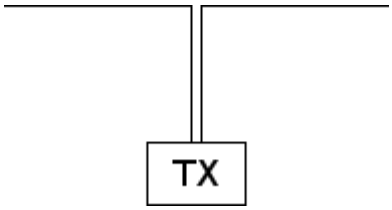
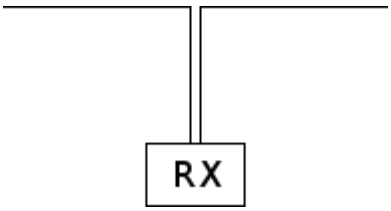
Nature of Light: What is a Photon?

We're told that the photon is a quantum of electromagnetic energy like a shrink-wrapped radio wave. But scientists can't observe a photon. They can only observe the consequential effects of its destruction. So how do they know it is electromagnetic? Maybe it is something else.

The Aerial and the Atom

The classical view of electromagnetic radiation is as follows: A dipole aerial, fed by a radio transmitter, emits radio waves. These travel away from the dipole at the speed of light. They form ever-expanding spheres of electromagnetic energy of alternating polarity. Unimpeded, they will travel outwards forever to the extremities of the universe.





Suppose these ever-expanding spheres hit another dipole of the same electrical dimensions. It is connected to a receiver tuned to the same frequency as the transmitter. It absorbs an exceedingly small fraction of the energy originally transmitted. Most of the energy bypasses the dipole and the waves continue their journey.

Suppose we have an atom that has been hit into an excited metastable energy state. This atom sooner or later falls back to a fully-stable lower-energy state. In doing so, it emits a *quantum* of electromagnetic energy called a photon. Unimpeded, this photon travels outwards forever to the extremities of the universe. But suppose that, on its travels, this photon encounters something of the same microscopic scale. We observe that such a thing generally absorbs either *all* the photon's energy or *none* of it. The photon either ceases to exist or continues onwards complete and intact.

Notwithstanding, it is possible for a photon effectively to give up only part of its energy. For example, it may hit an electron. In this case it will usually only give up part of its energy to the electron and then continue on its way in a somewhat different direction as a reddened photon. That is, a photon of lower frequency and hence lower energy.

By this reckoning, a photon contains a distinct quantum of energy. However, this quantum is not an integral number of any universal quantity. It is a quantity that varies continuously with its *frequency* - or perhaps more correctly, with the *rapidity* with which it attempts to switch the electric field polarity of the space through which it travels.

We are told that both radio waves and photons are the same kind of electromagnetic phenomena. The only difference between them is their frequencies (and hence wavelengths). With the capacity to deliver *all* of its energy to a single distant recipient, the photon behaves as if it were an intact particle rather than an ever-expanding spherical wave.

If television stations transmitted their signals the way atoms emit photons, then only one television receiver could receive any one "photon" of the transmission. So theoretically, each viewer would see only bits of the programme. However, a "television photon" would be an extremely small energy packet. Consequently the resulting graininess of the received signal would not be perceptible.

The Energy Quantum

Physicists say that a light wave sometimes appears to behave as a stream of particles because the energy of an electromagnetic wave is *quantized*. This energy can only be exchanged in multiples of a *minimum amount*. This amount, however, is variable. Its size depends on the *frequency* (and hence the wavelength) of the electromagnetic wave. For an electromagnetic wave of frequency *f* Hz (cycles per second), the minimum (indivisible) *quantum* of energy, $e = f \times 6{\cdot}626 \times 10^{-34}$ joules. It is an extremely small amount of energy. The constant, $6{\cdot}626 \times 10^{-34}$, is known as Plank's constant. It is supposedly the same for all electromagnetic waves all over the universe.

At the atomic level, the quantum of energy appears quite big. It is enough to excite an atom. A photon has one quantum of energy. The precise size of its quantum depends on the frequency (wavelength or colour) of the light of which it is 'made'. At the more familiar scale of radio dipoles, on the other hand, the quantum is extremely small. Furthermore, the energy in a *radio-frequency* photon is vastly smaller than that in a *light-frequency* photon. Consequently, a very large number of *radio photons* per second from the transmitting dipole will impact the receiving dipole, even at extreme distances.

Are Radio Waves Quantized?

This is assuming, however, that radio waves from an artificial transmitter are indeed quantized. But perhaps they are not. The question is, what, at the atomic scale, is actually doing the quantizing? Is quantizing imposed by a kind of fundamental lattice structure within space-time? Or is quantizing simply the result of the way the energy is produced by the atom or other mechanism that emits it?

The energy states of an atom are observed to be quantized. This is probably the result of the atom being a finite-state machine. It can adopt a finite number of stable and metastable energy states. Many scientists visualize each state as a different valid configuration of standing waves. If the atom jumps from one discrete configuration of standing waves to another, the energy difference is released as a travelling wave that carries away this energy difference. This travelling wave is the photon.

The *modus operandus* of our radio transmitter is not the same as that of an atom. Perhaps we could construct a radio transmitter to behave like an atom emitting a photon. Maybe we could get a klystron-like device to generate multiple standing waves in a cavity and then trigger it into falling to one less, releasing the excess energy through a waveguide. However, there seems to be no reason to suppose that radio signals are somehow naturally quantized in the photon sense.

What Does the Quantizing?

A valid inference is that the frequency of a photon is determined by the quantity of energy in it, and not the other way around. It appears that when the atom pushes out its quantum of energy, this energy is released as an electromagnetic pulse with a fairly complex (information-rich) profile. This pulse is frequently described as a *wave packet*. I have never been quite sure what is meant by this or whether researchers actually know the precise form of the pulse.

One view is of a pulse made up of several waves of a frequency determined by the formula (energy) $e = hf$ (frequency), where *h* is Plank's constant. The amplitudes of these waves start at zero at the leading edge of the pulse. From here they grow to a maximum in the middle. Then they diminish back to zero at the trailing edge. However, the phase of these waves changes continually so that the peaks appear to be travelling from one end of the pulse to the other. It is as if the whole pulse had been produced by something analogous to drawing a bow across a violin string. The energy is

released as a characteristic musical note whose frequency is proportional to the total energy expended in drawing the bow across the string.

Another possible view is that the photon is a *modulated* soliton or double soliton (a soliton who's electric and magnetic fields swing both positive and negative). The modulation makes the profile of the soliton more complex or information-rich.

But what actually causes the energy to be released as a packet? What mechanism is imposing Plank's formula? What is this thing that is analogous to the violin string? Is it some kind of quantizing lattice within the fabric of space-time? Or is the violin string part of the structure of the atom that emits the photon? If it is the former, then all electromagnetic waves will be quantized. If it is the latter then only electromagnetic energy emitted by atoms will be quantized into photons: radio and television signals will not be quantized. The fact that Plank's constant is the same no matter what kind of atom releases the photon leaves us only two options:

1. either the release of the energy quantum as a series of waves is a property of free space,

2. or that the quantizing mechanism is a common component of all atoms.

My intuition prefers the idea that it is the atom itself that releases its quantum of energy in accordance with Plank's formula and that quantization is not enforced by a fundamental characteristic of free space. In this case, free-space would be quite capable of conveying photons that did not conform to Plank's formula. Hence, free space is perfectly capable of conveying non-quantized radio transmissions.

This begs a few questions. Are *all* phenomena that manifest themselves to our experience as light *quantized?* Perhaps some light sources exist that do not package their light as photons. Perhaps they emit ever-expanding spheres of electromagnetic energy at *light frequency* in the same way that aerials emit radio waves. Has the Young's *double slit one-photon-at-a-time* experiment been attempted with a purely thermal light source? Light from a laser or a light-emitting diode is atomic. Light from the sun and stars is atomic. Does a strictly non-atomic source of light exist? Is such a thing possible?

What would happen if we were to push and pull a free electron back and forth by means of an electric field oscillating at *light frequency?* Would it produce photons? Or would it produce electromagnetic waves in the form of ever-expanding spheres? Is there something within the fabric of space-time that prevents continuous oscillation from being sustainable at light-frequency? Does space-time divide an electromagnetic oscillation into photonic packets like the blue shock diamonds seen at the exhaust nozzle of a rocket caused by the gas travelling faster than sound?

Point-to-Point Delivery

The prevailing view is that an atomic light source emits electromagnetic energy in quantized bursts called photons rather than as a continuous stream of waves like a radio or television transmitter. However, there is a further difference between the emission from a radio dipole and the emission from an atom.

Suppose a radio dipole were to emit a short burst of electromagnetic energy with the same wave-packet profile as a photon. It would travel outwards at the speed of light from the dipole as a short train of ever-expanding concentric spheres. It could be received by many different receivers located at different distances and directions from the transmitter. Suppose, on the other hand, an atom emits a photon. It appears to travel intact to a single destination, namely another atom. This it excites into

a higher energy state. This photon, therefore, is received *in its entirety* by only one receiver. This behaviour suggests that the photon be a particle - a confined non-diverging bubble of energy.

The *transmitting* atom and the *receiving* atom can be vast distances apart. For example, a photon emitted by an atom in the primordial outer reaches of the cosmos can be received by an atom within the retina of an astronomer's eye. It has taken billions of years and has travelled an unimaginable distance. During its journey it must have had at least some very close encounters with many other atoms or microscopic particles. Yet none of them became its receiver. Why? Its destiny was to be absorbed by one particular atom half a universe away.

One outlandish possibility could be that the atom that emits the photon and the atom that absorbs it are some kind of atomic soul-twins. They are linked by a strange mycelium that traverses the vast reaches of space-time that separates them. Alternatively, perhaps their link is through a short hidden dimension across which they are next door neighbours.

A more believable possibility is that the atom that absorbs the photon must be a similar or compatible type to the atom that emitted it. Furthermore, perhaps the *absorber* has to be in a similar or complementary *state* at the time the photon arrives as the *emitter* was when the photon left it. Maybe this *state* is very finely tuned and significantly complex. And perhaps this complexity acts as a key to the "door" through which the photon may enter. This suggests that the photon be not a simple particle but a microscopic subsystem carrying a very complex signature. This signature would obviously have to be imprinted upon it by its *emitter.*

So much for speculating why such distant atoms should exchange a single photon. But what determines the photon's trajectory through the vast expanses of space-time? What makes the photon end up at one single destination complete and intact? Obviously because it is a small self-contained particle that is shot out in a particular direction and follows a particular trajectory from its source to its sink. Of course, it may be deviated along the way by powerful gravitators like massive stars or black holes. This leads us to suppose that the photon's mass is centralized and is not spread all over a vast spherical wave-front, which would be the case if it were a wave. However, there exist experiments in which a photon appears to exhibit the behaviour of a wave.

Wave/Particle Paradox

Classic experiments like Young's slits and Newton's rings show that light beams can be made to interfere with each other. In so doing, they produce light and dark fringes where two waves respectively reinforce each other and cancel each other out. At college in 1964, I used a laser in conjunction with an interferometer to measure lengths very accurately. The interferometer relies on the principle of light behaving as a wave in order to perform its function. The geometry used to explain how the interference of two coherent light beams produces interference fringes is very simple and straight-forward. This is why it is so nice to think of the interference fringes as being produced by waves.

So then, if the photon be a wave, how does it manage to translate all its energy from one atom somewhere in the universe to another atom that could potentially be billions of light-years distant? As a wave, the photon would travel outbound from its emitting atom as a short train of concentric spherical shells of electromagnetic energy. These shells would expand such that they travel away from their source at the speed of light. The total energy of the photon would become spread ever more thinly over the ever-increasing area of the expanding sphere.

When the photon reaches its destination, it would have to deliver all its energy to a single atom. This energy would be spread over the vast surface of the short train of enormous concentric spherical shells that form its electromagnetic wave. These spherical shells of electromagnetic tension could, by

then, be billions of light-years in radius. The destination atom would absorb the photon. Thus, all the energy distributed over this astronomically large sphere would be instantaneously gathered into the space of a single atom. This does not seem plausible.

Galactic Soap Bubble

If this were so, the energy distributed throughout the sphere would have to travel billions of light years in an instant. It would be like the energy in the surface tension of a big soap bubble when it hits the point of a pin, except the "pin" would have to be at the diametrically opposite side of the sphere from the absorbing atom. This would mean that the energy flowed across the surface of the sphere at a speed gargantuanly faster than the speed of light. This, of course, is forbidden by The Theory of Relativity.

One attempt to overcome this anomaly is to postulate that somewhere, in a hidden dimension, all the points on this gargantuan sphere are at the same point, thus making fairly instantaneous communication possible under the constraints of Relativity Theory. It is as if, within this hidden dimension, the surface of the sphere undergoes a mathematical transformation to make it appear as a point. This is far-fetched since this hidden dimension would have to manifest an entirely separate transformation for every pair of atoms in the universe that ever exchanged a photon.

A Probability Wave?

Modern science has tried to circumvent the problem of this faster-than-light energy gathering. It has done so by postulating that the spherical shells are not composed of tangible force-fields. They are not travelling waves of electromagnetic energy. Instead, they exist as a packet of *probability waves*. These are waves whose amplitudes at different places at different times represent the *probabilities* of the photon being at those places at those times. When the photon is absorbed by an atom, its probability wave collapses instantly. The probability of the photon being at the recipient atom thus instantly becomes 1 (representing certainty). In consequence, at every other point on the spherical wave-front, the probability must become instantly zero.

These probability waves are postulated to obey the same rules as real waves. Thus they interfere with each other according to the geometry of constructive and destructive interference that produces the familiar light and dark fringes of the Young's slits and Newton's rings experiments.

This appears at first sight to explain the wave/particle paradox observed when the Young's slits experiment is performed with low-intensity light. Here, photons are shot at the slits one at a time so that they can be seen hitting the screen one at a time. Of course, one does not observe the actual photons hitting the screen. One sees merely the indirect amplified effect of the electron being liberated by each hit. The photons appear to hit the screen according to a very random distribution. Over time, however, we see that many thousands of hits collectively form the familiar light and dark fringes seen in the classical experiment.

But how can individual photons always end up falling into this ordered distribution? It is as if an approaching photon had prior knowledge of where its predecessors had already hit the screen. Then, armed with this knowledge, it controls its trajectory to hit the screen at the next appropriate place in the building up of the overall "interference" pattern.

Quantum mechanics attempts to explain this apparent "interference" pattern as interference between the probability waves of the participating photons. But the photons arrive a tangible fraction of a second apart in the Young's slits one-photon-at-a-time experiment. This means that one photon was emitted, travelled and became absorbed long before its successor existed. Presumably, therefore, the

probability wave aspect of the photon also was emitted, travelled and collapsed long before the probability wave of its successor existed. How, then, could they interfere with each other? Are we to suppose that the first probability wave left its mark upon the fabric of space-time, rather like the engines of an aircraft leave a condensation trail in the sky? No, because this would cause the photon to lose energy. This it clearly doesn't since all the photon's energy arrives at its destination.

There is a further problem. In order to produce the familiar interference pattern, the probability wave of a single photon must be a simple sine wave. The interference between two photon probability waves can therefore only produce the overall form of the fringe pattern. It cannot create the granular detail of where each individual photon must hit the screen to build up the interference pattern from thousands - if not millions - of separate hits. There simply is not enough *information* embedded within the postulated *probability wave* to tell the photon exactly where it is supposed to go in order to play its part in the formation of the overall "interference" pattern in the long-term.

Finally, there is a problem with the collapse of the probability wave at the instant its photon is absorbed. The size of the spherical shells of the probability wave at this point can be billions of light-years in radius. At the instant the photon is absorbed, the probability of the photon's presence at the point of absorption becomes 1. Consequently, it instantly becomes zero everywhere else. This fact has to be communicated instantly to all parts of the probability wave, which could be by then billions of light-years across.

The Theory of Relativity requires that nothing can be communicated faster than light. This restriction must therefore apply to all possible vehicles of information. The probability wave cannot therefore collapse faster than the speed of light. Thus it could require billions of years to collapse. Meanwhile, the probability wave would remain finite for a long time in far-flung parts of the universe. This would give many other atoms the opportunity to absorb the same photon, which is impossible.

Other Ideas That Don't Wash

Various other scenarios have been postulated to explain the apparent wave/particle duality of the photon as evinced by the one-photon-at-a-time version of the Young's slits experiment.

Absorption Wave Idea

One of these is that, while one atom emits a photon as an expanding spherical wave, its future recipient emits an equal and opposite *absorption wave*. This may be thought of as an energy invoice issued by the future recipient, which the emitting atom pays (at the same instant!) by issuing a cheque (the photon). As the photon sphere expands outwards, it encounters the absorption sphere from the recipient. The two spheres expand towards each other. Eventually they touch. Then they start to merge into each other sharing a common *circle of contact* at which the two advancing waves cancel each other out.

The problem with this is how the future recipient "knows" that a distant atom is about to emit a photon destined for it. Also, a photon is emitted suddenly and absorbed suddenly, whereas the two spheres could take billions of years to coalesce and cancel out. In any case, the absorption wave would have to travel backwards in time in order to end up at the time and place of the photon's emission. This may be mathematically representable but it is not conceptually plausible.

Pilot Wave Idea

Another postulation is that the recipient emits a pilot wave first in order to lay the track for the photon to travel back along. This is somewhat analogous to the way lightening strikes.

However, this pilot wave would also have to travel backwards through time. Furthermore, this postulation is stymied by the fact that it is *I* who decide where I am going to shine my torch: not the object I am going to shine it at.

Snake Skin Analogy

Then there is the *snake skin* postulation. According to the Theory of Relativity, time stands still when you are travelling at the speed of light. Therefore, from the point of view of a photon, the universe appears to be frozen at an instant in time. Consequently, from the point of view of the photon, its emission and absorption are coincident. They occur at exactly the same instant, even though they could be separated by billions of light years. One could thus argue that, from the point of view of the photon, it is simply an event that occurs instantaneously within what is apparently the same atom.

We can visualize the photon as a stationary phenomena frozen in time and space - a twist or kink in the fabric of space-time. This requires that we visualize the *emitting atom* as something that is moving through space-time. While so doing, it casts off the photon, like a snake casts its skin. The atom then moves on away from the photon at the speed of light, leaving it behind like a piece of dropped litter. The *absorbing atom* then heads towards the stationary photon at the speed of light, encounters it and absorbs it. The *absorbing atom* thus removes the kink in the fabric of space-time left there by the *emitting atom.*

Each of the two atoms is moving at the speed of light relative to the photon. However, the relative velocity between the two atoms themselves is obviously much less. For this to be so, the *emitting atom* must be spewing out space-time in all directions at the speed of light and the *absorbing atom* must be gobbling up space-time at the speed of light. The upshot is that all points in space-time must be both spewing out and gobbling up space-time in all directions at the speed of light. This is uncomfortably far-fetched.

Travelling Microbubble

There is a corollary to the idea of time standing still from the point of view of the photon. Suppose the photon emitted by the atom is an electromagnetic disturbance that expands spherically at the speed of light. Now suppose that somehow, at its instant of birth while it is still microscopically small, the whole of this expanding sphere is catapulted sideways at the speed of light. This is theoretically possible because it contains no so-called "rest mass".

Because the whole sphere is moving in a particular direction at the speed of light, time has stopped from its point of view. Consequently, it can no longer continue to expand. It remains the size it had at the instant it was catapulted sideways. And thus it continues on its vast journey to the other side of the universe. Here, while still microscopically small, it is absorbed by the atom in the astronomer's eye.

This is almost credible. But it may mean that the trailing hemisphere of the photon is travelling backwards in time. It is a *receding* wave-front.

The Observer's Handicap

We want to learn about the nature and structure of human beings. But the only way available to us to even detect the presence of a human being is to wait until one crosses the road and then run it down

with a truck. We then make deductions as to its nature by observing how it interacted with the truck. How much would this enable us to learn about the physical structure and functionality of the human life-form? How much would it enable us to deduce about human emotion, relationships, history, art, literature, music, family life, political intrigue, sports, leisures and all the other facets and nuances of human life?

The only way we have to observe a photon is to observe the effect of destroying it. If we try to observe a photon in transit, we must necessarily destroy it in the process and thus thwart our objective. We can, however, deduce indirectly that its trajectory appears to be bent by powerful gravity and statistically deviated by Young's slits. In the 'single-shot' Young's slits experiment, we know that a single photon leaves the light source as a natural quantum of light-energy. We know the effect when it hits the screen. But we know nothing about it while it is in transit. We can only initiate *the event* of its creation and observe *the event* of its destruction. We observe *events* not particles. We cannot observe particles.

Quantum mechanics assumes that the thing that is in transit is a photon, and that it is both a wave and a particle. To support this, scientists create weird scenarios. But why suppose that what travels is a wave/particle? All we can factually say about it is that it is a quantum of energy that is observed to behave in a certain way. This is fine because the essence of something really is simply its behaviour. The behaviour of the photon is what essentially defines it. Thinking of its behaviour as that of a particle or that of a wave are simply attempts by us to aid our perception of it in terms of familiar things we see and experience. They are not necessarily properties of the thing itself.

Enigma of Young's Slits

The behaviour of many photons passing through Young's slits is that of a wave that produces a banded interference pattern. *Interference* is merely how we perceptualize - in terms of something familiar to us - the way in which the pattern on the screen forms. On the other hand, individual photons - passing through Young's slits one at a time - exhibit the behaviour of single particles creating the same banded pattern statistically over time. An individual photon can hit any point within the area of the pattern. The consequence is that thousands of such photon impacts eventually form the banded pattern that is consistent with a wave. However, this clearly does not appear to be being formed by wave interference as manifested in a ripple tank.

Many attempts have been made to visualize the flight of the photon in terms of macroscopic wave dynamics and particle dynamics familiar to our human experience. Many of these attempts are quite far-fetched. One idea is that a single photon goes through both slits at the same time. There is another idea that the universe splits into two universes at that point and in one universe the photon goes through one slit and in the other universe it goes through the other slit. In some versions of the experiment, scientists have tried to detect which slit the photon goes through. But the act of detection destroys the photon, so it never reaches the screen. Even trying to detect secondary effects of molecules going through Young's slits modifies their status such that they fail to produce the normal interference pattern.

A further enigma is: why do Young's slits have to be close together to produce the familiar interference pattern? Why cannot you widen the slits and then move the screen proportionally further away to achieve the same result? If the pattern depends simply on path difference, why can't we make a cinema-sized version of the Young's slits experiment? Is the reason for large-scale versions not working something simple like the sonic, ultrasonic or thermal vibration of the sides of the slits? Or is it something more fundamental like the photon having a small but macroscopic aura that embraces both slits only when they are sufficiently close together? This could possibly allow the photon to interfere with itself on passing through one slit but only with the other slit present. This

would also allow us to visualise the photon still as a particle with a centralized mass whose trajectory gets bent when it passes close to a massive star.

But perhaps what we are seeing on the screen is not an interference pattern in the same sense that we see in a ripple tank and measure with radio aerials. Perhaps the photon contains something in addition to travelling electromagnetic energy. Perhaps it is a kind of vehicle for electromagnetic energy. How else could it transport a divergent phenomenon like electromagnetic radiation point-to-point? Where else can we see something that looks like an interference pattern but has nothing to do with waves? This is certainly *not* a rhetorical question but I do have a suggestion.

Problem With Probability

The amplitude of a photon's *probability wave* at any particular time and place is said to represent the *probability* of the photon being there. But *probability* is a subjective concept. It is a property of the observer's perception. It quantifies the limitations of his ability to sense a particular object or event. It is not a property of what he is observing. Probability is a concept that belongs to the logic of doubt and certainty. To say *subjectively* that you are 90% certain about something is a reasonable notion. On the other hand, to say *objectively* that a particle has a 90% *probability* of being in a given place at a given time is irrational. If the particle exists, it is where it is when it is.

In the single-shot Young's slits experiment, each photon is said to have a particular *probability* of hitting the screen in a certain place. It is said to be far more *likely* to hit the screen in the middle of a light band than in the middle of a dark band. It has *probabilities* of various intermediate values of hitting positions in between. These *probabilities* appear to vary across each bright band according to a *standard distribution*, which is represented graphically by the familiar bell-shaped curve.

There is overwhelming evidence that the universe, and all that is therein, is governed by *deterministic* laws. If this be true, the precise position at which each photon hits the screen is *determined* by law. Hence, the variation in the positions at which different photons hit the screen must be a result of variations in the initial conditions under which each respective photon was created and the various influences it encountered along its trajectory. Is it possible to generate mathematically an apparent *probability distribution* pattern, like the bell curve, *one dot at a time* like photons hitting the screen of the Young's slits experiment?

The Multi-Body Problem

Consider a single planet orbiting a star far away from all neighbouring stars and planets. The orbit of the planet will most likely be a fairly circular ellipse. If we take into account relativistic effects, the orbit will be an ellipse that precesses around the star, tracing out a kind of rosette shape. It is pretty well deterministic according principally to Newton's laws and, more rigorously, Einstein's augmentations.

Now consider a planet orbiting a binary pair of stars. If the planet is comparatively a long way from both stars, its orbit will not be too dissimilar from the single star situation above. However, if the planet is comparatively close to the two stars so that its orbit sometimes actually ventures between the two stars, its orbit will be very complex indeed. Consequently, it will be very hard to calculate. We have encountered what is called the *three body problem.*

Take the idea a stage further. Consider a star within a galaxy full of millions of other stars. What kind of orbit does it trace out as it orbits the centre of mass of the galaxy? Its orbit will be so complex that it would be impossible to calculate. Yet it forms as a result of the same laws that govern the orbit of the single planet round the single star. It is still deterministic.

Let us consider a plane containing the axis of the galaxy. Let us see where our star will "punch a hole" in this plane each time it orbits the centre of mass of the galaxy. We see quite a complex pattern building up. However, although very vague at first, this pattern does have bounds. The star can't punch a hole just anywhere. We get what looks like a *probability distribution* of where the star is more likely to "punch a hole" in our imaginary plane and where it is progressively less likely to "punch a hole". However, the pattern is produced by a mechanism governed by the *deterministic* laws discovered by Newton and Einstein. The *probability distribution* is simply how *complex determinism* appears to us.

If we make a mathematical transformation to "view" this orbital phenomenon from a simplified "angle" we get a picture of our punched plane that looks like this. Notice that the pattern builds up gradually from random dots that appear all over the place. All these dots, however, are always bound to fall only within the confines of this strange attractor, which gradually takes on better definition as more dots appear. It's very like the way the "interference" pattern builds up gradually from the hundreds of successive photon hits on the screen of the *one photon at a time* Young's slits experiment. Of course, the shape of the pattern is completely different. But the way in which it forms is very similar. Could the so-called interference fringes of the Young's slits experiment be, in reality, a *strange attractor* for photon trajectories?

Let us now make our "galactic plane" solid so that stars cannot pass through it. Then suppose that we cut out of it a pair of "Young's" slits. How will this change the shape of the attractor for thousands of stars orbiting within the galaxy? Suppose we cover up one of the slits. How again will this change the form of the attractor? Do we get any effect that is similar to when we cover up one of Young's slits? Is there some way we can build up a distribution pattern that looks like the "interference" pattern of Young's slits built *one point at a time* by iterating a simple non-linear difference equation from particular initial conditions? I do not know. I haven't tried. But it would be interesting if someone did.

A Chaotic Orbit

There is one idea that may be considered a bit outlandish. The *emitting atom* and the *absorbing atom* are mere portals in a plane through which the photon's orbit passes. The photon's orbit is in 4-dimesional space-time. The plane through which its orbit passes represents our 3-dimesional version of space-time. We can therefore sense the events of emission and absorption but not the rest of the orbit. When absorbed, the photon - or what ever it becomes - continues on its orbit in a hidden dimension. It then emerges again as a photon emitted from another atom. This photon then goes on to make another orbit.

Although outlandish, this idea could account for how one photon appears to be aware of where other photons have landed before it. How else could it "know" where to land in order to play its part in building up Young's fringe pattern? This may not be the correct picture of reality, but its *modus operandus* appears to work. Perhaps the truth involves some other way of physically configuring a chaotic (or complex dynamical) orbit for the photon.

A Chaotic Atom

Perhaps the chaotic orbit idea can be used to concoct an alternative view of the atom. Perhaps the atom is a *finite-state machine* whose various stable and metastable states are *complex dynamical* strange attractors. Each state is thus a mode of chaos.

The Earth's weather has a very complex dynamic. It is nevertheless a stable system. It follows the famous 3-dimensional butterfly attractor. Although it undergoes vast seasonal and ad hoc changes, it

always stays within the bounds set by this mathematical attractor. However, scientists say that the Earth's weather system could - with sufficient provocation - flip into a different stable state. This too would be complex and would follow a completely different graphical attractor. They call it the White Earth state. This is because in this state, the Earth would be covered totally with a light peppering of snow. Also, the air would be a lot thinner and storms would be more violent but highly localized.

The main - or ground - state of an atom could be a complex dynamical state like the Earth's atmosphere. The atom can, however, be flipped into a higher metastable energy state. This normally happens when it is hit by an electron or some other microscopic "particle". In this state, the dynamic of the atom would then follow a completely different strange attractor. It would be analogous to our planet's atmosphere when flipped into the White Earth state. So although the atom appears superficially to be a finite state machine, each of its finite states could be a hive of complex dynamical activity.

A stable state is one whose strange attractor is completely closed. Theoretically, the atom could remain forever in such a state. A metastable state, from which it can fall back to a stable state, has a strange attractor with exit routes that link back to the stable attractor. These would be like tributaries of a river that join the main flow. A metastable state can sustain its dynamic for an unpredictable length of time. Eventually, however, it must veer down an exit path that links back to the stable attractor. The fall from a metastable state to the stable state precipitates a release of energy. This, in the case we are considering, is manifested as a photon.

We can imagine these strange attractors as very complex orbital paths followed by planet-like electrons. For example, the hydrogen molecule would be a binary star system with two orbiting planets. In such a configuration, the orbits of the planets would be extremely complex. In a low energy state, perhaps the electrons would venture along paths that went on occasions between the two nuclei. In a high energy state, perhaps both electrons would stay well clear of both nuclei. On the other hand, we can imagine these strange attractors as the envelopes of waves that bear chaotic (very complex) modulations. We can imagine the waves as localized expansions, compressions, twists or kinks in the fabric of space-time. These could be formed of electromagnetic, gravitational and other fundamental force fields. But these imaginings are simply to help our perception. The *essence* of what we are looking at is simply its behaviour.

Perhaps somebody out there would like the challenge of creating a chaos-based mathematical model of a hydrogen molecule. A good initial project would be to create a projection of the real electron attractors on a plane through a central axis of the molecule. Intuitively, this should be possible using simple non-linear difference equations - somewhat like Hénon's strange attractor.

A Chaotic Photon

A photon travels from one point to another intact. It does not diverge spherically during its journey as does a radio wave. It does not become progressively weaker at points distant from its source according to the inverse square law as do radio waves. It begins its journey with a specific quantum of energy. And, unlike a radio wave, it delivers the full quid to its destination. Photons form alternating light and dark fringes in the Young's slits experiment. However each individual photon seems to "know" where it is supposed to land. It hits a spot such that, from its impact and those of its peers, the characteristic fringes gradually take form. Most photons, of course, hit the light areas of the pattern. But the dark fringes are not no-go areas. Fewer - but never *zero* - photons hit in the dark areas. There is no part of the fringe pattern that is completely "phased out" from photon impacts.

It is almost universally believed that a photon is a form of electromagnetic radiation like a radio wave. To suggest otherwise would perhaps be the most unforgivable heresy of modern science. The evidence given for this is that light travels at the same speed as radio waves. However, gravity waves also travel at the speed of light. Consequently, *ipso facto* gravity is an electromagnetic wave? I think not.

A photon also exhibits a behaviour that is analogous to the polarization of radio waves. But this does not mean to say that the apparent forces at play in the photon are electric and magnetic. The photon could exhibit apparent polarization if it were a travelling vortex that could have either a right-handed or left-handed twist. The vortex would not have to be formed necessarily from electromagnetic force fields. It could be formed of some other kind of force field, or a combination of different kinds.

Perhaps the so-called *speed of light* should not be thought of as proprietary to light. Nor to radio waves or even gravitational disturbances. Fundamentally, it is the maximum speed at which *knowledge* of an event at one point in *time and space* can be communicated to any other point in *time and space* - independently of whatever kind of vehicle conveys that knowledge. It is simply the maximum speed at which *information* can travel.

So perhaps the photon is not what it has been presumed to be. Perhaps it is something else - something whose form and nature fit comfortably with *all* of its observed modes of behaviour.

If the photon be a particle, it cannot be *only* electromagnetic, otherwise it would diverge. It would necessarily have to include some means of containing this energy spatially to prevent it from diverging. One reason it may not diverge could be that, travelling at the speed of light, time is frozen from its point of view. We mentioned this idea earlier. However, if this were so, radio waves would not diverge either. To remain stable and centralized, the photon must embody opposing forces with different degrees or forms of non-linearity. This is necessary in order to create a niche of equilibrium within which the photon's energy can remain captured.

If, on the other hand, the photon be a wave, it must travel within something that acts as a wave guide. How else could it deliver all its energy point to point? This does not seem plausible. There is, however, a plausible way energy could be transmitted point to point as a non-particle. It could travel in the form of some kind of travelling twist within the fabric of space-time.

An atom falls from a higher metastable configuration to a lower stable configuration. In so-doing it releases energy in the form of a torque. This torque is propagated at the speed of light along the *axis of torque*. When the advancing *torque wave* hits an atom lying along the *axis of torque*, that atom absorbs the *torque energy*. This drives the atom to a higher energy state or causes it to emit an electron - or whatever. Presumably the torque could be either right-handed or left-handed.

Such a *torque wave* would probably be much more complex than a simple twist. Perhaps we could think of it as a modulated twist. The way in which this twist would be modulated would, in effect, be a complex signature. This signature could be almost unique for each photon created. The precise form of a photon's signature would be a function of the precise state of its emitter at the time of its creation. It would be a function of the point reached on the *strange attractor* of the emitting atom's meta-state at the instant the atom fell to its main state. The signature would also be influenced by the particular point on its main *strange attractor* from which the atom re-entered its main state.

In flight - even if that flight takes billions of years - the photon seems to dissipate none of its energy. It uses none of its energy to maintain light-speed. Consequently, it must be in a state of free-fall. Does this mean that space itself is exploding at the speed of light? To remain stationary (relatively speaking) must concentrations of energy be held in some kind of force-field container?

The Gyroscopic Photon

Let us consider yet another outlandish option. The photon really comprises an electron-positron pair. Their masses have become completely hidden by the Jones-Laithwaite gyroscopic effect. They are held together by a force of attraction (or a localized warping of space-time, if you prefer). You may like to imagine the particles as solid spheres of fundamental material. Alternatively, you may prefer to think of them as the centres of oscillation of ellipsoidal wave structures. You may even like to imagine them as mathematical *strange attractors*. Essentially, they must have individual spin momenta perpendicular to their collective spin momentum. They must also be held together by what we can most easily visualize as mutual attraction. Their motions are not necessarily simple. They may have a simple rhythm, but this could be modulated with a chaotic melody.

Perhaps the photon is a structure analogous to a Jones-Laithwaite fly-wheel model. If so, it can transport all its energy from one point to another without divergence. It can contain mass which, along its axis of motion, appears to tend towards zero despite having rotating and revolving entities of finite mass inside it. This enables it - and perhaps even mandates - that it travel at the speed of light. Light slows down inside certain media like glass. Perhaps this is because force fields within the medium push the revolution of the "fly-wheels" slightly away from perpendicular to their axis of rotation. Such a photon would appear to be deflected by gravity more than would be expected from its kinetic mass alone. This is because its non-kinetic mass is hidden only in line with its direction of travel. The gravity, on the other hand, is "pulling" the photon in a direction that is not in line with its trajectory.

Admittedly, the vision of the photon as a pair of particle "fly-wheels" in some kind of frame is not very appealing. However, these so-called "fly-wheels" may in reality be spinning vortices of force that, among other things could:

1. expand and contract spherically according to a chaotically modulated oscillation,
2. expand and contract between circular and elongated ellipsoids while spinning,
3. buckle dynamically according to a chaotically modulated standing wave pattern,
4. comprise radially organized vortices like the petals of a flower.

Let us ease the strain on the imagination. Think of the two spinning entities as thin circular ellipsoidal skins. What the skins are made of is not the important thing here. Let us imagine that it has a material equivalence to the skin of a soap bubble. The skin is very thick at the periphery of each "fly-wheel" and very thin towards the centre. The "substance" of each is therefore concentrated at the rim. The fly-wheels are spinning rapidly with their axes of spin in line. They spin in opposite directions. They are held in position relative to each other by a balance or equilibrium between opposing types of non-linear forces (or warps in space-time). They are orbiting each other. Because they are axially aligned, their plane of revolution is perpendicular to their planes of rotation. Their shapes oscillate chaotically within constrained limits.

Imagine a point on the rim of one of the ellipsoidal fly-wheels. It will describe a very complex orbit that is constrained to lie upon a semi-torus. Give the pair of fly-wheels a small displacement oscillation so that they oscillate towards and away from each other slightly. A cross section through the attractor traced out by the particle on the rim of one of the fly-wheels will now take on an eventual form not too dissimilar from Hénon's strange attractor.

Back to Young's Slits

But what about Young's slits? Can a single photon built around this kind of model interfere with itself? To get interference fringes, there are conditions:

1. there must be more than one slit,
2. the slits need to be close together.

If photons behaved like waves, there should be interference no matter how far apart the slits were. If nowhere else, we should at least see an interference pattern on the screen in the vicinity mid-way between the slits. But this is not the case. So there is a limit to the separation between the slits if a single photon is to "interfere" with itself. If it is to "interfere" with itself, part of it must pass through both slits. So we are left with these options:

1. the photon is quite large, having a diameter greater than the separation of the slits,
2. the photon is small but has an *aura of influence* whose diameter is greater than the separation of the slits.

If the photon has a sphere of influence of this kind of macroscopic but still small size, it is not inconceivable that it could all collapse onto an intercepting atom in a very small time. Even if it were 10 cm diameter it would probably only take about a nanosecond to collapse. All its energy could thus be delivered to a single atom. The atom would then emit an electron. This in turn would be multiplied by our detector. We would then see the small flash of light at the appropriate place.

But why the phased pattern on the screen? How does each individual photon "know" where to go in order that, together with all its peers, it builds up this pattern of light and dark fringes?

Perhaps it is necessary for the *centre* of the photon to hit an atom in order to be absorbed by it. A photon, whose centre does not go through one slit or the other, is thus stopped before it gets to the screen. A photon whose centre passes through one slit or the other gets to the screen. However, perhaps the photon's surrounding aura is of such a nature that it passes through the material in which the slits are cut. It could, however, be warped, buckled or deformed by it in the process. Perhaps this is what causes the photon to deviate. If the photon's aura is composed of some form of chaotically modulated standing wave, the photon will be deflected chaotically, but *within an overall pattern* that is determined by the length of the fundamental standing wave.

But what gives an individual photon the correct *chaotic signature* to make it hit the screen at its appointed place so that, together with all its peers, it builds up the pattern of light and dark fringes? The form of this fringe pattern must somehow be a projection of some kind of *strange attractor* somewhere else. And it must be somewhere shared by all the photons hitting the screen and forming the fringe pattern. It must be a projection of a common characteristic of each photon's origin. The appropriate *chaotic signature* must have been bequeathed to each photon by the atom that emitted it. The fringe pattern must be a projection of a chaotic phenomenon within the emitting atom.

Let us think of the atom once again as a finite-state machine whose stable and meta-stable states are standing waves with chaotic overtones. The quasi-oscillatory motion of each state ostensibly follows a *strange attractor.* We think of this strange attractor as real. However, it may not exist as such in real-space: it may be something that exists solely in our mathematical *phase-space* that merely represents the behaviour of what is actually going on in the atom.

It is not difficult to imagine how a photon could be given a unique chaotic signature during its creation. To create the photon, the atom must fall from a higher-energy meta-stable state to a lower-energy stable state. There are bound to be an almost infinite number of chaotic nuances that an atom's meta-stable state could have at the instant it is triggered (by whatever) to collapse to the lower energy stable state. Likewise, there are bound to be an almost infinite number of chaotic nuances that an atom's stable state could have at the instant it arrives there. It all depends at what point on the higher meta-state's strange attractor the atom was at when the collapse was triggered, and at what point it entered the strange attractor of the lower stable state. The almost unique signature of the *orbit of collapse* is thus bequeathed to the photon that is created by this collapse.

This unique *chaotic signature* then determines how the photon deviates to one side or the other when it encounters the two slits.

We can speculate that the variance in the orbit of the strange attractor of the atom's states somehow exhibits the characteristic of a standard distribution. The fundamental frequency of the photon's standing wave structure will then somehow phase these chaotic standard distributions into discrete bands. Thus the fringes are a manifestation of the chaotically modulated standing wave characteristics of the emitting atom.

Caught Up a Blind Alley

Unfortunately, not a single one of these ideas on the nature of the photon seems wholly satisfactory. The *quantum mechanical* train of thought seems to have steered itself into a blind alley. This certainly appears to be the case with the nature of the photon and with the rest of the microscopic world. Science seems to have no conceptual understanding of what is happening at these microscopic scales. Notions like *closed circuit localized dimensions* and *superpositions of state* are but vain attempts to make conceptual sense out of the results of mathematical derivations. They are totally at variance with the common sense we acquire from our experience of the normal world. We are asked to have faith that the nonsense the mathematics is telling us is correct. We are expected to accept that our inability to conceptualize is a failing of the mind, not the mathematics.

I believe there are two kinds of mathematics. There is the *kind* that exists in its own right. It has an abstract existence. It works with tangible truths that are independent of physical manifestation. Perhaps the prime example of this is Number Theory (no pun intended). On the other hand, there is a *kind* of mathematics that is simply a form of shorthand. It is used to express rigorously the forms and behaviours of observed physical phenomena. It is formulated within a specific realm of observation. Within this realm it can be used to transform views of observed phenomena. This allows them to be seen from angles from which they cannot be directly observed. However, in order to delve into the unknown, scientists often extrapolate the use of this *kind* of mathematics. They apply it to other areas where they cannot be sure if its rules, operators and variables still represent reality.

Conceptual thought is built on the foundation of real experience. So when scientists extrapolate mathematically beyond what can be conceived by thought, they are on dangerous ground. Mathematics of this second *kind* - when it strays beyond the bounds of what can be understood conceptually - is essentially without foundation. This is what seems to have happened with Quantum Theory. It may therefore be wise to stop and think laterally for a new route along which to re-engage with conceptual thought.

This is not easy because there are at least two very strong forces that stifle the development of new thought. The *first* is excessive academic conservatism. The *second* is the official confiscation of any new development that is perceived to have national security implications for the country within which its originator resides.

Notwithstanding, I believe in a much simpler explanation for the behaviour of light.

PREV | © 11 April 2006 Robert John Morton | NEXT

© This content is free and may be reproduced unmodified in its entirety, including all headers and footers, or as “fair usage” quotations that are attributed as follows: “ - [article name] by Robert John Morton http://robmorton.20m.com/”