Nature of Light: Wave or Particle?

> *Current theory is a conceptual mess. It asks us to believe in structures and processes that do not make sense. This it does because the mathematics predicts what is observed. Perhaps the mathematics gives the right answers for the wrong reasons.*

The Current Mess

Maxwell's Equations use observed electrical and magnetic phenomena, and the natural constants derived from them, to express the dynamics of electromagnetic waves. Also, derived from these equations is the assertion that electromagnetic waves diverge away from their source at a constant velocity. The magnitude of this velocity is, by universal convention, represented by the letter **c**. Later experiments showed that light travels at the same speed as that predicted by Maxwell's equations for electromagnetic waves. This led people to suppose that light were therefore an electromagnetic wave. However, gravity waves also travel at the same speed; and they are not assumed to be electromagnetic. Experimental apparatus, like Young's Slits, demonstrate that light passes along its path from its source to its sink as would a wave. It produces wave-interference effects the same way that water waves do on a pond.

On the other hand, observations of the photoelectric effect led people to suppose that light also behaves as a particle. When a metal is irradiated by light, its atoms sporadically liberate electrons that can be detected electrically. It seems that each atom liberates an electron specifically in response to being "hit" by a light-particle. These light-particles are referred to as *photons*. However, an atom of a metal will only liberate an electron in response to being "hit" by a photon that is "made of" light of, or less than, a certain critical wavelength. The critical wavelength depends on the type of metal. The wavelength of the light of which the photon is "made" is thought to be inversely related to the energy carried by the photon. Furthermore, the Young's Slits experiment has been done with very low intensity sources of light in which individual photons appear to be hitting the screen one at a time. This lends weight to the "particle" view of light. But it is impossible to see how particles could, individually and in mutual isolation, fall collectively into an interference pattern.

Light is light. And it does what it does. If it does something that a wave cannot do, then it is not exactly a wave. If it does something particles cannot do, then it isn't exactly a particle. There is no plausible way that particles can travel independently and produce a collective effect like interference. There is no plausible way that a spherically-diverging wave can deliver a quantum of energy from point to point - from source to sink, especially when the distance between them could be billions of light-years.

To circumvent this paradox of light, science postulated that light is really made of particles (photons) but that these are somehow guided on their way by a virtual *probability wave*. This *probability wave* must behave just like a real light wave would if light were in fact a wave. This, however, presents another paradox. When the photon becomes absorbed by an atom, its probability wave has a spherical surface whose radius is equal to the distance the photon travelled from its source. This could be billions of light-years. And once the photon has been absorbed, the amplitude of the probability wave must everywhere else instantly collapse to zero. How can news of the photon's absorption by an atom be communicated instantly to every point on this potentially vast sphere? Bear in mind that information itself cannot propagate faster than light.

There is yet another problem with the idea of light being made of photon particles. Light has a property we refer to as a frequency, and, by consequence, a wavelength. These are properties of a wave. They are properties of *real* waves, giving rise to *real* effects like colour. Hence the photon must be a *real* wave-type entity: not just be "associated with" a virtual or conceptual *probability* wave. The essence of a photon must therefore be a wave.

But waves travel. And they do so by continually expanding spherically. They thus continually become larger and larger, spreading their essence (or energy) ever more thinly. In other words, they diverge. If the photon be a particle, how does it stop its wave-like essence from diverging? What contains it within the microscopic dimensions of a fundamental particle? The only kind of container conceivable in this situation would be something like a contour of equilibrium between opposing force fields. These fields would have to be of opposite senses and differing degrees of non-linearity. This would make the photon particle rather a complex structure. This structure would be essentially a self-contained object. It would have no inherent motivation to travel at a high constant universal velocity with respect to everything else the way a wave does.

In the previous article I reviewed lots of weird and wonderful concepts used by science to try to get around this wave/particle paradox. I speculated that the photon could be a travelling twist within the fabric of space-time. I conceptualized it as a galactic soap bubble, a snake's skin, a travelling microbubble. I considered it as being guided by a pilot wave that laid out its path first. I suggested it may comprise a primary energy wave and an absorption wave that travelled backwards in both space and time from its destination to meet it. I considered chaotic orbits in atoms and even concocted a system of gyroscopic particles that screwed their way through the fabric of space-time. I also considered other exotic ideas. But each of these ideas had serious flaws. Not a single one really hung together. In this area, science seems currently to be up a blind alley.

What We Can Observe

We need to look again at what we can observe. We need to separate this carefully from what we deduce or speculate about. Human observers are very handicapped when trying to observe the nature and behaviour of light. We cannot construct a mechanism to generate light waves directly the way we can with radio waves. We can only induce natural microscopic mechanisms like atoms to generate them for us. We cannot observe light being emitted from a source. We cannot observe light travelling like we can observe water waves on a pond. We cannot know directly what light is like as it travels through space.

We can only observe the secondary effect of its energy having been absorbed by an atom. We observe that an atom absorbs light energy in *quanta* and that the amount of energy in each of these *quanta* depends on the colour of the light. In other words, the size of each *quantum* or packet of energy absorbed by an atom in any single *absorption event* is proportional to the frequency of the light that delivered the energy to the atom.

By setting up radar-type experiments, we can deduce the time taken for light to make a round trip to a distant mirror and back, and hence calculate its speed.

What We May Deduce

From experiments like Young's Slits, we can deduce indirectly that, *while it was in transit* from a source to an observer, light appears to have behaved as a wave. Maxwell's equations describe a wave: not a particle. An atom appears to be elevated to a higher energy-state, or to liberate an electron, as a result of receiving energy from incident light. In such an event, the atom receives a prescribed quantity of energy from the incident light. The amount of energy received is the amount required by the atom to attain its higher energy-state or to liberate an electron. However, the atom can only receive the quantity of energy necessary to elevate it to its higher energy-state, or to liberate an electron, *if* the incident light is of a sufficiently high frequency (or is of a sufficiently short wavelength).

This does not necessarily mean that the light arrived as a packet of energy that was of the precise magnitude required to elevate the atom to its higher energy-state. It could be that the atom simply absorbs the precise quantity of energy it requires to elevate itself to its higher energy-state. Nor does this necessarily mean that when an atom falls from a higher to a lower energy-state that it emits a light-particle. It could be simply releasing a predetermined *quantum* of energy into its electromagnetic environment. This need not be in the form of a particle. It could simple be a *contribution* to the ambient electromagnetic flux, the size of which could be determined by mechanisms within the atom itself.

What We Must Consider

We know that light appears to behave as a wave while in transit but that atoms both absorb and release electromagnetic energy in discrete packets or *quanta*.

We must therefore consider what really causes the *quantizing* of the energy that is absorbed and released by an atom. Is it the fundamental fabric of space-time that constrains light (electromagnetic energy) into discrete *quanta* or packets during transit? Or is the apparent packaging caused by the way in which the atom itself does the absorbing and releasing of electromagnetic energy? Is the size of the *quantum* - and hence Plank's constant and the frequency of the radiation - solely to do with the structure and mechanics of the atom?

We must also consider another very important issue. We cannot view the passage of a single quantum of electromagnetic energy, released by an atom, from its source to its destination. Neither can we consider such a quantum in isolation. We can only observe the secondary cumulative effect of a *vast number* of sources and sinks collectively emitting and absorbing a *vast number* of such quanta of electromagnetic energy.

Rather than travelling separately and intactly as an independent photon-particle, each quantum of electromagnetic energy, emitted by each atom, could be simply like a drip of water added to an ocean. Once in the ocean, a drip loses its individuality. It becomes an indistinguishable part of the ocean. A quantum of electromagnetic energy, released by an atom, could therefore lose its individuality, becoming simply a miniscule contribution to the local electromagnetic field flux. Conversely, when an atom absorbs a quantum of electromagnetic energy, it could be simply taking, from the local electromagnetic flux, the amount of energy it needs to raise itself to a higher energy-state. It absorbs a drip from the electromagnetic ocean.

Some Theoretical Consequences

In a light-source of macroscopic size, a vast number of individual atoms will be contributing their quanta of electromagnetic energy to the general electromagnetic flux in their vicinities. In specially made coherent light-sources, such as lasers and light-emitting diodes, each atom is triggered to emit its contribution in phase with all the others. For most light-sources, however, each atom emits its quanta spontaneously in its own time. The phasing of its emission must be random. The resulting electromagnetic flux pattern created will therefore be very chaotic and complex. It will be a phase composite of all the emissions of all the atoms that make up the light-source.

In a high-temperature light-source, the atoms will also be in motion in all directions at significant fractions of the speed of light. Quanta emitted by atoms moving at different speeds will therefore suffer Doppler shifts of differing amounts. This should produce the effect of spreading the frequency (or colour) of the source in a standard distribution from a central colour. This, of course is a separate phenomenon from so-called "black body" radiation, whose central colour is related to temperature.

What We May Conclude

From our reasoning in this alternative view of light, we conclude the following. Electromagnetic energy travels between a source and a sink as a wave. Each individual emission event releases a quantum of electromagnetic energy. This quantum joins (becomes part of) the general complex dynamical electromagnetic wave system that pervades the universe. Individual sources move, thus causing a Doppler frequency spread from their characteristic central frequency. Electromagnetic energy distributes spherically as a complex dynamical wave system. Energy is absorbed from this general wave flux in discrete energy packets. The size and spectrum of each energy packet is determined by the nature and current dynamical state of its absorber (atom).

This comfortably resolves the paradox of Young's Slits. Light travels as a wave. It therefore creates the interference pattern according to the simple wave interference geometry as observed. But what about the ultra-low intensity version of the Young's Slits experiment where light appears to hit the screen one photon at a time? What we are observing are not necessarily particles of light hitting atoms. We can't see or detect particles of light in flight. What we are observing are individual *light-absorption events*. We are seeing events in which quanta of free energy become captured by atoms.

We may suppose that, in order to become elevated to a higher energy-state, an atom must be "hit by" a certain minimum amount of energy. Less than this threshold amount will not elevate the atom to its higher energy state. Exactly this threshold amount will precisely elevate the atom to its higher energy-state. More than this threshold amount will elevate the atom to its higher energy-state, with some energy to spare. This energy could be supplied by an electromagnetic wave. The wave must contain at least the threshold energy, within the atom's *catchment space*, in order to elevate the atom to its higher energy-state. The atom absorbs its required energy from the wave. The weakened wave then continues its journey with its amplitude diminished by the amount of energy absorbed by the atom.

However, for the wave to contain sufficient energy isn't all there is to it. If the energy is delivered to the atom at too slow a rate, the atom falls back to its lower state faster than energy can be supplied to elevate it. Rather like treading water too slowly to stay afloat. The wave must therefore also deliver energy to the atom at or above a certain minimum rate. To do this, the *rate of change of electromagnetic intensity*, presented by the wave as it passes the atom, must be above a certain minimum threshold also. This *rate of change of electromagnetic intensity* is what we, and our instruments, perceive variously as frequency, wavelength and colour.

There is a vast number of atoms in any light-source of macroscopic scale. Each of these atoms releases a quantum of energy sporadically into its electromagnetic locality. A vast number of microscopic contributions to the local electromagnetic flux are made sporadically at different times from different positions. The resulting topology of the electromagnetic flux is consequently very complex. If we consider just two of the spatial dimensions and use the third dimension to indicate intensity, the resulting graphical representation of the electromagnetic terrain would be very rugged. It would comprise graphical mountains and valleys of every size, depth, slope and gradient. And it would be random in texture, without regularity or repetitive pattern. This would all be racing outwards at the speed of light, with the mountains becoming progressively lower and the valleys progressively shallower the further they travelled from the source. At the atomic scale, the electromagnetic flux is thus very granular. This would mean that the chance of a sufficiently large peak hitting a distant atom would, at the atomic scale, be fairly random.

Furthermore, in order for an atom to be able to capture a quantum of light energy from an electromagnetic wave, that atom may have to be in an appropriately *receptive* state. In its ground level energy-state, an atom may not always be in a receptive state. Even while locked in its ground-level energy-state, an atom is a highly dynamic structure. It is in constant morphic motion. Perhaps this motion is complex - a metronomic fundamental modulated with chaotic overtones. And perhaps it is only receptive to incoming electromagnetic energy at one or more instants in its chaotic cycle.

Consequently, for an incident electromagnetic wave to be able to knock an atom so that it latches into a higher energy state, I suggest that at least the following conditions must be extant:

1. there must be sufficient electromagnetic energy density in the vicinity of the atom,
2. this energy density must be changing at a sufficiently fast rate,
3. the atom must be at a receptive point in its complex dynamical cycle.

At the atomic scale, the incident electromagnetic flux arriving at an atom is randomly granular. At the time a flux peak arrives, there is only a certain probability that the atom will be receptive to it. The combined effect of these two factors will make the *probability*, of the incident flux kicking the atom sufficiently for it to latch into a higher energy state, quite low.

This can explain how real waves can create random flashes in the low intensity version of the Young's Slits experiment. Two different probabilities are in play. The real electromagnetic waves interfere with each other at the slits the way waves do. But even very low intensity waves carry the random granularity of their myriad atomic sources at the scale of an atom's catchment space.

The probability, of sufficient flux hitting an atom that is receptive at the time, is random at the scale of an atom's catchment space. On the other hand, the probability of sufficient flux being present, at the relatively larger scale of the light waves themselves, is what we see as the interference pattern. This is why an absorption event happens mostly in a light band and much less frequently in a dark band of Young's interference pattern.

What We Could Do

The only practical place where we can investigate electromagnetic waves directly is at radio frequencies. There we can actually make an artificial generator that does the job that the atom does for light. From all observations, radio transmitters generate real waves. Aerials radiate waves: not particles. The particle theory of electromagnetic waves implies that we can't detect "radio photons" because they are far too "small". In other words, a "radio photon" contains only a miniscule fraction of the energy contained within a "light photon". But does this really make sense? What mechanism exists within a radio transmitter or its aerial that would chop and pack a radio signal into miniscule particles? Could a radio wave really be a flux of miniscule particles guided by a virtual probability wave? Does this probability wave - a virtual mathematical convenience - actually respond to the electrical length of a dipole antenna or the physical dimensions of a klystron cavity? This does not seem plausible.

It seems far more credible to me that a dipole antenna, driven by a radio transmitter, radiates electromagnetic waves. We use radio transmitters to convey information. We send radio and television entertainment programmes. We also use radio to send messages, data and navigational information. For these purposes, we generally send out a continuous wave that is modulated in some way with the information we wish to send.

But suppose, for the purpose of research, we were to build a radio transmitter that did not simply generate a continuous wave. Suppose we were to build a radio transmitter that behaves like an atom as it falls from a high meta-stable energy-state to a lower stable one. We could construct it to do this randomly or when some kind of trigger mechanism is operated manually. When triggered, it would emit a "quantum" of electromagnetic energy.

We could determine the size of the "quantum" and the profile of the electromagnetic waveform digitally within a computer program. The computer program would also determine randomly when the transmitter were to emit a "quantum" according to some form of chaotic cycle. This could then be made to drive a radio transmitter to create the "quantum" as a shaped burst of electromagnetic radiation at a suitable radio frequency.

If we use a suitable microwave frequency, we could even set up a pair of appropriately sized "Young's Slits" and experiment with interference patterns on a large scale. Then let us see if our single "quantum" produces the same random "impacts" observed by the so-called "one photon at a time" version of the Young's Slits experiment. Of course, the screen would have to be a vast battery of receiving aerials with receivers attached. These receivers must have a chaotic cycle that makes them receptive only at certain random times. This could be done by software in a computer connected to the receivers.

Perhaps this could open up a practical way of investigating other microscopic phenomena. If nothing else, it would enable us to establish at least one thing that the photon is not.

The Ætherial View

Notwithstanding, in my seven essays about The Universe [see side panel], I gradually built up an observer-centred view based on the notion that the universe is made of an all-pervading velocity fluid, which I refer to as the æther. I call it a velocity fluid because it can only exist while travelling at the speed of light. Furthermore, it only manifests itself to objects that are accelerating. It does not interact in any way with objects travelling at constant relative velocity. It flows convergently, at the speed of light, into nanoscopic sink-holes at the centres of all fundamental constituents of matter, including all observers.

In this view, which is expounded fully in my essay entitled Events and Waves, a light-source simply etches electromagnetic stresses into the observer's passing ætherial influx. A photon is thus simply an electromagnetic inscription which an atom [in falling from a high metastable energy state to a stable lower one] writes upon the passing æther. This passing æther continually flows radially inwards towards the observer at the speed of light, whether or not it be carrying any electromagnetic inscriptions [photons].

The atom's etching process could be directional. In other words, it may only etch upon æther flowing in a particular direction in the way a directional radio antenna beams radio waves. Because the etchings are electromagnetic stresses within the æther, they may tend to spread spherically. Countering this spreading, however, is the spherical convergence of the æther as it approaches the observer. This could explain how the energy [the photon] released by the atom is apparently transferred point-to-point.

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