energy emitted or absorbed when a transition takes place. This is achieved by multiplying both sides of Equation 2-4 first by *c*, the velocity of light and then by *h*, Planck's constant [2]. Gathering terms and substituting the analytical value for R_H gives:

$$E_{n_1,n_2} = \frac{1}{2}mc^2\alpha^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad \text{Equation 2-5}$$

Where *m* is the rest mass of the electron and *α* is the Fine Structure Constant (Alpha) which was first described by Arnold Somerfield in 1916.

The Rydberg formula tells us the amount of energy released when the electron orbiting the hydrogen nucleus makes a transition from the n_1^{th} energy state to the n_2^{th} energy state, or conversely the amount of energy absorbed if the transition is in the other direction. By letting $n_2 = \infty$ we obtain the energy associated with a transition to or from the maximum possible energy state of the electron and its energy in the n^{th} energy state, that is we obtain the *energy potential* [3] of the atom in the n^{th} energy state. Doing so leads to the Rydberg Series

$$E_n = \frac{1}{2}mc^2\frac{\alpha^2}{n^2} \qquad \text{Equation 2-6}$$

The Rydberg Series is particularly useful because it allows us to easily calculate the energy associated with any transition simply by taking the difference between two values in the series.

E_n is the energy potential of the n^{th} energy state and represents the difference between the energy of the electron in the n^{th} energy state and the most energetic energy state possible, the ∞ energy state or *energy ceiling* of the atom. The energy ceiling of the atom represents the maximum energy that an orbiting electron could ever possibly have. It is reasoned here that, since nothing can ever travel faster than the speed of light, the energy ceiling is limited by the speed of light to be

$$E_{max} = \frac{1}{2}mc^2 \qquad \text{Equation 2-7}$$

It is also reasoned here that the electron orbiting the atomic nucleus must do so at the constant radius, that is to say at the same orbital radius for every energy state. Anything other than this would imply the existence of the physically impossible 'quantum leap', the ability to move from A to B without occupying anywhere in between. This in turn means that there can be no change in

[2] Note that this is the long form of Planck's constant
[3] Note that energy potential is not the same as potential energy.

potential energy when the electron transitions from one energy state to another energy state. All changes in energy must therefore be kinetic in nature. Hence the energy of the electron in the n^{th} energy state must be

$$E_{v_n} = \frac{1}{2} m v_n^2 \qquad \text{Equation 2-8}$$

where v_n is the orbital velocity in the n^{th} energy state.

It is the difference between the energy ceiling and the energy in the n^{th} energy state that is expressed in the Rydberg series, so by definition

$$E_n = E_{max} - E_{v_n} \qquad \text{Equation 2-9}$$

$$\frac{1}{2} m c^2 \frac{\alpha^2}{n^2} = \frac{1}{2} m c^2 - \frac{1}{2} m\, v_n^2 \qquad \text{Equation 2-10}$$

Equation 2-10 can be simplified to give

$$c^2 - v_n^2 = c^2 \frac{\alpha^2}{n^2} \qquad \text{Equation 2-11}$$

And further simplified to give

$$\sqrt{\frac{c^2}{c^2 - v^2}} = \frac{n}{\alpha} \qquad \text{Equation 2-12}$$

The term on the left hand side of Equation 2-12 will be recognized from Equation 2-2 as the Lorentz factor Gamma (γ) and hence

$$\gamma_n = \frac{n}{\alpha} \qquad \text{Equation 2-13}$$

Since $1/\alpha = 137.036$ we can rewrite Equation 2-13 as

$$\gamma_n = 137.036\, n \qquad \text{Equation 2-14}$$

Where $n = 1,2,3,4,5 \ldots \infty$

From this we see that the variable of quantization is the Lorentz Factor, Gamma, which takes on values that are integer multiples of the inverse of the Fine Structure Constant, and not the angular momentum as is currently held to be the case.

By setting *n=1* in Equation 2-14 we can calculate the orbital velocity in the base energy state using the equation for Gamma; Equation 2-2 and 137.036 as the value of Gamma. This gives us an orbital velocity close to the speed of light at 99.9973372% of c. This means that the dynamic range of the orbital velocity between the lowest or base energy state and the energy ceiling of the atom is extremely small.

The Fine Structure Constant

Equation 2-14 also provides us with a physical understanding of the hitherto mysterious Sommerfeld Fine Structure Constant, Alpha, (α). It is seen as the reciprocal of the value of Gamma for the orbital speed of the electron in the base energy state. Successive energy states being associated with

integer multiples of this value. In other words it is the extent to which the orbital circumference is foreshortened by relativity for the orbiting electron when in the base energy state.

Alpha can be calculated analytically based on the value of other well-known constants and is given by

$$\alpha = \frac{Kq^2}{\hbar c}$$ Equation 2-15

But from Equation 2-13

$$\alpha = \frac{n}{\gamma}$$ Equation 2-16

Hence

$$\frac{Kq^2}{\hbar c} = \frac{n}{\gamma}$$ Equation 2-17

And taking the angular orbital momentum of the electron to be equal to Planck's constant

$$\hbar = mcR$$ Equation 2-18

Hence

$$\frac{Kq^2}{R^2} = \frac{mc^2}{R}\frac{n}{\gamma}$$ Equation 2-19

However, although this equation is in balance, since the electron is travelling at near light speed, the mass terms in Equation 2-18 and Equation 2-19 should each be multiplied by Gamma. In order to preserve the integrity of these two equations therefore it is necessary to introduce a second factor Gamma into the denominator of each equation

$$\hbar = m\gamma\, R\frac{c}{\gamma}$$ Equation 2-20

$$\frac{Kq^2}{R^2} = \frac{m\gamma\, c^2}{R}\frac{n}{\gamma^2}$$ Equation 2-21

We are forced to ask where this additional Gamma term comes from and what is its physical significance. None of the terms on the Left Hand Side of these equations is affected by relativity. On the Right Hand Side the radius term *R* is not affected by relativity and we have just accounted for the mass term. This can only mean that these additional Gamma terms are associated with the orbital velocity term. Furthermore the exponents of the Gamma and velocity terms match in the two equations.

In physical terms this suggests that the effective orbital velocity as far as angular momentum, centripetal/centrifugal force and acceleration are concerned is the actual velocity divided by Gamma.

The idea of a velocity term which is affected by relativity tells us what causes the atom to take on discrete levels of energy, but it still does not tell us why the variable Gamma should be quantized in this way. Gamma is known to vary continuously between one and infinity as the velocity increases,

so we need to understand why it only takes on these certain discrete values in the context of the dynamics of the atom. That is we need to understand the mechanism which causes Gamma to be quantized.

Relativistic Velocity

The conventional wisdom is that both the stationary observer and the moving observer agree on their relative velocity, that velocity is invariant with respect to relativity.

In order to measure the speed of an object moving at close to the speed of light in real time it is necessary for a stationary observer to use two clocks, at least conceptually. One clock must be set up at the point of departure and another at the point of arrival. The two clocks must then be synchronized before the measurement can begin[4]. The time that the moving object leaves the point of departure is noted on the departure clock and the time of its arrival is noted on the arrival clock. At least one of these measurements must then be transmitted to the other location before the difference can be taken and the speed calculated. Any attempt to measure such a velocity in real time is thwarted by the fact that the clock would have to move with the moving object and so would itself be slowed down due to the effects of relativity.

There is however one circumstance where this is not the case, where it is possible to measure velocity using a single clock; that is when the moving object is in orbit. Under this circumstance the object returns to its point of origin once per orbit and so it is possible, conceptually at least, to measure its orbital velocity in real time using a single clock provided the measurement is made over one or more complete orbits. The restriction that orbital period can only be measured or experienced over a whole number of complete orbits amounts to a sampling process and, as we have seen, sampling processes lead to aliasing.

Based on this it is possible to define a velocity term which straddles the two domains; that of the stationary observer and that of the moving electron. Such a velocity is calculated as the distance as it is measured by the moving observer, and foreshortened by relativity, divided by the time as measured or experienced by the stationary observer.

When orbital velocity is measured over a complete orbit, the distance value which contributes to the measurement is subject to aliasing in exactly the same way as the measurement of the distance around the world was earlier. The orbital period however is measured in the domain of the stationary observer and so is not subject to aliasing. This means that the distance travelled during the orbital period can be regarded as having multiple values but this means that so also does the Relativistic Velocity which is distance divided by time.

Synchrotron Radiation

When an electrically charged object follows a curved path, it normally radiates a type of radiation called *Synchrotron Radiation*. However the electron orbiting the hydrogen nucleus does not appear to do so. If it did, the electron would lose energy and eventual its orbit would decay and it would spiral into the nucleus. Clearly this does not happen and so we can conclude that the orbiting electron does not emit such radiation. But why not?

The answer is to be found in Equation 2-20. Although the two Gamma terms could be cancelled to give us the orbital radius, their presence combines to effectively constrain the orbital radius to this value. As Gamma gets larger the scope for the radius to deviate gets less. This provides us with an explanation as to why the orbiting electron does not decay due to the emission of synchrotron

[4] Since the two clocks are stationary with respect to one another they will run at the same rate and therefore it is possible to synchronize them.

radiation. Rather than being driven in any conventional manner to adopt a circular orbit, here the electron is constrained by the combined effects of relativity and Planck's constant to always have a constant value. It is as if the electron is orbiting on a hard surface, one which it cannot penetrate and from which it cannot depart. This is more akin to the way in which we view general relativity, where objects move in straight lines on a curved space.

Force Balance

As the Actual Velocity increases, getting ever closer to the theoretical speed of light, the Relativistic Velocity decreases and hence the centrifugal force also decreases eventually reaching a point where it matches the electrostatic force tending to pull the electron towards the nucleus. The two forces first come into balance when the Actual velocity is such that Gamma equals 1/Alpha or roughly 137.036. That is when the Relativistic Velocity is equal to $c\alpha$.

The situation is shown graphically in Figure 2-1 which shows the centrifugal force derived from the Relativistic Velocity plotted against Gamma, highlighted in black. It also shows the electrostatic force acting between the electron and the proton (in red) which is independent of Gamma and therefore constant. The two curves intersect when Gamma is equal to 1/α that is when it equals approximately 137.03 at which point the orbital circumference as perceived by the electron has a value of $2\pi R\alpha$ as the first of its infinity of aliases.

However as we have seen, the orbital path length is multivalued due to the effects of aliasing and so the Relativistic Velocity must similarly have multiple values. If the Relativistic Velocity is considered to have multiple values then so too does the centrifugal force which is derived from the Relativistic Velocity. Also shown in Figure 2-1 are the aliases for the centrifugal force, which are in turn derived from the aliases for the Relativistic Velocity. Here the first ten aliases of the derived centrifugal force are shown with respect to Gamma. Only the first is highlighted, corresponding to the base energy state of the atom but all of the aliases are equally valid at the same time and any one of them which has the correct value will result in a stable atom.

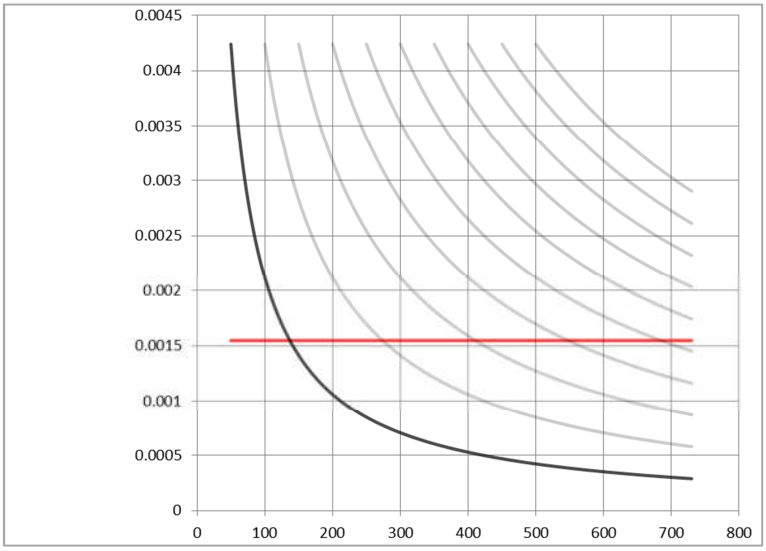

Figure 2-1 Aliased force vs Gamma

Figure 2-2 shows the situation as the Actual Velocity increases; the alias for the Relativistic Velocity associated with *n=2* will eventually have a value such that the forces are again in balance, corresponding to the second energy state at which point the orbital circumference as perceived by the electron has a value of $2\pi R\alpha$ as the second of its infinity of aliases. The situation will repeat for each successive energy state.

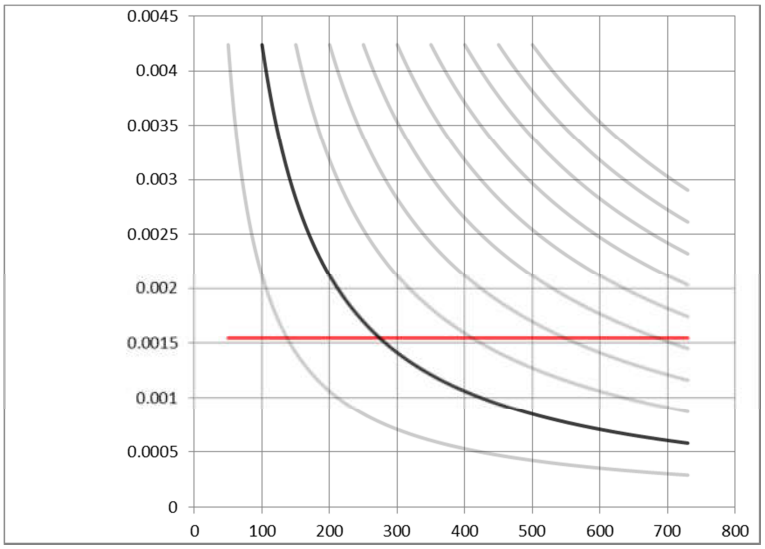

Figure 2-2 The second energy state

The situation is somewhat analogous to the detents in a mechanical gearbox.

Energy Levels

We can calculate the values of Actual orbital velocity for each energy state since.

$$v_n = c\sqrt{1 - \frac{\alpha^2}{n^2}}$$ Equation 2-22

And the energy is $1/2mv_n^2$

The differences between the energy in the n^{th} state and the energy in the ∞ state forms the Rydberg series, from which we can calculate any of the other series for the hydrogen atom. These values are given in for the first few energy levels in Table 2-2 and they precisely match the values predicted by the Rydberg formula.

n	$v_{n/c}$	$1/\gamma_n$	ω_n	Energy eV	ΔEnergy eV
1	0.999973371	0.007297559	7.76324511E+20	255485.925	13.607
2	0.999993343	0.003648853	7.76340016E+20	255496.130	3.402
3	0.999997041	0.002432577	7.76342887E+20	255498.020	1.512
4	0.999998336	0.001824435	7.76343892E+20	255498.682	0.850
5	0.999998935	0.001459549	7.76344357E+20	255498.988	0.544
6	0.999999260	0.001216291	7.76344610E+20	255499.154	0.378
7	0.999999457	0.001042536	7.76344762E+20	255499.255	0.278
8	0.999999584	0.000912219	7.76344861E+20	255499.320	0.213
9	0.999999671	0.000810861	7.76344929E+20	255499.364	0.168
10	0.999999734	0.000729775	7.76344977E+20	255499.396	0.136
∞	1.000000000	0.000000000	7.763451838E+20	255499.532	0.000

Table 2-2 Energy level, velocity, frequency energy and Δenergy

It is because the Relativistic Velocity decreases with increasing actual velocity combined with the phenomenon of aliasing that the variable Gamma is quantized and the atom can enter a succession of stable states.

The Morphology of the Atom

In the Bohr model and all the other models which are based on the quantization of angular momentum, the size of the atom varies with its energy level. In the case of the Bohr model the orbital diameter increases as the square of its energy level, in the case of de Broglie's idea of the wavelength, the orbital diameter associated with each harmonic increases linearly with the energy level. Were this to be the case it would have some interesting consequences. Since there is no upper limit to the energy level of the atom it follows that there is no upper limit to its diameter. Under these circumstances it is perfectly possible to have an atom with a diameter of say a meter or even a kilometer.

Under such circumstances it is impossible to imagine how the atom could maintain the same set of physical and chemical properties as its energy level changes. The physical and chemical properties of the atom depend intimately on its morphology. In particular the electrical forces between atoms bound into molecules, even properties such as density must depend on the atom having basically the same morphology over the entire range of possible energy levels.

In the solution developed here the morphology of the atom remains substantially constant across all of the different energy levels. An atom in the base state has the same orbital diameter as one at the energy ceiling, the only difference is the orbital velocity which varies over a very small dynamic range between 99.9973371% and 100% of the speed of light.

Orbital Frequency

We saw earlier that the effect of relativity on the perception of orbital frequency for the stationary and the moving observers. For the stationary observer the orbital frequency of the electron in the hydrogen atom remains more or less constant and is given by:

$$\omega = \frac{c}{R} = \frac{mc^2}{\hbar}$$ Equation 2-23

However for the electron, which is moving at close to the speed of light, the orbital frequency is given by

$$\omega = \frac{c\gamma}{R} = \frac{mc^2\gamma}{\hbar} = \frac{c\,n}{R\alpha} = \frac{mc^2 n}{\hbar\,\alpha}$$ Equation 2-24

This means the orbital frequency experienced by the moving electron is that that seen by the stationary observer increased by a factor of 137.03 times the energy level *n*. From the presence of the integer multiplier *n* in Equation 2-24 it can be seen that the frequencies experienced by the orbiting electron form a harmonic series, starting with a base frequency in the base energy state, where *n=1,* and rising in integer multiples with each succeeding energy state. This shows that at the heart of the discrete energy levels of the atom lies a harmonic series, much as de Broglie suggested, only rather than appearing directly in our observable domain, it appears instead in the domain of the moving electron and the mechanism that causes this to happen is relativity.

For the stationary observer, the relationship between frequency, velocity and orbital radius is simply the orbital velocity divided by the orbital radius. It is a similar situation for the orbiting electron, only this time the velocity is the velocity affected by relativity described above. Hence there is a

consistent relationship between the wavelike description of the particle and its particulate description, a sort of wave / particle identity, one which is consistent with how we regard orbital frequency generally.

On the other hand there are two different velocity terms, one seen by the stationary observer and one experienced by the moving electron. Equally there are two different frequency terms again one seen by the stationary observer and one seen by the moving electron. We can describe this as a wave duality and a separate but related particle duality.

While trying to justify his ideas about the wavelike nature of the particle, Louis de Broglie hit upon the idea that there are two solutions to the dynamics of the hydrogen atom. He was never able to find a causal link between these two solutions and never able to convince his colleagues that such a link was necessary, largely because he was not able to abandon the idea that angular momentum is quantized. In the end he migrated towards what he called *Pilot Wave Theory*. Here we recognize that there is are two separate but related descriptions of the said dynamics, one viewed from the perspective of the stationary observer and one from the perspective of the moving electron, an idea which resonates with de Broglie's *dual* solution; only here we have found the causal link between them to be special relativity.

Zero Point Energy

The model also provides an explanation for Zero Point Energy. Debate has raged about the existence and the nature of zero point energy since the concept was first introduced by Planck in 1911. With at least one interpretation showing that the atom is possessed of energy even when it is cooled to absolute zero. When an atom is cooled to absolute zero it ceases to have Brownian motion and therefore has zero kinetic energy. However the orbiting electron still has kinetic energy. The electron is orbiting at close to the speed of light and so has energy equal to $1/2mc^2$ exactly in line with prediction.

The Atom

In this model for the hydrogen atom the postulate that angular momentum is quantized has been overturned and replaced with the idea that the variable of quantization is Gamma, the Lorentz factor. The driving force behind this quantization is the postulate that certain orbital velocity terms are affected by relativity. The result is a far simpler more prosaic model for the atom. The electron orbiting the atomic nucleus is seen as being objective in nature, having deterministic position and deterministic velocity at all times, overturning the idea of probabilistic reality which lies at the heart of the standard model.

The electron orbits at a constant radius irrespective of energy level and at a velocity close to the speed of light. This is a necessary condition if the quantum leap is to be regarded as an absurdity. The model examines what conditions must apply for this to be the case. The constant orbital radius of the electron means that the morphology of the atom does not change substantially with energy level, consistent with an atom whose physical and chemical properties are the same independent of energy level.

The model is based on the assumption that orbital velocity is a hybrid term comprising distance measured under the effects of relativity with time measured in the domain of a stationary observer, dubbed here as Relativistic Velocity, and it is this combined with the fact that the electron is in orbit that leads to the notion of an implied sampling function. Quantization thus becomes a function of a single variable and so does not involve the complex and unexplained interactions between variables that quantization of angular momentum would imply.

The model produces energy levels which exactly match those of the empirically derived Rydberg formula. The absolute value of energy is seen as being close to $1/2mc^2$ which is considerably higher than that of the Bohr model and of other subsequent models. However it does provide an explanation for the so called Zero Point Energy, which hitherto has been unexplained. Here is seen as the residual energy possessed by the atom when all Brownian motion of the atom as a whole has ceased.

Validation of existing quantum theory can only take place in the classical domain, since everything in the quantum domain is contingent on the assumption that angular momentum is quantized. Other than the concept of Relativistic Velocity, the model here makes use of classical, Newtonian, mechanics and provides an explanation for the discrete energy levels of the atom. As such it effectively unifies quantum mechanics and classical mechanics.

The model also provides an explanation for the hitherto unexplained Fine Structure Constant. Here we see that Alpha is the ratio of two lengths. They are; the orbital circumference as measured by the moving electron and foreshortened by relativity and the orbital circumference measured by the stationary observer both at the point at which the atom is stable. This occurs most obviously in the base energy state when the actual orbital velocity is such that the Relativistic Velocity is scaled by the factor Alpha. But it also occurs as an alias in each stable state of the atom.

The fact that measurements are being made in two different domains, separated by the effects of relativity means that there appears to be two solutions to the dynamics of the electron leading to the idea of a duality of wave like characteristics, such as wavelength and frequency and a duality of particle like characteristics, such as orbital path length and orbital period. At the same time the relationship between the wavelike and particle like characteristics is consistent within each domain leading to the idea of a wave / particle identity, a wave duality and a separate but related particle duality.

Finally the conventional laws of physics apply and are simply extended down from room scale to that of the atom with one slight modification. That is in our understanding of how relativity affects objects with regards to objects in circular motion. There is no need to invent an alternative reality based on probability with all of the exotic paraphernalia that it implies. Uncertainty does exist and is inescapable, but is seen as a practical issue of measurement and not as some inherent property of the particle. There is however no escaping from the myopic view that uncertainty confers. This means that we are forced to adopt statistical means to deal with objects on the scale of the atom and hence much of what is termed quantum mechanics remains valid and unaltered. It is the understanding of what sort of reality that lies behind that changes.

Chapter 3 The Photon

"In speaking of the Energy of the field, however, I wish to be understood literally. All energy is the same as mechanical energy, whether it exists in the form of motion or in that of elasticity, or in any other form. The energy in electromagnetic phenomena is mechanical energy." - James Clerk Maxwell

Introduction

Visible light is just a small part of a much of a much broader spectrum of electromagnetic radiation, ranging from radio waves at one end through microwaves, visible light and X Rays to gamma rays at the other end of the spectrum. All of these different and seemingly diverse types of radiation are the various manifestations of one type of particle; the photon.

Light is known to travel through a vacuum at close to 300,000 km per second. It is this high speed which gives the photon its special significance. The fact that light travels at such a high speed means that it acts as a sort of universal messenger, distributing and transporting information and energy throughout the universe. The known universe is only known because of the existence of light and more recently other forms of electromagnetic radiation. It is through our senses and sensors, acting on incident photons, that mankind knows about the very existence of the solar system, the stars, the planets and the galaxies. It is the fact that light travels (more or less) in straight lines which allows us to determine the position of objects in space and from this their motion. Based on an understanding of the photon and the atom, our knowledge extends beyond the mere presence and position of these objects scientists are able to extrapolate to discover the chemistry and composition of these distant objects.

A complete understanding of the nature of the photon is therefore vital to an understanding of the universe itself. Conversely if the model of the photon is even slightly wrong the effects, magnified by the vast distances and times involved, are likely to seriously distort our view of the way the universe works.

Wave or particle?

The idea of light as a stream of particles dates back to at least 55BC when Lucretius wrote in *On the nature of the Universe* . *'The light and heat of the sun; these are composed of minute atoms which, when they are shoved off, lose no time in shooting right across the interspace of air in the direction imparted by the shove.'* The idea of light as a wave emerged much later and was largely due to the work of Huygens. Since then evidence has emerged of light behaving as both a wave and as a stream of particles. Hooke supported the view of Huygens and believed that light was a wave, while Newton was of the opinion that it was "corpuscular" in nature.

Experimental evidence for light as wave emerged in the early 19th century when Thomas Young described his double slit experiment which clearly showed that light was capable of interference, a phenomenon which is normally associated with waves. This was reinforced later in the 1860's when James Clerk Maxwell published his paper containing his eponymous equations. These wave equations were based on the earlier work of Faraday and showed that electromagnetic radiation propagated as a wave travelling at the speed of light.

Then to counter this, in 1900 Max Planck showed that radiation from black bodies could only occur in discrete packets or quanta[ii]. Initially Planck believed that this quantization effect was merely a quirk of the mathematics necessary in order to solve the equations; however, in his landmark 1905 paper on the photoelectric effect, Einstein showed conclusively that the quantization effect was real

and this led Einstein to propose the existence of the photon as the particle of light.[iii] Further experimental evidence emerged when Compton demonstrated that X Rays are red shifted as they passed through a carbon target, a phenomenon which could only happen as a result of collisions between discrete X Ray photons and electrons in the carbon atoms and which is known as Compton Scattering.

It seems that light has both wave like and particle like properties and can be treated as either a particle or a wave as the circumstances require. Since the middle of the 20th century an uneasy truce has arisen in the form of the Wave Particle Duality. This seeks to suggest that light is simultaneously both a wave and a particle, but that it only manifests itself as one or the other when an observer is looking for that particular property and centres on the idea of subjective reality. But this is more of an uneasy compromise, a truism that fails to explain what the photon is and simply describes what we are able to observe.

Polarization

Most people are familiar with polarization having had a pair of polarizing sunglasses. These cut down glare and the way they do this is quite simple. When light is reflected off a horizontal surface, such as the surface of a lake or river, those photons which are polarized horizontally are reflected preferentially, and it is this which causes the glare which can be so annoying. The lenses of a pair of sunglasses each contain a polarizing filter, only this is arranged so as to only let vertically polarized light pass through. The result is that the horizontally polarized glare is suppressed.

We can think of the plane polarized filter as a sort of grating which only allows light whose polarization is aligned with the grating to pass through. The conventional way to illustrate this is based on the idea of light as a wave as shown in Figure 3-1 for the case of a horizontal polarizer.

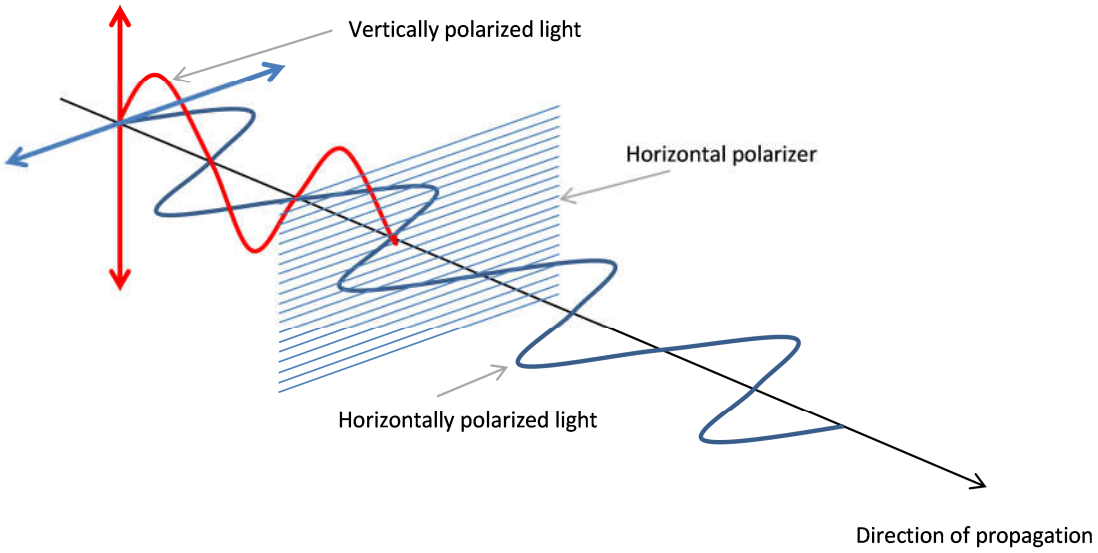

Figure 3-1 Horizontal polarization viewed as a wave

The incident light is randomly polarized, after passing through the filter the light is plane polarized, in this case horizontally. The model based on a simple grating and light as a wave works well for plane polarized light, but is almost incomprehensible when used to describe circular and elliptical polarization.

A more intuitive model deals with light as a stream of photons rather than as a wave and can deal with all types of polarization including circular and elliptical polarization. The incident beam of light is regarded as a stream of photons and each photon is seen as flat disk. The disk is spinning about an

axis that passes through its centre. Photons which align with the polarizer will pass straight through, while whose orientation is at an angle to the polarizer may be blocked. The disk based metaphor helps visualize how photons can have plane, circular or elliptical polarization. The projection of the disk in the direction of travel will correspond to the type of polarization.

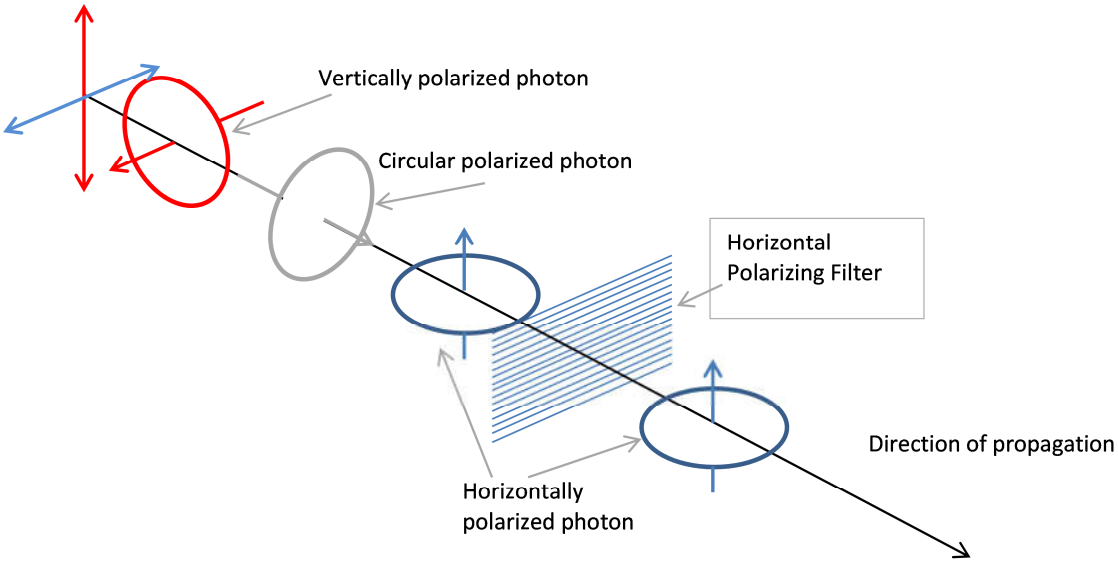

Figure 3-2 Horizontal Polarization viewed as a particle having the form of a flat disk

The orientation of the axis of the disk and hence that of the photon is not confined to a single plane, it can be in any direction. In randomly polarized light the distribution of these axes of rotation may be thought of as being evenly distributed over a sphere.

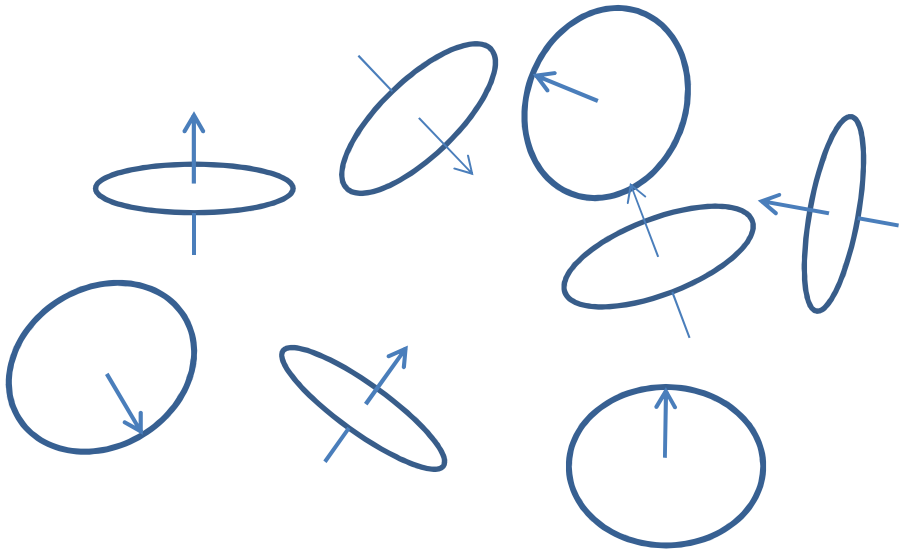

Figure 3-3 Randomly polarized photons

Not all photons which are not aligned with a polarizing filter are blocked. Photons which arrive at a polarizing filter may have their polarization altered by the filter so as to align with it and so emerge as plane polarized. We can imagine this as being a mechanical process rather like inserting a coin into a slot machine. As the photon enters the material of the polarizing filter it is twisted so as to force it into alignment with its polarizing properties of the filter. The probability that this will

happen depends on the angle between the axis of rotation and that of the polarizing filter and is independent of the longitude of the axis of rotation.

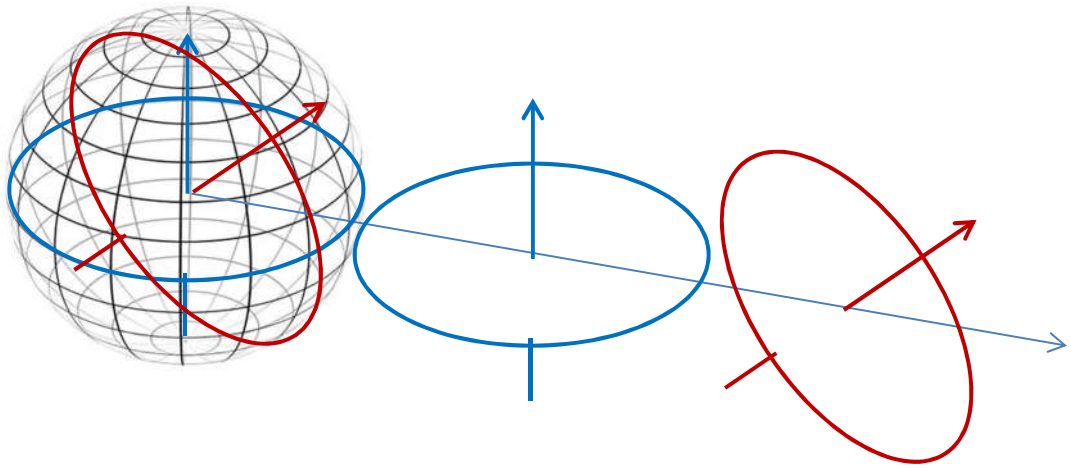

Figure 3-4 Distribution of axes of rotation

The law governing the relationship between the angle of polarization of incident light and that of a polarizing filter was first identified by Étienne-Louis Malus (1775- 1812). Malus' law states that the intensity varies as the cosine of this angle squared[5]. Malus' law is not confined to plane polarization. It works equally for all polarization. What matters is the angle between the axis of rotation and that of the polarizing filter. So any photon whose axis lies on a line of latitude will have the same probability of being reoriented by the polarizing filter.

For example, if the polarizing filter is horizontal then any photon whose axis lies on latitude 45° will have a 50% probability of being modified to pass through the filter. At higher latitudes the probability increases while at lower latitudes the probability gets less. However there are more photons with axes in the lower latitudes than the higher ones and so overall the probability remains at 50%. Hence an ideal polarizing filter will always reduce the intensity of a beam of randomly polarized light by 50%.

This disk based metaphor is able to fully describe all of the various ways in which polarization can affect a beam of light and to do so in a way which is readily understood. Regarding the photon as a disk in this way is consistent with the photon as a discrete entity. If the disk is rotating about its axis it will also have those properties which are associated with a wave such as wavelength, frequency, phase etc.. It begs the question as to whether the metaphor represents a real description of a physical photon. Such an idea is attractive because it solves the problem of how light can travel through a vacuum. At the same time it addresses the issue of how the photon can be regarded as both a wave and a particle at the same time.

Maxwell's Equations

Maxwell's equations are predicated on the idea that a changing magnetic field induces an electric field and a changing electric field induces a magnetic field. Taken together these two coupled fields

[5] Note that Malus' law refers to the angle of the polarization, not the angle of the axis of rotation. If reference is made to the angle of the axis then Malus' law would mean that the intensity varies as the square of the sine of this angle.

oscillate and the whole propagates at a velocity which Maxwell showed to be equal to the speed of light. There are problems with this idea which Maxwell himself acknowledged[6]. His equations suggest that there are two separate and independent mechanisms which can sustain an electric field. On the one hand we know that the presence of a charged particle creates an electric field. Maxwell presumed that a changing magnetic field could also create an electric field and to do so in empty space. In order to do so it is necessary to endow empty space with those properties necessary to sustain such a relationship, namely permittivity, and this is effectively to reinvent the ether, which we know does not exist.

It should be remembered that Maxwell developed his equations some 35 years before J.J. Thomson discovered the electron and it was 10 years after that before Rutherford discovered the proton and so Maxwell was unaware that charged particles even existed. It comes as no surprise therefore that he simply assumed that the electric field was created as a result of changes in a magnetic field. It is highly unlikely that there are two separate and independent mechanisms that could lead to the presence of an electric field. We know for certain that a constant electric field exists in the region of a charged particle. Indeed the permittivity of free space is closely related to the electrostatic force constant that determines the forces between charged particles in the inverse square law. This means that it must be the existence of an electric field sustained purely by a changing magnetic field in otherwise empty space that has to be called into question.

It is reasoned here that Maxwell confused cause and effect. It is not the combined effects of permeability and permittivity that causes light to travel at the speed it does, but the light travelling at this speed which causes us to think that space has the particular values of permeability and permittivity that it does. This being the case it means that an electric field can only exist in the presence of a charged particle. The implication of this is clear: if an electric field can only exist in the presence of a charged particle and the photon has an associated electric field then the photon must contain a charged particle. However since the photon is overall electrically neutral, then there must be equal numbers of positive and negative such particles.

We have seen how by regarding the photon as a disk we can perfectly explain polarization. It follows logically to suggest that such a disk is in reality the orbital path followed by a pair or pairs of charged particles in mutual orbit. Such a system would present itself as an oscillating electric field and such an oscillating electric field would produce an oscillating magnetic field. It would have an axis of rotation about which the particles were in orbit and this in turn would determine its polarization. It would have an orbital frequency and a wavelength and all of the other characteristics we typically associate with a wave. At the same time it would be a discrete entity and so have a particulate nature. In other words it would have all of the characteristics that we associate with a photon.

There is however just one problem with this idea and that is that the photon has no mass. The problem with the idea of a particulate photon has always been how to reconcile the fact that mass is a fundamental property of all particles with the fact that the photon would appear to have no mass at all. It begs the question as to whether there is a type of particle, as yet undiscovered, which carries electric charge but has zero mass. This seems highly unlikely since particles with electric charge are relatively easy to manipulate and so would almost certainly have been discovered if such a thing existed.

If all particles have mass but can combine to form a photon with zero mass then it suggests that there is another type of mass which has yet to be discovered. From here it is a simple step to argue that the photon has zero mass because it is made up of two particles of opposite mass. In other words that mass is capable of existing in both positive and negative forms.

[6] "In speaking of the Energy of the field, however, I wish to be understood literally. All energy is the same as mechanical energy, whether it exists in the form of motion or in that of elasticity, or in any other form. The energy in electromagnetic phenomena is mechanical energy." James Clerk Maxwell

Negative mass

Conventional wisdom holds that all forms of mass are always positive, however there is no direct evidence to support this view. Mass is unusual in that it manifests itself in two quite distinct forms and it is only by judicious choice of constants that these happen to have the same numerical value. On the one hand there is gravitational mass which is described by Newton's gravitation equation and deals with the static forces between objects that have mass. The equation relates the masses of the two objects to the distance between them and describes the resulting force acting between them.

$$F = \frac{Gm_1m_2}{D^2}$$ Equation 3-1

The overall form of this equation is similar to that governing the force due to electrical charge, which also obeys an inverse square law.

On the other hand there is inertial mass, which is described by Newton's second law: force equals mass times acceleration.

$$F = ma$$ Equation 3-2

Inertial mass is a measure of the resistance of an object to acceleration, so the larger the inertial mass, the greater the force that is required to accelerate it at any given rate.

In searching for a type of particle that could have negative gravitational mass, it is fairly obvious that antimatter is the most suitable candidate. It is argued here that antimatter has negative gravitational mass but that inertial mass is always positive. Inertial mass is a dynamic force and so it depends on their being some sort of motion involved. The fact that the object is accelerating must mean that, even if the object was not moving at one instant, then it will be some small interval later. Because the object is moving, it is subject to the effects of relativity. Normally these do not have any significant effect unless the velocity is close to that of light, but there is one important aspect of relativity, which is often overlooked, and which applies no matter what the velocity.

Recall that the factor Gamma is defined as

$$\gamma = \frac{c}{\sqrt{c^2 - v^2}}$$ Equation 3-3

The presence of the square root term in the equation means that Gamma can be taken to be either positive or negative. So we can argue while gravitational mass may take on values which are either positive or negative, inertial mass, which is the product of gravitational mass and Gamma, can be thought of as being always being positive.

In practical terms this means that all objects display inertia which acts as resistance to acceleration, irrespective of whether their gravitational mass is positive or negative. It means that Newton's second law should correctly be rewritten as:

$$F = |m|a$$ Equation 3-4

We know that for every particle there is an equivalent antiparticle whose properties are diametrically opposed to those of the particle, so where the particle has positive charge, its antiparticle equivalent has negative charge. The conventional wisdom holds that this does not apply to mass, which is taken to be the exception to this rule and so is always positive. No experiment has ever succeeded in weighing antimatter. Experiments which determine the mass of antimatter are all

geared to determining the inertial mass, which is always positive, and so it is simply assumed that gravitational mass is also positive.

It is argued here that antimatter is diametrically opposed to matter in respect of its gravitational mass as well as all of its other properties, that antimatter is truly a reflection of matter in all aspects and that mass is no exception. In other words that it has negative gravitational mass and that mass adds arithmetically in much the same way as electric charge.

Such antiparticles would then have some interesting properties; they would be gravitationally repulsive to conventional matter. An antiparticle released into space near a massive object would 'fall' upwards, away from it, rather than towards it. This in part would help explain why antimatter is relatively rare here on earth or indeed anywhere in our galaxy.

Antimatter is the mirror of matter. For each particle of matter there is an equivalent particle of antimatter. So for example the electron has an antimatter equivalent which is called the positron, the proton has an antiparticle equivalent called the antiproton and so on for each of the fundamental particles of nature. However the antiparticle of the photon is the photon.

It is the symmetry of the photon as both a particle and its own antiparticle, combined with the idea that mass is a bipolar additive quantum value and taken with its electrical neutrality which reinforces the idea that the photon is not just a simple particle, but a composite or compound particle. In this the photon can be thought of as being composed of a pair of objects, or possibly pairs of objects, a particle and its antiparticle equivalent, locked in mutual orbit and having zero aggregate charge and zero aggregate mass.

There are a number of reasons to suggest that the particles which go to make up the photon are an electron and a positron. First is that of particle pair formation. When a high energy photon passes in close proximity to an atomic nucleus it can sometimes be seen to disappear to be replaced by an electron and a positron. It would seem reasonable to suppose that the photon itself contains a positron and an electron and that this process is one of decomposition into its component parts. The association of Planck's constant with the photon as well as the electron on orbit around the hydrogen atom provides another clue.

The opposite effect is also observed; when a positron and an electron collide they are seen to disappear to be replaced by a photon in a process that is termed annihilation. As the positron approaches the electron the attractive electrical force increases as the distance gets less according to the inverse square law. However the two would not simply smash into one another, instead they would approach following a spiral path, creating what is sometimes described as "positronium", a supposedly short lived element which then decays to a photon. Here we examine what would happen if during that process the pair of particles was seen to enter a stable state where they are able to continue in mutual orbit. The system would have zero mass which in turn would mean that it would accelerate to a speed limited by the speed of light with no expenditure of energy. The system would present itself as having an oscillating electric field and an accompanying oscillating magnetic field. Being a physical entity it would be capable of traversing empty space without the need for a supporting ether or any of the other euphemisms for the ether that have emerged over recent years.

The Photon as a Binary System

Light presents itself as an electromagnetic wave having positive and negative excursions but overall is electrically neutral. A particulate photon must therefore contain both positive and negatively charged elements, however when positive and negative electrical charges are co-located the charges cancel one another out. The two areas representing positive and negative electric charge within the

photon must therefore be physically separated, in keeping with the idea that the photon is a composite binary system comprising particles which have symmetrically opposite characteristics. So we need to understand just how and why these particles can maintain their separation and also to understand that despite the fact that they are locked in mutual orbit, they do not emit synchrotron radiation, which would cause their orbits to decay.

Exactly the same considerations as apply to mass can be applied to electric charge. If gravitational mass is bipolar and can take on both positive and negative values then two such particles of opposite polarity would have gravitational mass which cancelled out. The compound particle formed by these two elements would have zero aggregate mass, it could be considered to be neutral with respect to mass in exactly the same way that they would be electrically neutral.

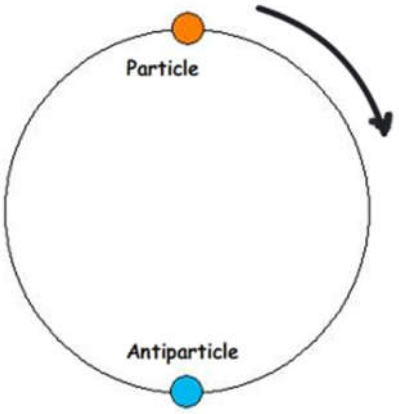

Figure 3-5 The Binary Photon

The model proposed for the photon is that of a binary system consisting of a pair of such particles, an electron and a positron. They are physically separate, but locked in mutual orbit. Where one has positive charge the other has negative charge and where one has positive mass the other has negative mass. The particles form a symmetrical pair with respect to one another and so overall the photon has zero aggregate charge and zero aggregate mass and the is by definition its own antiparticle.

Having zero aggregate mass means that the photon does not carry any direct kinetic energy. However since the two particles are physically separate they do carry energy associated with their orbital motion. We can think of this as a sort of miniature flywheel composed of two lobes which are diametrically opposed.

A binary system provides a simple physical model for polarization.

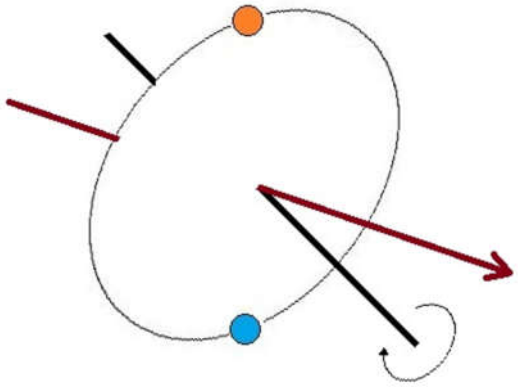

Figure 3-6 Polarization

The paths described by each of the two constituent particles as the photon travels through space are a combination of helix and cycloid; the exact form depending on the polarization. For circular polarized light the two paths will form a double helix. For plane polarized light the two particles follow paths which are overlapping cycloids, while for elliptically polarized light they follow overlapping compound helio-cycloids.

Arc Length

In all of these cases however the length of the path taken over a complete cycle or over a whole number of cycles, the arc length, is the same. Mathematically the simplest of these cases is that of the double helix, Figure 3-7. Considering just one of these particles and cutting the cylinder along which such a helix is inscribed and unrolling it, it is evident that the path length followed by each particle forms the hypotenuse of a right angled triangle, the other sides being the distance travelled over one cycle and the circumference as shown in Figure 3-8.

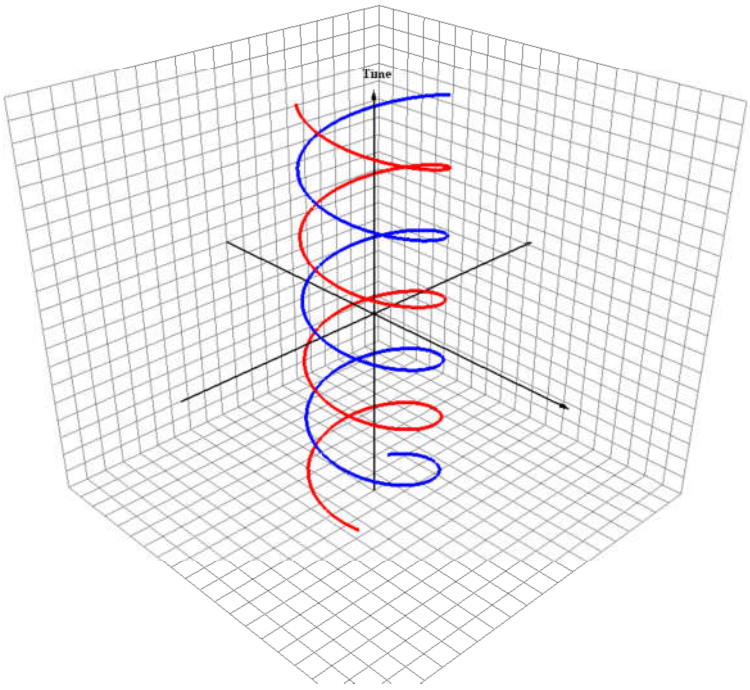

Figure 3-7 Trajectories of the Particles

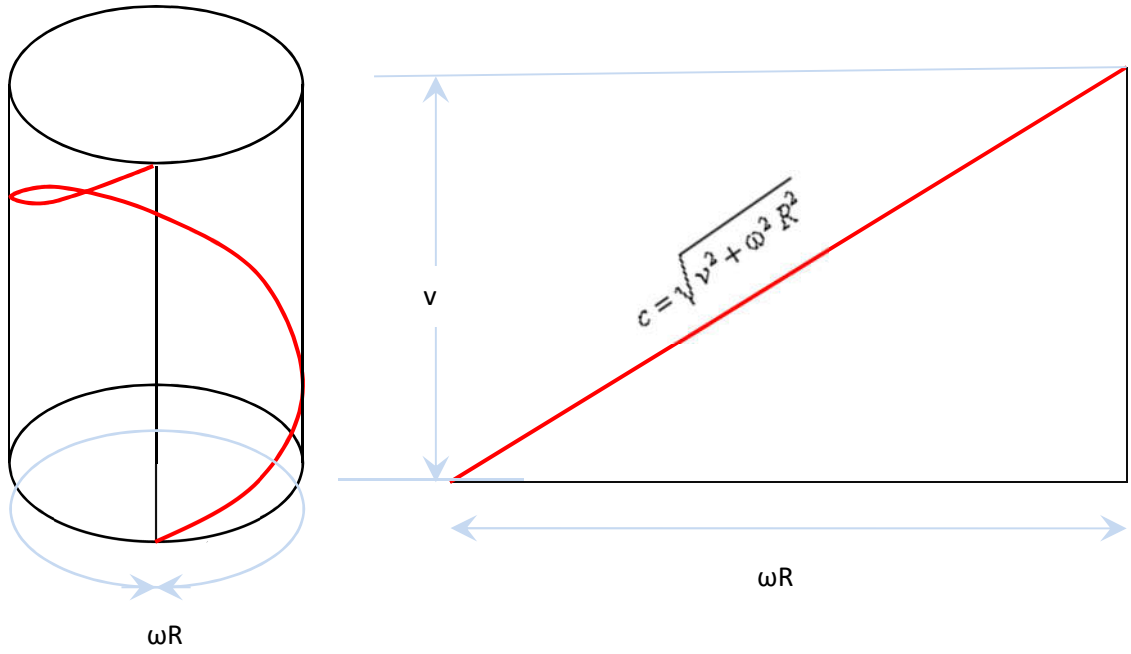

Figure 3-8 Velocity of Propagation of the Particles

Nothing can travel faster than light, however the two particles are travelling along their respective trajectories at very close to the speed of light and as a first approximation can be considered as travelling along their respective paths at the speed of light.

The progress made in the direction of travel, the propagation velocity, must then always be less than this and can be calculated using Pythagoras theorem as:

$$v = \sqrt{c^2 - \omega^2 r^2}$$ Equation 3-5

- Where *v* is the velocity of propagation, *ω* is the angular frequency and *r* is the radius of the photon.

From this it can be seen that *v* is always less than *c* and so it seems that not even light can travel at the 'speed of light'!

The term 'speed of light' is something of a misnomer. Here it is used to refer to *c* which is taken to be the limiting velocity beyond which nothing can travel. The term 'velocity of propagation' is used to describe the speed with which the photon propagates in its direction of travel and the term 'trajectory speed' is used to describe the speed of the constituent particles along their respective trajectories.

Relativity

Einstein showed in his Special Theory of Relativity that an object's mass varies with its speed in relation to an observer. When the observer and the object are both at rest in the same reference frame the object displays its so called Rest Mass. At any other speed with respect to the observer the object possesses a higher mass known as its Relativistic Mass. In this case the speed of the particles is close to that of light where relativistic effects are significant. Relativistic Mass is always higher than the Rest Mass and is calculated by multiplying the Rest Mass by the Lorentz factor γ (Gamma).

Gamma is related to the velocity of propagation, *v* and to the "speed of light", *c* and is given by the formula:

$$\gamma = \frac{c}{\sqrt{c^2 - v^2}}$$ Equation 3-6

The photon is moving at velocity *v*, close to the speed of light and therefore subject to the effects of relativity. For us stationary observers, observing the photon, the masses of the two particles which make up the photon are both increased by the factor Gamma.

Equation 3-5 and Equation 3-6 can be combined to eliminate the, as yet unknown, term for velocity, *v*. In the resulting Equation the two c^2 terms under the square root cancel one another out, leaving a simple value for Gamma:

$$\gamma = \frac{c}{\sqrt{c^2 - (c^2 - \omega^2 r^2)}}$$ Equation 3-7

$$\gamma = \pm\frac{c}{\omega r}$$ Equation 3-8

The photon is moving with respect to us stationary observers and so its mass appears to us to be increased by the factor Gamma and so the effective mass of each of the two particles is

$$m_1 = m_0\gamma = \pm\frac{m_0 c}{\omega r}$$ Equation 3-9

Where m_1 is the Relativistic Mass of the particle and m_0 is the Rest Mass of the particle.

Orbital Radius

Having calculated the effective or relativistic masses of the two particles, it is now. possible to calculate the energy of the photon. This takes the form of the rotational energy of the two particles about a common axis. The energy possessed by a point object rotating in a circular orbit at a fixed radius from an axis is given by the standard textbook formula:

$$e = \frac{1}{2} I\omega^2$$ Equation 3-10

Where *I* is the Moment of Inertia and *ω* is the angular velocity. The moment of inertia of such a mass *m* rotating about an axis at a radius *r* is given by the standard textbook formula:

$$I = mr^2$$ Equation 3-11

Because the photon is moving in a reference frame different to ours it is necessary to use the effective mass rather than the rest mass in order to calculate its energy.

$$I = \frac{2m_0 c}{r\omega} r^2$$ Equation 3-12

Which can be simplified to give:

$$I = \frac{2m_0cr}{\omega}$$ Equation 3-13

While the two particles each display inertial mass, the aggregate mass is zero and so the photon has no direct kinetic energy. And the energy can now be calculated from the combined moment of inertia of the two particles.

The total energy therefore is:

$$e = \frac{\frac{1}{2}2m_0cr}{\omega}\omega^2$$ Equation 3-14

After simplification this gives an equation for the energy of the photon as:

$$e = m_0rc\omega$$ Equation 3-15

Planck also developed a formula for the energy of the photon, which he expressed in terms of its angular frequency and a constant of proportionality. We can combine these two formulae for energy to eliminate the energy term and so calculate the orbital radius of the photon.

$$e = \hbar\omega$$ Equation 3-16

Equating these two formulas for the energy of the photon; it can be seen that:

$$\hbar = m_0rc$$ Equation 3-17

Rearranging this equation we get the radius at which the particles orbit:

$$R = \frac{\hbar}{m_oc}$$ Equation 3-18

Since $\hbar$, m_0 and *c* are all constant, it follows that *r,* the radius of the photon, is also constant. It also is evident that this must be true for all frequencies. In which case the equation can be rewritten using *R* to denote that the orbital radius is constant.

Using the known value for the rest mass of the electron substituting in Equation 3-18 for the radius of the photon it is possible to calculate the value for *R* as:

$R = 3.86159 * 10^{-13}$ **metres** Equation 3-19

This value is not unknown in physics where it is referred to as the Reduced Compton Wavelength.

Bandwidth and Maximum Energy

Having determined that the radius of the photon is constant for all frequencies it is possible to re-examine Equation 3-5 relating frequency to velocity and so determine the frequency characteristic of the photon.

$$v = \sqrt{c^2 - \omega^2R^2}$$ Equation 3-20

With *R* as a constant it is evident that there is an upper limit to the frequency of the photon which is reached when the frequency is such the term under the square root reaches zero. This condition occurs when $\omega R = c$ and so the upper limit for the frequency of the photon is

$$\omega_{max} = \frac{c}{R}$$ Equation 3-21

Using Planck's equation it is then possible to calculate the maximum energy of a photon.

$$e_{max} = \hbar\omega_{max} = \hbar\frac{c}{R} = m_0 c^2$$ Equation 3-22

Where m_0 is the rest mass of <u>one</u> of the two particles which make up the photon

At this maximum frequency it can be seen that the velocity of propagation is zero; that is the photon is stationary.

A photon which is stationary has energy of mc^2 which is exactly in line with Einstein's equation. That is each of the particles is travelling at a speed of c and there are two of them, so each individual particle has energy of $1/2mc^2$ for a total of mc^2. As the photon moves relative to us it has less energy, we can think of this as a red shift, to the point where if it is travelling at the speed of light it would have zero energy.

Substituting the value for the rest mass of the electron into the equation for the maximum energy of the photon shows e_{max} to be 511 KeV and the maximum frequency ω_{max} to be $7.7634*10^{20}$ **Radians/sec** or $1.2356*10^{20}$ **Hz**.

Plotting the velocity of propagation against frequency using a logarithmic frequency scale gives the characteristic shown in Figure 3-9.

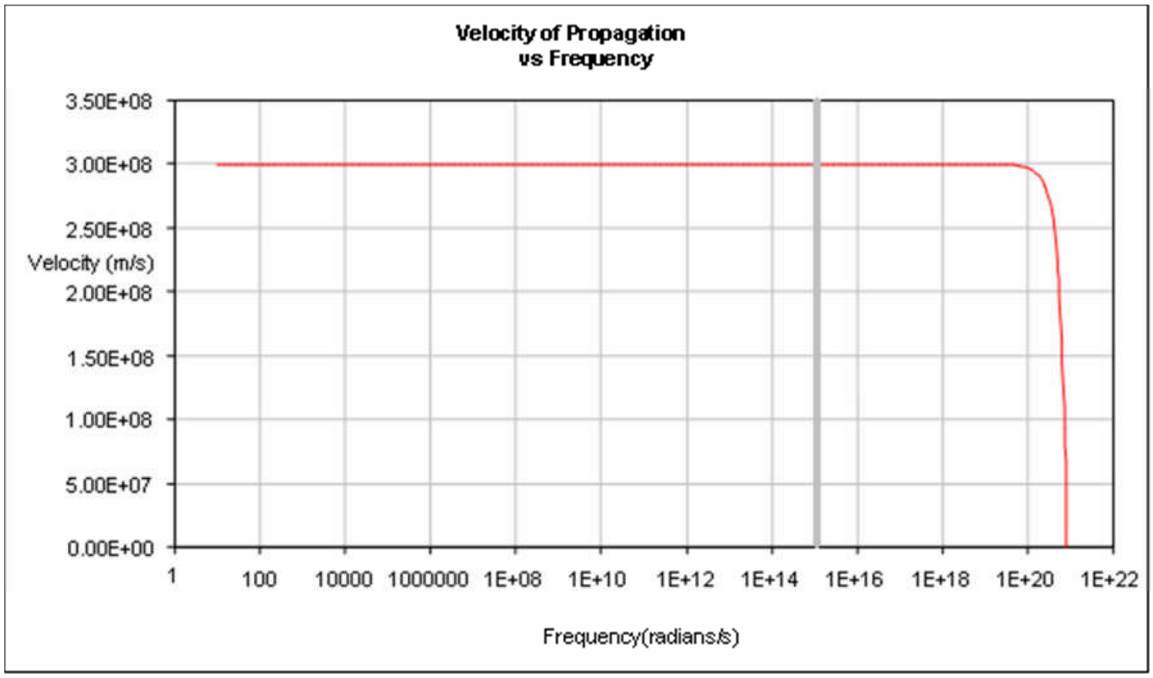

Figure 3-9 Velocity of Propagation vs Frequency

Overall, the characteristic is that of a low pass filter with velocity close to the speed of light over a range of frequencies extending from zero to approximately 10^{19} radians/sec, after which the velocity starts to fall off at an increasingly rapid rate to zero. It should be noted that 10^{19} radians/second is well into the gamma ray part of the spectrum.

Visible light occupies the frequency range from approximately $2.7*10^{15}$ to $4.7*10^{15}$ Hz and is indicated by the dark band in Figure 3-9. Over the visible spectrum the velocity of propagation lies within 10^{-9} % of that of the speed of the particles along their trajectories. The velocity of propagation remains within 1% of this speed until the frequency is beyond 10^{20} and then falls off rapidly to a maximum frequency at $7.7634*10^{20}$ **rads/sec**.

Time Dilation

According to Einstein's Special Theory of Relativity time is a function of speed. Objects that move fast experience time at a slower rate than other objects moving more slowly. Two clocks, one running on earth and the other running on a spaceship orbiting the earth at high speed, will show different times. The moving clock will run slower than the stationary clock - and it is not just the clock that runs slower, it is time itself, so an astronaut on the spaceship will be younger than his twin brother who stays behind on earth. The effect only becomes significant at speeds comparable to the speed of light.

From Equation 3-8 and Equation 3-21 we see that

$$\gamma = \frac{\omega_{max}}{\omega} \qquad \text{Equation 3-23}$$

Time in the domain of the photon is slowed down. The extent by which it is slowed is the factor Gamma. An external observer sees the photon travelling with velocity *v* and frequency ω. An observer travelling in the domain of the photon will see the same number of cycles but in a domain where time is slowed. Such an observer will therefore see the frequency of the photon as being higher by a factor Gamma. An observer in the domain of any photon will therefore see it as having a frequency of ω_{max}.

This answers an interesting question which was first posed by Einstein. Einstein once famously asked what it would be like to ride on a beam of light, here finally is the answer. To an observer riding on a beam of light, or at any rate travelling alongside and observing a photon, then no matter what the frequency or energy of the photon in some other domain, the observer will always see it as having the maximum possible frequency and energy in its own reference frame. This does not conflict with Einstein's idea that the speed of light is constant for any observer, since the speed of light refers to the universal speed limit and not the velocity of propagation of the photons. In that sense the photon is subject to the limitations of the "speed of light" and not the cause of it.

All photons thus look the same when viewed from within their own reference frame. At maximum energy a photon has zero velocity of propagation. By arranging to move at the same velocity as a photon, an observer is entering the domain of the photon and in so doing he is adjusting his own clock in such a way that the photon frequency appears to be ω_{max} and its energy appears to be e_{max}.

This also provides another insight into why the photon must have constant radius for all frequencies. To any observer travelling alongside the photon and experiencing time at the same rate as the photon, all photons look alike. They all have the same frequency ω_{max}. The same photon see by an observer in a different reference frame would have a different frequency and would of necessity be moving with respect to that reference frame. It would have to have the same orbital radius however, since the radius is measured at right angles to the direction of travel and is unaffected by relativity. In a sense all photons are identical, the difference between photons of different frequency and of different energy comes down to a question of the reference frame from which they are observed and how this reference frame relates to that of the photon itself. This is also consistent with the characteristic of Figure 3-9, which shows that a photon with zero velocity of propagation must have frequency $\omega_{max.}$

The idea that photons have a constant radius and are seen to have the same frequency within their own reference frame greatly simplifies the calculations involved in determining their dynamics. It simplifies the calculations concerning the forces that bind the constituent particles together, since it is now only necessary to consider the one domain of the photon itself.

Binding Force

Viewed from within its inertial frame, the photon appears as a positron/electron pair in mutual circular orbit. The axis around which these particles orbit is stationary, while the particles themselves are orbiting at a frequency of ω_{max} and at radius R.

From Equation 3-18 the orbital radius is given by

$$R = \frac{\hbar}{m_o c}$$ Equation 3-24

An observer located at the orbital axis would see the electron and the positron passing at a speed close to that of light where the effects of relativity would certainly be manifest. Such an observer would therefore see the mass term (m_0) increase due to relativity by a factor Gamma. Note that this is a different Gamma to that concerning the velocity of propagation. However the radius is constant normal to the direction of travel. It must have the same value for any observer including one located at the orbital axis. In order to maintain the balance of Equation 5-25 there must be a second Gamma term in the numerator.

$$R = \frac{\hbar}{(m_o \gamma)} \left(\frac{\gamma}{c}\right)$$ Equation 3-25

Since both R and $\hbar$ are constants, this additional Gamma term can only be associated with the velocity term c. This suggests that the orbital velocity should be considered as being affected by relativity. In effect this means that orbital velocity is taken to be the orbital circumference measured in the domain of the electron or positron and foreshortened by relativity, divided by the orbital period as measured by a stationary observer located on the orbital axis. I describe this type of velocity as “relativistic velocity” and postulate that relativistic velocity applies to orbital motion including angular momentum and centripetal and centrifugal forces. Relativistic velocity is the second of two postulates that form the basis of this work.

The forces acting between the two particles must be in balance for the photon to be stable. This means that the electrical force of attraction between the two particles must be equal to the centrifugal force tending to pull them apart. However it is argued here that the centrifugal force should be calculated based on the relativistic velocity and not the actual velocity of the respective particles. The electrical force is given by the inverse square law. Note that the distance between the particles is 2R and hence the factor 4 when this is squared. The centrifugal force is given by the standard textbook formula.

$$\frac{Kq^2}{4R^2} = \frac{(m_0 \gamma)}{R}\left(\frac{c^2}{\gamma^2}\right)$$ Equation 3-26

Where m_0 is the rest mass of the electron and v is the orbital velocity and is close to c where it is necessary to consider the effects of relativity and so substitute relativistic velocity into the standard formula.

This can be rearranged in terms of Gamma to give

$$\gamma = \frac{4Rm_0c^2}{Kq^2}$$ Equation 3-27

Equation 2-15 gives a formula for the Sommerfield Fine Structure Constant and we can substitute this into Equation 3-27 to give

$$\gamma = \frac{4}{\alpha}$$ Equation 3-28

From this it is possible to calculate the orbital speed of the electron/positron pair as 99.9998336% of the speed of light.

The structure of the photon

The model proposed for the photon is that of a simple binary system. It comprises a particle and an antiparticle pair locked in mutual orbit and is based on two simple postulates affecting the way in which the laws of physics work. Gravitational mass is postulated to be a bipolar additive quantum value capable of taking on values which are both positive, in the case of matter, and negative, in the case of antimatter. Certain velocity terms which are associated with orbital motion are postulated as being affected by relativity. In particular this applies to angular momentum and to centrifugal and centripetal acceleration and force.

The resulting model is mechanically simple. The energy of the photon, radiation energy, is stored and transmitted in mechanical form. Transformations between energy and matter as predicted by Einstein are seen as a simple mechanical process in which particles and antiparticles combine to create photons or in which photons decompose to create matter and antimatter.

The particles themselves are seen to be objectively real point particles in the classical sense. They are possessed of deterministic properties such as charge, mass, momentum, angular momentum etc. The wavelike nature of the photon is then fully explained by the orbital motion of these particles and hence the wave particle duality becomes redundant as an explanation for the physical nature of light.

Uncertainty is then seen to be a practical issue associated with measurement where the measurer and measurand are of comparable physical dimensions. It is not, as the current theory holds, an intrinsic property of the particle.

The model provides a simple explanation for a number of properties of light and other EM radiation, including polarization, particle paring and the transformation of matter to energy and vice versa.

The photon is seen to have a finite bandwidth beyond which it cannot exist.

[ii] Planck, M. (1901) *On the Law of Distribution of Energy in the Normal Spectrum* Annalen der Physik vol. 4, pp 553

[iii] Einstein, A (1905) *On a heuristic point of view concerning the production and transformation of light* Ann. Phys., Lpz **17** pp 132-148

Chapter 4 The Dual Nature of Reality

"I think that a particle must have a separate reality independent of the measurements. That is an electron has spin, location and so forth even when it is not being measured. I like to think that the moon is there even if I am not looking at it." - Albert Einstein

The leader of the team of doctors … held up one finger directly in front of Yossarian and demanded, 'How many fingers do you see?'
'Two,' said Yossarian.
'How many fingers do you see now?' asked the doctor, holding up two.
'Two,' said Yossarian.
'And how many now?' asked the doctor, holding up none.
'Two,' said Yossarian.
The doctor's face wreathed with a smile. 'By jove, he's right'. He declared jubilantly. 'He ***does*** *see everything twice.'* - Joseph Heller, Catch 22.

Planck's constant

Bohr's model for the atom was based on the idea that Planck's constant was the fundamental unit of angular momentum and that each energy level was associated with a integer multiple of this basic unit. That assumption was carried over into all subsequent models within quantum theory. The assumption has been seen to be false. Angular momentum is not quantized; instead we find that it is the Lorentz factor, Gamma, which is quantized. Here Planck's constant is still seen as the orbital angular momentum of the electron, but rather than being quantized, it is constrained by the dynamics of the atom to have a particular value for all energy states.

But why exactly is Planck's constant; constant at all? Why is the angular momentum forced to take in this particular value?

Planck's constant is a measure of the orbital angular momentum of the electron orbiting the hydrogen nucleus. It is the product of three variables, the mass of the electron, its tangential velocity and its orbital radius.

If angular momentum were quantized it would require a complex interplay between these three variables plus that of the energy level of the atom such that when the velocity changes so too does the orbital radius and vice versa. The velocity must somehow be cognizant of the change in the orbital radius in order to comply with the quantization requirement or the radius must cognizant of the change in the velocity. The problem with this is that there is no mechanism which could cause this to happen. There is no causal link between changes in orbital radius and orbital velocity. The only link is that they must do this to comply with the quantization requirement, which is rather like saying it is quantized because it is quantized.

The argument that the Bohr model is no longer relevant and has been superseded by a more advanced theory simply does not hold water. All of these subsequent models rely on the assumption that angular momentum is quantized and so the fact that it is discredited in the context of the Bohr model is sufficient to discredit it everywhere.

Now let's consider what happens when orbital velocity is seen as being affected by relativity. The answer is to be found in found in Equation 2-20 from Chapter 2 and is inextricably linked to question

as to why the electron orbiting the hydrogen atom does not emit synchrotron radiation. The equation is that for the orbital angular momentum as seen from the point of view of a stationary observer located at the atomic nucleus. For him the electron is moving at near light speed and so both its mass and its velocity are affected by relativity but in the opposite sense. The equation links Planck's constant to the orbital radius, the mass and the velocity of the orbiting electron, but it also includes the factor Gamma, only here it occurs twice, once in the numerator, where it acts to modify the rest mass of the moving electron in line with relativity, and once in the denominator where it acts to modify the orbital speed to create the Relativistic Velocity term.

$$\hbar = m\gamma\, R\frac{c}{\gamma}$$ Equation 4-1

A closer examination of the terms of the equation reveals that the rest mass of the electron is constant and the speed of light is constant. The orbital radius is measured at right angles to the direction of travel of the electron and is therefore unaffected by relativity and so remains constant. The result is that Planck's constant, which is a measure of the angular momentum of the electron, is invariant with respect to orbital velocity and so must be constant.

The mass term and the velocity term are both affected by relativity, but in the opposite sense to one another. The mass increases by the factor Gamma, while at the same time the velocity is reduced by the same factor Gamma. The result is that the angular momentum remains the same. The important point to note here is that there is no complex interaction between these two variables. Each one separately, independently and blindly obeys the laws of special relativity and the result combines to cancel out, leaving the angular momentum unchanged as the orbital velocity varies.

If we now view the angular momentum from within the reference frame of the electron, the electron is possessed of its rest mass and its orbital velocity is near light speed, which in this context is seen as being invariant with respect to relativity. The radius is the same as for the stationary observer and so the orbital angular momentum is given by the formula

$$\hbar = mRc$$ Equation 4-2

Hence there is a not only an invariance for Planck's constant within the domain of the stationary observer but also an invariance between the value for Planck's constant between this domain and that of the moving observer.

Strictly speaking then Planck's constant is not a constant at all, it is invariant with respect to velocity close to the speed of light and it is invariant between the reference frames of the stationary and moving observers.

All of three of the factors which make up angular momentum are continuous variables and so in general angular momentum is itself a continuous variable. However in the context of the atom it is coerced into taking on a particular discrete value by virtue of the effects of relativity.

As the orbital velocity increases, so does the value of Gamma. This causes the effective mass of the electron to increase, but at the same time the orbital path length, and therefore the Relativistic Velocity decreases in the same measure. We can think of this rather like a mathematical see-saw, as one goes up the other goes down, with Planck's constant at the fulcrum between these two. The two Gamma terms balance one another out but at the same time they force the angular momentum of the orbiting electron to maintain its constant value. One cannot alter without the other altering and the sensitivity to any such change increases with Gamma. The higher the value of Gamma, the more tightly the angular momentum is constrained to be a constant value. Since the rest mass and the speed of light are both constants, this means that the orbital radius is also constrained to have a fixed value. There is no force accelerating the electron towards the orbital nucleus in the conventional sense, instead we can think of it as the geometry of the space in which the electron

exists being curved, in much the same way that space-time is considered to be curved in General Relativity and it is this that accounts for the absence of synchrotron radiation from the orbiting electron.

As to angular momentum itself, it is not quantized but is continuous and, in general, is capable of taking on any value. However the effects of relativity combined with an orbital velocity near light speed constrain it to have a particular value in the context of the atom.

Planck's constant is inextricably linked to the orbiting electron. In particular it is linked to the mass of the electron which is a characteristic unique to this particle. Which begs the question as to why it should be associated with the photon? This provides further evidence, if it were needed, that the photon must contain an electron, since where else could it obtain angular momentum with such a tightly bound relationship?

Duality, Waves and Particles

Louis de Broglie published his PhD thesis in 1924 outlining his idea that particles could be regarded as waves. He identified the wave with Planck's constant divided by the linear momentum of the orbiting particle, effectively inventing a new type of wave, which led to the idea of the energy levels of the hydrogen atom being associated with a harmonic series. Bohr was quick to pick up on the idea and try to use it to explain away the quantum leap. De Broglie received the Nobel Prize for his work in 1929 but spent almost 40 years trying to justify his thesis. However the real contribution of Louis de Broglie was not his ideas about particles as waves. His real contribution was to recognize that there are two solutions to the dynamics of the atom.

In the base energy state these two solutions are identical. The wavelength of the orbiting electron is related directly to its angular momentum divided by its linear momentum and is equal to its orbital circumference, exactly the same as for any orbiting object on any scale. Things are somewhat different in the higher energy states. For example in the second energy state, the orbital circumference has increased by a factor four over that of the base energy state and so its wavelength when viewed as a particle has increased by factor four. However de Broglie asserts that there is a new type of wave whose wavelength is Planck's constant divided by the linear momentum while at the same time asserting that its angular momentum is an integer multiple of Planck's Constant. This new type of wave has a wavelength exactly half that of the orbiting particle. In the third energy state it is one third of the orbital circumference of the particle and so on forming the harmonic series. From this it can be seen that de Broglie's harmonic series is not so much an insight as a foregone conclusion.

The solution adopted by those pioneers was to argue that both forms existed at the same time in what has come to be known as the 'wave particle duality'. In this type of wave particle duality, the duality exists **between** the wavelike characteristics and the particle like characteristics of the entity and in effect they represent two different solutions. As a consequence the conventional relationships between the particle like properties and the wavelike properties break down and so the wavelength can no longer be said to be the orbital velocity divided by the orbital period. It is argued that what we describe as a discrete particle exists as both a wave and a particle at the same time and that the results obtained depend on what is being measured or tested and that both results are equally valid. It therefore becomes necessary to create a new set of physical laws which operate on this scale. And it is not just a new set of laws, but the very idea of what constitutes a material particle is called into question. It is said to exist in some sort of nebulous state as neither particle nor wave, but to exist as both at the same time. When it is observed, it undergoes some sort of metamorphosis, transforming into either a wave or a particle depending upon what the observer is looking for. The situation is further compounded by the fact that there is nothing to wave. The fastest moving part of the whole system is the orbiting particle, so quite what is waving

to form these higher harmonics remains a mystery. The ether does not exist, but has to be somehow reinvented in order to explain the wavelike behavior.

Special relativity is unique among physical phenomena in seemingly providing two answers to the same question, a sort of natural duality. So for example there are two distances between points in space, one measured by the stationary observer and one by the moving observer, equally there are two time intervals and, where cyclic behaviour is observed there are two frequencies and two wavelengths. Special relativity would therefore seem to be a natural place to start when looking for duality.

In any reference frame we can imagine a set of measurements such as distance, time, mass etc. which are those experienced by a stationary observer. For an object which is moving with respect to that reference frame those same measurements have different values which are related to the first through relativity. Distance is foreshortened, time is dilated and mass is increased. For objects which are moving relatively slowly these two sets of measurements are very similar, with minor exceptions such as the polarity of inertial mass. At higher speeds these two sets of measurements begin to diverge quite markedly. A particularly significant point of divergence occurs when the speed is such that the Lorentz factor, Gamma, has a value of 137.03 or a multiple thereof. This particular speed is associated with the stable orbits of electrons within the hydrogen atom and with the stability of the bipolar photon. For objects in orbit certain of these measurements take on multiple values all of which are valid at the same time and it is this that leads to the discrete energy levels that are found within the atom.

In all of this the wave characteristics of the electron derive directly from its orbital motion. The wave is an **attribute** of the particle, brought about by this motion rather than something which is inherent to the particle. Whether it is viewed from the perspective of the stationary observer or from that of the moving electron, the relationship is between the wavelength, frequency and velocity is consistent with classical theory. Wavelength is related to the orbital angular momentum divided by the linear angular momentum. For the stationary observer the orbital velocity is to all intents and purposes equal to the speed of light and the radius is $\hbar/mc$ and so its angular frequency is more or less constant at $mc^2/\hbar$. For the moving electron the orbital velocity is its Relativistic Velocity in the n^{th} stable state and the radius is the same as that of the stationary observer. The orbital frequency is $nmc^2/\hbar\alpha$ and thus forms a harmonic series.

It is more sensible therefore to speak of a wave/particle identity in which frequency, wavelength, amplitude and phase are all related within their respective domains with orbital radius, circumference and period in this conventional way. The duality exists between the two domains, hence there are two frequencies, one in the domain of the electron and one in the domain of the stationary observer and there are two orbital path lengths, one in the domain of the electron and one in the domain of the stationary observer. And, it is argued here, there are two velocities. It is better to describe this as a wave duality and a separate but related particle duality.

In the case of the photon there are two different wavelengths, one observed by the stationary observer and one by the moving photon. In the domain of the photon the orbiting electron and positron each follow a circular path and there is no translational motion. The wavelength is constant and equates to the orbital circumference. As we have seen the orbital speed is close to that of light. The relationship between these three properties is exactly that we would expect and is consistent with classical mechanics. That is to say velocity is the product of wavelength and frequency.

For an external stationary observer the propagation velocity of the photon varies from a maximum when it has low energy to a zero when it has maximum energy. Hence the wavelength of the photon varies; being long at low energies, at least in theory it could extend up to infinity, to zero at

maximum energy. Once again the classical laws relating to waves still apply; velocity is the product of wavelength and frequency.

The current received wisdom places no upper boundary on the energy of the photon. Given the above it is easy to see why. Strictly speaking it is not the upper frequency or energy that is boundless, it is the wavelength that is considered to have no lower limit, and from the point of view of a stationary observer the wavelength does indeed extend all the way down to zero.

The measurement of the energy possessed by a single photon is a practical impossibility. The uncertainty principle prevents us from doing so. Instead what can be measured is the wavelength of a beam of photons and it is from this that the energy of the individual photons is then calculated. Effectively this means we are measuring the average wavelength of an indeterminate number of photons and it is from this that we can calculate the energy of the individual photons within the beam. The only wavelength that can be measured in this way is that observed by a stationary observer and this does indeed extend all the way down to zero.

It is easy to see why the upper bound for the energy of the photon is so obscure. Conventionally the energy of the photons in such a beam is taken to be, Planck's constant multiplied by the speed of light and divided by the wavelength. This is based on the implicit assumption that the speed of the photon is equal to the speed of light. Here however the speed of the photon varies with frequency and is equal to zero when the wavelength is zero.

This then leads to a discrepancy between the value measured in this way and the actual value of the energy. The fact that this discrepancy only occurs at extremely high frequencies, well into the gamma ray part of the spectrum is perhaps also to be considered.

Maxwell's Equations

Maxwell's equations describe the photon as a pair of interlocking sine waves, one magnetic and one electrical and they sustain one another because of the properties of empty space. However to endow empty space with such properties is, in effect, to reinvent the ether. All of the evidence however points to the fact that the ether does not exist.

Here the photon is composed of two discrete particles in orbit around one another and moving through space. This means that the source of the electric fields moves through space with the photon. The motion of these two particles then creates the oscillating magnetic field. The paths of the two particles have the form of two interlocking cycloids. Cycloids are created when a generating circle moves through space, whereas a sinusoid is generated as a projection of a circular motion where the generating circle remains stationary in space. This is why Maxwell's equations imply the existence of the ether, the circular motion of an otherwise stationary medium which causes the wave to propagate.

For most of the easily explored part of the spectrum the wavelength of the electromagnetic wave is very long compared to the diameter of the generating circle. Under these conditions the cycloid is an extreme form of what is termed a "Curtate Cycloid". Such an extreme curtate cycloid is practically indistinguishable from a sinusoid generated using similar parameters. What this boils down to is that Maxwell's equations are a good approximation for frequencies where the wavelength is significantly greater than the orbital diameter of the photon but break down at higher frequencies.

The Fine Structure Constant

The Fine Structure Constant (Alpha) is a repeating theme throughout atomic and nuclear physics and yet it is until now one of the great unsolved mysteries of modern physics. Richard P Feynman, one of the gurus of quantum physics, said of the Fine Structure Constant:

"It has been a mystery ever since it was discovered more than fifty years ago, and all good theoretical physicists put this number up on their wall and worry about it. Immediately you would like to know where this number for a coupling comes from: is it related to pi or perhaps to the base of natural logarithms? Nobody knows. It's one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man. You might say the "hand of God" wrote that number, and "we don't know how He pushed his pencil." We know what kind of a dance to do experimentally to measure this number very accurately, but we don't know what kind of dance to do on the computer to make this number come out, without putting it in secretly!" [iv]

It is frequently described as *Coupling Constant*, an appropriate epithet in the light of what we have discussed, since it couples a measurement of distance in the domain of the moving electron with that of time measured in the domain of a stationary observer.

There is nothing mysterious or special about the fact that the Fine Structure Constant is a pure number, lacking units or dimensions. It simply means that it derives from the ratio of two values which have the same dimensions, in much the same way as π is dimensionless because it is the ratio of two lengths.

Bohr was able to solve his equations in order to match the energy levels of the Rydberg formula and as a consequence was able to derive an analytic formula for the Rydberg constant. When Sommerfeld linked the Bohr velocity to the speed of light he opened the door to allow the Fine Structure constant to be expressed in terms of other known physical values, but the reason why it should have that particular value remained a mystery.

The introduction of Relativistic Velocity solves the mystery and shows that it is indeed the ratio of two quantities. We can think of it as the ration of two lengths, although it is equally valid to describe it as a ratio of two times or even two masses. In terms of length, it is the ratio of the orbital circumference measured by a stationary observer to that measured by the moving electron in the hydrogen atom in the base energy state. It also occurs in each stable energy state as one of the multivalued orbital circumferences that occur due to the phenomenon of aliasing.

We can also think of Alpha as being the ratio of two times, the period of the orbit as seen by the stationary observer and the period as seen by the moving electron in the base energy state. Similarly we can view it as being two frequencies, the orbital frequency as seen by the stationary observer to that seen by the moving electron in the base energy state.

Alpha occurs again in the photon, only this time the ratio is equal to 4*Alpha, rather than simply Alpha. The 4 comes about because the while the orbital radius is the same for both the electron in the hydrogen atom and the electron and positron in the photon. They are diametrically opposed in the photon and hence the electrical force is less by a factor for due to the nature of the inverse square law.

Force

This idea of duality can be extended to encompass force.

Historically it is argued that there are four fundamental forces, the electro weak force, the strong nuclear force, electricity and gravity. There have been various attempts to unify these four forces

into a single force and there has been some success with the strong, weak and electric forces. Gravity on the other hand remains elusive.

As the orbital velocity increases the relativistic velocity gets less. Were it not for this the centrifugal force acting on the electron within the hydrogen atom would be too large to hold it in a stable orbit. It is the reduction in this force due to the effects of relativistic velocity that allows the electron to enter a stable orbital state around the atomic nucleus. Although it is not strictly the case, we can think of this as equivalent to a reduction in the centripetal force created by the electric field acting between the electron and the nucleus; a sort of weakened electric force that exists by virtue of relativity. Between this and the conventional electrostatic force there is a sort of dual relationship, similar to that between distance, time or frequency measurements. The force is reduced by the same factor Gamma and the atom is stable whenever Gamma is an integer multiplier of 1/Alpha. So it is this same mechanism of relativity that leads to an apparent weakening of the electric force.

This idea of a duality of force can be extended further to include gravity as well as the electrostatic force, only this time it serves to increase the force rather than reduce it. For atoms other than hydrogen the atomic nucleus contains more than one proton. Protons have a positive electric charge and positive charges repel one another. Being very small means that the forces, which are subject to the inverse square law are very large which begs the question as to what force can possibly overcome the repulsive forces created by these positive charges in order to bind the nuclear protons to one another.

Relativistic velocity acts in such a way that it serves to reduce centrifugal force acting on an orbiting body as the velocity gets close to that of light. There is no limit to the extent of this reduction and so at a high enough orbital velocity the force will be effectively reduced to zero. At the same time as the velocity increases ever closer to that of light the mass of an object increases for an observer located at the orbital centre. There comes a point where the gravitational attraction between the increased mass of the protons is sufficient to match the electrostatic repulsion caused by the charges on the protons. At this point the nucleus will be stable.

Hence the strong nuclear force can be thought of as a sort of dual for gravity brought about by the effects of relativity in much the same way as the weakened electric force was a dual for the electrostatic force. It can be said to exist by virtue of relativity.

This means that we can reduce the number of forces of nature from the currently conceived four forces to two fundamental forces; electricity and gravity, and two further virtual forces, one for electricity as a weakened electric force and one for gravity as a strengthened gravitational force.

This combination of attraction and repulsion of these two fundamental forces is the fully subscribed set of forces for two bipolar static forces. Any additional such forces would only ever add to or detract from these two forces.

Gravity		
+	+	Attractive
+	-	Repulsive
-	+	Repulsive
-	-	Attractive

Electrostatic force		
+	+	Repulsive
+	-	Attractive
-	+	Attractive
-	-	Repulsive

Table 4-1 Forces of attraction and repulsion

Quantum theory asserts that force is 'mediated' by particles, each force has an associated particle (except gravity), so the electromagnetic force is said to be mediated by the photon and the strong nuclear force is mediated by a type of Meson called the Gluon. It is never quite explained how this process takes place.

Clearly, if the photon is composed of an electron and a positron in mutual orbit, it is not possible for it to be involved in such a process. In any event, it has never been explained just how the photon can cause an attractive force when it carries momentum and is therefore only capable of pushing things away, as for example with the solar wind.

It is a similar story with the Gluon, which is after all a hypothetical entity. The attractive force between protons within the nucleus is a modified version of gravity caused by the effects of relativity and so the Gluon disappears from the lexicon of particles.

Energy

We are taught in school about the various different types of energy. There is kinetic energy, electrical energy, chemical energy, thermal energy and so on. Later on we may learn that there is energy associated with the atom, so called binding energy and similarly with the atomic nucleus. Some of these various different energy types have been unified, most notably with the kinetic theory of thermodynamics. Relativistic velocity and all that it implies allows us to complete this process and unify all types of energy to be kinetic in nature.

We have seen that the energy of a photon is carried as kinetic energy by the orbital rotation of its constituent particles acting as a flywheel. Given that the energy is mechanical in nature it follows that the conversion of energy into matter and matter into energy as represented by Einstein's famous equation is a mechanical process.

The strong nuclear force is seen as a mechanical force amplified on a nuclear scale by the effects of relativity and so the energy associated with this force is also kinetic. And the electroweak force is a modified version of the electrostatic force. As we list the other forms of energy that we encounter in nature these too are all seen to be kinetic, including heat and mechanical energy itself.

The Ether

Quantum theory is rather wedded to the idea of the ether, although the need for and belief in the ether dates back to antiquity. Over time there have been various attempts to eliminate it, but every time it has been reinvented, often with a different name, so Huygens and Descartes referred to it as

the Plenum, then it became the ether, more recently we have had the Fabric of Space time and Quantum Foam. Despite the name changes and some subtle changes in the way it is supposed to work these are all really just euphemisms for the ether.

Relativistic velocity and the associated model for the photon do away with the need for the ether completely. The photon, having material form and being composed of discrete particles which have a physical presence, can travel across empty space. It does not need a supporting medium. Its wavelike characteristics derive from the orbital motion of its constituent particles. It differs from Maxwell's model in that the locus of the charges follows a cycloid path rather than a circular one and it is this that causes the velocity of propagation to decrease with increasing frequency.

This means that an electric field can only exist in the presence of a charged particle and that empty space is just that, completely devoid of anything save the concept of mass length and time within a reference frame. Such a space has no properties. Properties such as permittivity, permeability and temperature which are traditionally associated with empty space exist only by virtue of the juxtaposition or motion of particles. All material substances and energy are composed of particles and combinations of particles of either matter or antimatter.

In a sense we can think of space as being defined by the inverse square law and relativity. The concept of space is linked to the idea of a reference frame, a set of co-ordinates which defines the space. In order to construct such a set of co-ordinates it is necessary to have a measure of distance, a unit of length. Ultimately the only way we can establish such a reference distance is by virtue of the forces acting between particles, and these are subject to the inverse square law. Even when we adopt the current strategy for establishing a standard length based on the wavelength of light emitted by a certain atomic transition we find that this too is intimately connected to the inverse square law. Einstein postulated that the laws of physics are the same in any reference frame and this is true for the inverse square law. Hence each reference frame has its own yardstick by which distance can be measured and that yardstick is the inverse square law.

Schrödinger's Wave Equation

Schrödinger based his wave equation on Louis de Broglie's idea of the particle existing as a wave. In this the wavelength is not the orbital circumference, but is instead an integer fraction of the orbital circumference. The equation and de Broglie's model are both based on the assumption that angular momentum us quantized in units of Planck's constant. The wave equation is readily derived by taking the canonical form of an undamped second order differential equation and coercing it to reflect this quantization. The result is an equation which contains an energy term which has to be expressed as containing both kinetic and potential energy. This latter potential energy is the same as is expressed by the change of radius in the quantum leap. In other words, Schrödinger's wave equation intrinsically assumes that there is a quantum leap.

With the introduction of Relativistic Velocity, the need for a quantum leap disappears. The electron is seen as a point particle having deterministic properties. In the resulting atom the electron always orbits at the same radius, equal in fact to the reduced Compton wavelength. There is no change in potential energy with change in energy level.

It is necessary therefore to draw up a new and different wave equation, similar to that of Schrödinger, whose solution is this type of wave. In fact there needs to be two such equations, one for the wave as experienced in each of the two reference frames.

The Mass of the Universe

The fact that antimatter has negative gravitational mass has important implications not only on the atomic scale, but also on a cosmic scale. Our knowledge of the universe is intimately associated with the photon. Almost everything we know about the universe is known because the information is carried to us by photons.

For each type of particle there is an alter ego, an antiparticle equivalent and the antiparticles are subject to exactly similar processes and forces as are particles. So for example a positron is capable of orbiting an anti-proton to form anti-hydrogen. And if it is true for hydrogen it is true for all of the other elements as well, so there must exist anti-helium, all the way up to anti-uranium. All of the chemical, atomic and nuclear processes that take place in matter have equivalents in anti-matter. However all of these elements and the corresponding compounds would have negative gravitational mass. The photon on the other hand is its own antiparticle.

It is therefore impossible to determine whether a photon arriving here on earth originated as a result of a process which took place in matter or the equivalent process taking place in antimatter. This means that we have no way of knowing whether a distant object is composed of matter or antimatter. Clearly all of the stars within an individual galaxy are composed of the same type of substance otherwise it would not have gravitational integrity. However there is no reason to conclude that other galaxies are made of the same stuff. It is equally likely to be predominantly antimatter or predominantly matter. This has important implications when we look at the origin, size and age of the universe. It means we have no way to determine the overall mass of the universe, this in turn means we cannot determine whether the universe is geometrically flat or geometrically curved. It means that all of the mathematics around dark matter and dark energy is subject to doubt and will require re-examination. And it means that we cannot readily determine the age of the universe.

Conservation

When matter is transformed into energy, it is the result of particles combining with antiparticles to produce massless photons. The individual particles are not destroyed, they do not evaporate, they continue to exist as part of a compound particle. Similarly when energy is transformed into matter it is the constituent particles of the photon which separate to continue their existence as discrete particles and antiparticles rather than as components of a photon. In other words particles are conserved throughout these transformation processes. This applies equally to both matter and antimatter and so we can extend our ideas about the laws of conservation to include a law of conservation of particles.

Particles can neither be created nor destroyed, they may combine with one another to form matter, antimatter and energy in such a way that the sum of the energy is equal to the sum of all the masses multiplied by the speed of light squared.

$$\sum e = \sum mc^2$$

Objective and Subjective Reality

During the 1930's and 1940's physics divided into two rival camps. On one side were the likes of Niels Bohr, Paul Dirac, Werner Heisenberg who supported the idea of subjective reality and the Copenhagen interpretation. On the other side were the likes of Albert Einstein, Louis de Broglie and Erwin Schrödinger who reasoned that reality had to be objective. In the intervening years physics

has drifted towards the point of view of Bohr and his cohort. The duality of dimensions which has its cause in relativity allows us to reconcile these two competing views.

If we measure the distance between any two objects in the universe while we are stationary then the result is the maximum possible distance between these objects. If we are travelling at any other speed in the direction of measurement then the result will be foreshortened due to relativity. An objective view of the universe is that we would obtain if we measured the entire universe from our stationary position.

The universe is objectively real, that is there is only one universe and all of the particles in the universe exist as point particles having deterministic characteristics such as position, velocity etc. Precisely how those particles are perceived by an observer depends on the reference frame of the observer. In this sense, Einstein is correct - the moon really is still there, even when he is not looking at it.

However at the same time the reality can be regarded as being subjectively real. If we take as an example a particle, say an electron, travelling from the earth to the moon at near light speed, say 99.5% of the speed of light, where Gamma has a value of roughly 10. To us, here on earth, the moon is some 400,000 km distant, to the electron it is just 40,000 km away from the earth. But it is not just the distance that is affected. Relativity affects all dimensions, so the electron, where time is slowed down by relativity, sees the earth turning on its axis in 2 hours and 24 minutes. As far as the electron is concerned, this alternative view extends, not just to the moon, but to the entire universe. From the electron's point of view the geometry of the universe is different to that seen by an earthbound observer.

The very shape of the universe depends on the reference frame of the observer and so to that extent it can be regarded as subjective and this extends down to the level of the individual particle. The moon and the earth can be thought of as part of a single reference frame. This is because the moon is not moving relative to the earth at anything approaching light speed and so Gamma in the moon earth system is unity to all intents and purposes. Ultimately however every single particle in the universe exists in its own reference frame and so experiences its own unique version of the universe.

We, earthbound observers, can only ever experience the universe from the perspective of our reference frame, that of the earth. The only way we can examine the universe from the perspective of a moving object is through our imagination and mathematics.

Multiverse

Multiverse theory asserts that there is more than one universe and that we are constrained to exist in just one of these many universes. In some versions of the theory universes are spawned at every interaction of every particle, leading to an unimaginable number of different universes coexisting at the same time. However the duality brought about by relativity provides us with an alternative and far more prosaic answer.

Suppose our electron travelling at 99.5% of the speed of light is in collision with another particle as it departs the earth for the moon. As a result of the collision it loses some of its energy and ends up travelling at 99% of the speed of light. Gamma no longer has a value of 10, now it has a value of roughly 7 and so in the instant of that collision, as far as the electron is concerned, the moon has jumped from being 40,000 km away to being 57,000 km away. Of course the moon hasn't moved, it is the distance scale of the electron that has changed. And not just the distance to the moon, every aspect of the universe according to the electron has changed in an instant. Its perception of the universe has been transformed in the instant of the collision to a 'new' universe.

The term Multiverse is something of a misnomer since in reality there is only one universe but every reference frame within that universe sees it from a different perspective. Perhaps the term *Virtual Multiverse* would be more appropriate, since all of the different perspectives exist by virtue of relativity. Every particle has a different perspective on the universe and that with every interaction that perspective changes. These changes are a consequence of the dual nature of reality and that dual nature is in turn the consequence of special relativity.

The Uncertainty Principle

When Heisenberg first discovered the uncertainty principle he proposed that the uncertainty derived from the fact that the object being measured was of the same order of magnitude to the tool used to measure it. In this case when one parameter is being measured, it necessarily alters other related parameters and so, for example, it is not possible to measure both position and velocity at the same time. This was and is a valid explanation of the phenomenon. It was only later that he changed his mind to argue that uncertainty was an inherent property of the particle or photon, in line with Bohr's idea of subjective reality. Such a change is not necessary. The explanation that uncertainty is caused by practical issues of measurement fits perfectly with observations and is consistent with an objectively real universe.

Uncertainty is unavoidable, especially here where the photon is seen as being composed of an electron and a positron. It is therefore very definitely of the same order of magnitude as an electron and so there is bound to be a trade off to the accuracy with which measurements can be made.

The fact that there is bound to be uncertainty with which we can measure on the scale of the atom, the electron and the photon, means that we are forced into using statistical methods and probabilities on this scale. Such techniques are the bedrock, not of quantum theory, but of quantum mechanics, much of which therefore remains valid.

Very little of quantum mechanics is reliant on quantum theory and the models it contains. For example if we look at Einstein's paper on the stimulated emission of radiation, which laid the groundwork for the maser, the laser, the led and a host of other devices, it owes nothing at all to quantum theory, but everything to the discoveries by Fraunhofer, Ângström and Kirchhoff and to the Rydberg formula.

Unification

The unification of observable phenomena into one overarching law is one of the primary goals of physics. In the 17th century Newton unified gravity with astronomy by formulating the inverse square law, while in the 19th century Maxwell unified electricity and magnetism into a single electro-magnetic force and Clausius together with Maxwell unified heat with mechanical energy with the kinetic theory of gases.

In the 20th century physicists have focused on efforts to unify the forces of nature into a single force. It is argued that there are four fundamental forces and the effort has been to try to find a way to combine all four into a single force. The introduction of the idea of relativistic velocity, a velocity term that is affected by special relativity, means that the four forces can be reduced to two fundamental forces and two forces that are these same two forces as they are affected by relativity. This effectively unifies the electrostatic force with the electroweak force and the strong nuclear force with gravity.

The model for the hydrogen atom in Chapter 2 describes the mechanism that causes the variable Gamma to be quantized, the underlying cause of which is relativity. As Gamma increases the centrifugal forces acting on the electron decrease and the electron enters a stable orbit. Further increases in the orbital velocity cause the electron to enter one of a number of stable states corresponding to multiple orbits with the same orbital period, leading to the idea of the stable energy states of the atom. Hence a simple modification of our understanding of how relativity affects orbital velocity means that classical mechanics can explain the energy states of the atom, effectively unifying quantum and classical theories.

In Chapter 3 the model for the photon leads to the idea that electro-magnetic radiation is mechanical in nature, which ultimately means that all types of energy are mechanical, effectively unifying energy. This too is based on the idea that relativity lies at the heart of the dynamics of the photon.

This duality affects every particle in the universe, leading to the idea that each particle's view of the universe depends on the circumstances of the particle, creating the illusion of subjective reality in an otherwise objectively real universe. This too is as a result of special relativity and effectively unifies subjective and objective reality into a single concept of reality.

Occam's razor

Occam's razor suggests that where there are two or more competing theories, then the one which makes the fewest assumptions is most probably correct. So it is worth comparing the assumptions made here with those of the current standard model.

Here there are just two assumptions. The first is that antimatter has negative gravitational mass. Nobody has ever successfully weighed antimatter, which means that the assumption is at least plausible. The second assumption is that certain velocity terms should be considered as being affected by relativity. Again the idea has never been tested and given that it provides a solution which is consistent with all of the other laws of physics as we understand them, then it is also at least plausible.

In the case of the current quantum theory the list of assumptions and implied assumptions is almost endless. The first and most obvious and fundamental assumption is that angular momentum is quantized. Not only does this violate the tenets of the scientific method, but it also leads directly to a number of absurdities or implied assumptions.

These include the quantum leap or whatever euphemism is used instead, wave particle duality, collapsing wave fronts, intrinsic uncertainty, action at a distance, the absence of synchrotron radiation without any reason, the presence of the ether, the absence of the ether, the simultaneous existence as both a particle and a wave, a wave with nothing to wave, collapsing wave-fronts: the list goes on. All of these supposed phenomena must exist if angular momentum is quantized and they all require that we abandon our understanding of how physical systems work at any other scale.

Hypothetical entities

The Copenhagen interpretation, which seeks to suggest that a particle exists in some sort of nether state as neither a particle nor a wave until it is measured at which time it "collapses" into one or the other according to what is being measured. Here however the particle exists as a real physical entity, it does not need to, nor does it collapse when observed. It exists objectively.

It is a similar story with Schrödinger's cat, which can finally be laid to rest and can be given a decent burial. Schrödinger devised his thought experiment as a criticism of the Copenhagen Interpretation.

The cat, you may recall, is sealed in a box with a device that may or may not kill it with a 50% probability and is said therefore to exist in a state of being both alive and dead and neither alive nor dead at the same time. When the box is finally opened, the history of the cat during this entire experiment suddenly, and as if by magic, comes into existence to reveal whether it died or not.

Relativistic velocity means that particles are objectively real. The cat is decidedly either alive or dead at every instant in time throughout the experiment, it is just that we cannot determine which, simply because the box is sealed. In the real world this means that the particle exists as a discrete material object and that it has deterministic velocity and position, but that we lack the tools to be able to measure both at the same time. In this sense the sealing of the box can be regarded as being analogous to the uncertainty principle.

The currently held view is that quantum theory is correct as far as it goes, but incomplete. As a result there have been various attempts to fill in the supposedly missing blanks. It is argued here that this is not the case and that quantum theory is fundamentally flawed and always has been and that the principle reason for this is that it relies on the invalid assumption that angular momentum is quantized. Over the years there have been various attempts to complete quantum theory. These have become ever more fanciful and far-fetched as time goes on. They include string theory, brane theory, multiverse theory, the anthropic universe, variations in the fundamental constants over time in particular the fine structure constant but also the gravitational constant. All of these and whole plethora of other such theories can be cast into the dustbin of history where they belong.

Conclusion

The assumption that angular momentum is quantized makes a complete mockery of the scientific method. It leads directly to the absurdity that is the quantum leap. The wave particle duality attempts to get around this, but in doing so it introduces a new type of wave, a hypothetical one based on Planck's constant rather than being based on total angular momentum as happens everywhere else. Such a wave has no physical significance, nothing to wave and no substance. Schrödinger developed an equation to describe such a wave and in doing so is forced to introduce a potential energy term, reflecting a change in orbital radius with change in energy level, effectively re-introducing the quantum leap via the back door but with a different name. Like a house built on sand, everything else in quantum theory stems from these suspect foundations. Later the Heisenberg uncertainty principle, which had a perfectly rational explanation as a problem of measurement, was hijacked by the advocates of quantum theory in an attempt to circumvent the quantum leap. But even with uncertainty de Broglie's standing waves are merely a euphemism for the quantum leap, a way of describing it without using the words 'quantum' or 'leap'.

There have been numerous attempts to validate the theory, in effect to bridge the gap between classical mechanics and quantum theory, so called 'unification'. They have all failed. Any attempt to validate quantum theory based on the theory itself is doomed to failure. Such self-referring proofs have no validity in logic. The only way to validate such a theory, or for that matter to devise a new one, is by starting on the classical side and proceeding from there.

If we try to do so simply by writing Newton's equations to describe the dynamics of the hydrogen atom, we obtain a single solution. Such an atom would have constant energy and would therefore be incapable of emitting or absorbing energy at different levels. There is clearly something wrong with Newtonian mechanics, some shortcoming or missing factor. This exactly what Niels Bohr attempted to suggest with his assumption that angular momentum is quantized, but that was an incorrect assumption, which means we must look elsewhere.

There is one obvious oversight in Newtonian mechanics, which was only discovered in 1905 and that is the effects of special relativity. Einstein showed that mass, length and time depend on the

reference frame within which they are measured and that when such reference frames are moving with respect to one another time runs at different rates, distances appear to be different and so does the mass of an object.

The Rydberg formula is an objective description of the behavior of the atom, telling us the energy levels of the absorbed or emitted electrons. If the quantum leap is a physical impossibility then it follows that the orbit of the electron cannot change with energy level. Restricting the Rydberg formula in this way reveals an atom in which the electron orbits at near light speed and the variable of quantization is Gamma, the Lorentz factor. The unit of quantization is then found to be the reciprocal of the Sommerfeld fine structure constant.

The atom can only achieve dynamic balance if the centrifugal force is moderated by relativity, which leads to the postulate that orbital velocity is also affected. If orbital velocity is assumed to be based on the distance traveled by the electron subject to, and foreshortened by, relativity, divided by the orbital period measured by a stationary observer then not only do the forces come into balance, but aliasing of the such a velocity term causes all of the various energy levels to be stable states of the atom. Such a hybrid velocity term addresses the issue as to why synchrotron radiation does not cause the electron orbit to decay. It also addresses issues such as zero point energy and the wave nature of the particle which derives directly from its orbital motion and finally solves the riddle of the fine structure constant.

Turning to the photon: photons are observed to decay into pairs of particles, an electron and a positron. Under different circumstances these particles in turn can combine to form a photon. It is reasoned here that the photon is therefore composed of such a pair of particles, locked in mutual orbit and travelling together like conjoined twins through empty space. There is no such process as annihilation, more one of combination, equally particle pairing is a process of decomposition into the photon's constituent particles. The dynamics of such a system are very similar to those of the hydrogen atom, both being examples of a so called two body problem. By applying the same assumption that orbital velocity is affected by relativity the dynamics of such a photon come into balance. The individual particles are travelling at near light speed along a cycloid path and the whole is propagating through space at somewhat less than the "speed of light". Hence the photon and its component parts are subject to the limits of the "speed of light" and not the cause of it.

The photon has zero aggregate mass because the positron is an antimatter particle and it is postulated here that antimatter has negative gravitational mass.

Taken together the models for the hydrogen atom and the photon described here do away completely with the need for the invention of the ether and all of the other fanciful notions that quantum theory implies, they address the issue as to how light can travel through otherwise empty space as well as settling the issue of the nature of reality.

The concept of duality is all pervasive. It affects everything from the scale of the universe right down to the scale of the atom, and most likely beyond. Its effects are most manifest on the scale of the atom where objects are moving relative to one another at close to the speed of light. It not only affects mass, distance and time but also frequency, wavelength, velocity and force. It is the mechanism which brings about stability within the atom and it confers the atom with its various stable energy states. It provides the mechanism that underpins the dynamics of the photon. The driving force behind this duality is relativity which provides us with its cause.

It is perhaps a fitting tribute to the genius of Albert Einstein that every single atom and every single photon in the universe depends for its existence on the effects of Einstein's Special Relativity.

Constants and formulae

Gravitational constant	G	6.6743×10^{-11}	$m^3\ kg^{-1}\ s^{-2}$
Electrical constant	K	$8.9875517923 \times 1^{09}$	$Kg\ m^3\ s^{-2}\ C^{-2}$
Charge on electron	q	$1.60217663 \times 10^{-19}$	C
Mass of Electron	m	$9.1093837015 \times 10^{-31}$	Kg
Mas of the proton	Mp	1.67262×10^{-27}	Kg
Planck's constant	h	$6.62607015 \times 10^{-34}$	J s
Planck's constant	ħ	$1.054571817... \times 10^{-34}$	J s
Planck's constant	h	4.14E-15	eV s
Planck's constant	ħ	$6.582119569... \times 10^{-16}$	eV s
Joules to eV	J-eV	$6.241\ 509\ 074... \times 10^{18}$	
Speed of light	c	299792458	m/s
Reduced Compton Wavelength	R	3.86159×10^{-13}	m
Fine Structure Constant	α	0.007297728	
	1/α	137.0289402	
Bohr velocity		2187803	m/s
Rydberg constant	R_H	10973731.568160	m^{-1}
Linear momentum	l	mv	$Kg\ m\ s^{-1}$
Angular momentum	L	mvr	$kg\ m^2\ s^{-1}$
Moment of inertia of body in orbit	I	mr^2	$kg\ m^2$
Kinetic energy	e	$\frac{1}{2}mv^2$	J
Kinetic energy	e	$\frac{1}{2}I\omega^2$	J
Electrostatic force	f	$\frac{Kq_1q_2}{d^2}$	N
Inertial force	f	ma	N
Lorentz factor	γ	$\frac{c^2}{\sqrt{c^2 - v^2}}$	
Reduced Compton Wavelength	R	$\frac{\hbar}{mc}$	m

Fine Structure Constant	α	$\frac{Kq^2}{\hbar c}$	
Planck's equation	e	$\hbar\omega$	J