The photon and its energy

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Abstract: The energy of the photon is described via the EM self-field model [Fleming 2003a]. The substructure of the ordinary photon has two sub-particles of equal mass and opposite charge. As in the application of the EM self-field theory to hydrogen atom, the photon has a total of five degrees of freedom, four associated with the electric and magnetic fields, and another associated with the ambient temperature. This mathematical model of the photon allows an extension of our understanding of the phenomenon of light. The rest-mass of the photon is considered non-zero. The eigenstates allow the photon's velocity to vary from the quantum proscription. Many physical phenomena can be understood in terms of the model including strings, Bose-Einstein condensation and the layers that form within the ionosphere. This report concentrates on the photon's application to 'hard' or 'ordinary' physics such as the layers that form within the ionosphere.

1. Introduction

The photon has been at the heart of physics since Newton first postulated his corpuscular theory of light in which light consisted of tiny particles. Around the same time, in 1679, Huygens presented his wave theory of light. Like water waves through the ether of water, light traveled as a wave. In 1905, Planck proposed his quantum theory of light whereby light takes the form of a discrete bundle known as a quantum or photon. According to the standard model of particle physics, photons are fundamental bosons (named after Bose) that mediate electromagnetic (EM) forces between other quantum particles in all matter. Thus the photon is currently considered a messenger particle for EM forces representing the fundamental quantum unit of EM energy. In essence, photons are discrete 'matter-waves', the smallest bundle of light or luminescent energy.

According to the EM self-field theory [Fleming 2003a], the photon can be investigated further. It may be considered a particle having two sub-particles of equal mass. These sub-particles both perform two orthogonal rotations, cyclotron and orbital rotations, providing a dynamic balance of the electromagnetic forces. Like atoms, photons are just one of a family of particles and systems, including galaxies and solar systems that have the capability to balance their internal or self motions. While the spinor relationships can be either circular or elliptical, other paths are possible where energies are changing during the motions. Unlike atoms, the mathematics of the photon is *not* quantum rather it is continuous although the photon itself is considered *the* quantum unit of EM energy. Its eigenstates are like atoms dependent upon the total energy of the photon, including the ambient temperature.

In this report we examine the characteristic energy of photons. In particular we look at how the photon's energy is distributed internally and how it can be modelled in a mathematically consistent manner using the EM self-field theory. These models have particularly simple geometric forms that lead to some interesting links to other areas of physics such as Bose-Einstein condensation and cosmology. In later papers we will look at some biological consequences of the photon and its structure, including the possibility of photonic compounds. These photonic compounds are analogous to atomic compounds often called elements. We will see also how energy within the weather cycle provides a link to biological physics. In this paper, the first in a series on the photon, we will stay firmly within the province of so-called ‘hard’ or ‘ordinary’ physics and leave all else, including the biology, for another day.

2. The mass of the photon

According to relativity, the total energy of a particle of mass ***m*** becomes large (resonant) as its velocity ***v*** becomes significant with respect to the speed of light ***c*** [Einstein 2000]:

$$E_{total} = mc^2 \Big/ \sqrt{1 - v^2/c^2} \qquad (1)$$

A series relationship, Eqn 2, may be derived by expanding Eqn 1 as a Taylor’s series where $v \ll c$. Eqn 2 can be expressed as the total energy of a particle moving much slower than light where the first term is its self-energy that is defined in terms of its rest-mass and the second term is its kinetic energy.

$$E_{total} = mc^2 + m\frac{v^2}{2} + \frac{3}{8}m\frac{v^4}{c^2} + \ldots\ldots \qquad (2)$$

$$E_0 = mc^2 \qquad (3)$$

$$E_{kinetic} = m\frac{v^2}{2} \qquad (4)$$

In terms of its rest-mass, the photon is often considered massless, so its velocity can be frequency dependent, thus enabling satisfaction of the Planck-Einstein relationship (compare Eqns 2 and 4)**.** A massless photon is also historically linked to vast quantities involved in the industrial and military usage of atomic energy. Physically however, there are problems with a massless photon. What happens as the velocity approaches the speed of light or at zero frequency? Many prefer to consider its rest-mass ‘negligible.’ While the photon’s rest-mass is insignificant compared to atomic energies, in some milieux it is the predominant source of energy. For instance, in certain important biological processes [Popp 1999]. This does not imply relativity is incorrect, rather our concept of mass-point needs rethinking.

According to quantum theory, the photon is treated as a probabilistic entity where we include some measure of uncertainty as to the photon’s actual position and velocity

[Heisenberg 1984]. In the EM self-field theory, the photon is modelled as a distributed mass-velocity system involving point-wise masses, provided they are not located at the origin of the reference frame. The ordinary definition of mass-point is thus enlarged to encompass self-sustaining systems that can have time and space averaged centers of mass at their origin, but at no time have an instantaneous mass-point at this origin. The photon has an internal energy due to its self-motions, and an external energy due to its external motions. Its total energy is analytic without a singularity due to the relativistic effects of the speed of light and, as we shall see, is capable of modelling light at zero frequency.

According to EM self-field theory the radiated photon has two energy components:

$$E^{ph}_{total} = h\nu \qquad (4)$$

$$E^{ph}_{total} = E^{ph}_{self} + E^{ph}_{kinetic} \qquad (5)$$

where $E^{ph}_{self} = m\frac{c^2}{2}$ (6)

and $E^{ph}_{kinetic} = m\frac{c^2}{2}$ (7)

where h is Planck's constant and ν is the frequency. In these equations the assumption is made that both the orbital and the cyclotron velocities are equal to the speed of light. In this form, the photon has a self-mass in keeping with Einstein's mass-energy relationship.

$$E^{ph}_{total} = mc^2 = h\nu \qquad (8)$$

These relationships, Eqns 4-8, only hold for certain photons that may be emitted as radiation from an atomic structure. Only those photons whose energy is mc^2 within the atomic structure will obey these equations. Other photons with higher energies (e.g. γ-rays) can be ejected from the nuclei of unstable elements. In these cases the energy associated with the cyclotron motion will differ from those above. In general EM fields of varying frequency will also differ from these balanced energies.

The EM self-field theory suggests that for a radiated photon moving at the speed of light─there are two internal sub-particles each half the total mass of the photon that move in two orthogonal directions (cyclotron and orbital motions). The two motions gain and lose energy independently of each other depending on the near and far-fields. On the other hand, for photons inside atomic configurations, both components of the photon's total energy are available to contribute towards the overall atomic mass balance and both gain or lose energy jointly if their energy is altered, for example, by addition of heat.

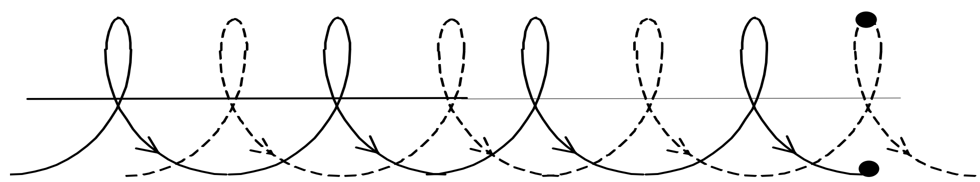

Figure 1. EM self-field model of radiated photon moving in a straight path along the axis of a special relativity frame of reference. In general frames of relativity, the path is curved, and this curved path obeys EM self-field theory for moving charged and dipolar particles [Fleming 2003b].

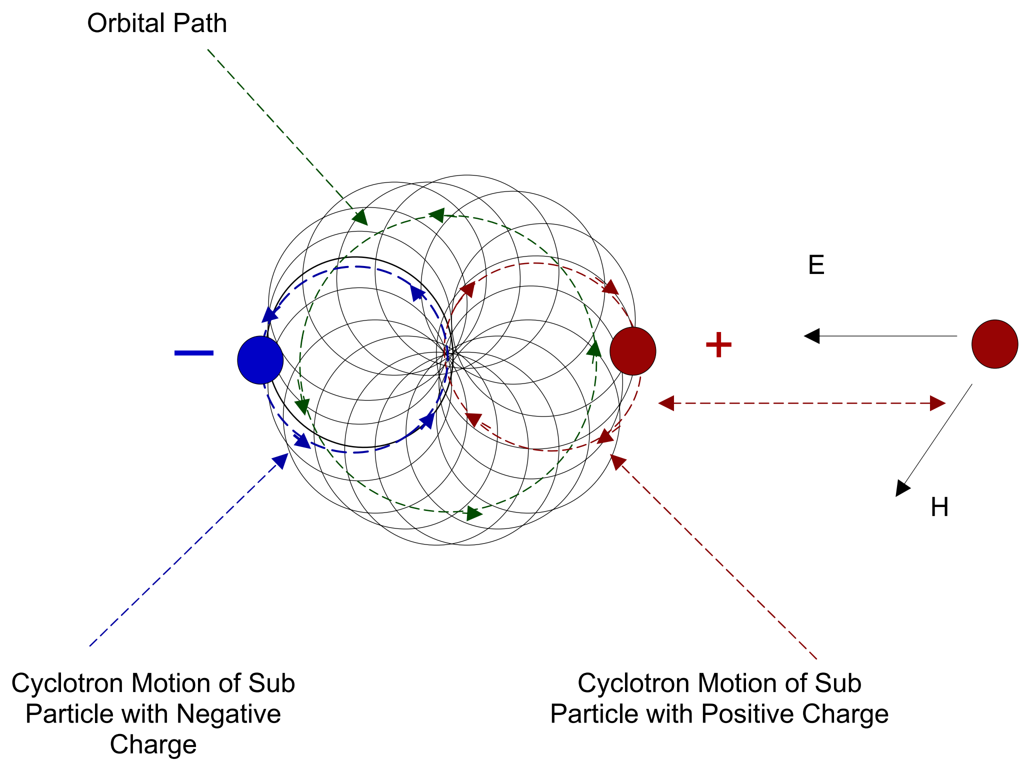

Figure 2. The EM self-field model of a stationary photon. There are two sub-particles, shown as red and blue, that move antisymmetrically wrt each other; the overall centre of motion remaining stationary. The diagram should actually show one cyclotron period per orbit. The picture illustrates the overall donut shape of the principle mode. Inside atomic structures, the photon in general transits between atomic sub-particles in which case it is not stationary. Note that as shown on the right, the E-field is oriented orthogonal to the orbital path and the H-field orthogonal to the cyclotron path.

3. The search for a lower limit to the mass of the photon

Searching for a lower limit of the rest-mass and hence the cut-off between classical and quantum electrodynamics involves the accuracy of Coulomb's electrostatic square law [Jackson 1998]. Avoiding any singularity due to a point-wise mass distribution, a 'Yukawa' form is assumed $(F_Y = 1/r^{2+\epsilon})$ where charge is spread out over the central region of the photon, or equivalently a Yukawa potential is assumed

$\phi_Y = {}^{1}\!/_{r^{1+j\mu}}$. Different experiments enable the limit to be tightened downwards. Due to earth's geomagnetic field, fluctuations in the torque of a Cavendish balance can be observed. The Jovian geomagnetic effect has also been similarly measured. In addition, magnetic fields have been found to permeate the cosmos. This universal magnetism may have arisen if photons possessed mass during the early moments of the 'big bang.' Schumann resonances occur at extremely low frequencies (8, 14, 20, 26, 32 Hz, etc.) and are the result of the earth-ionosphere region having a discrete geometry, a series of spherical layers, that form a large resonant cavity waveguide whose resonances are sensitive to variations in temperature. Using all these methods, the current best-estimate of the lower limit of the photon's rest-mass is $m_{ph} < 4 \times 10^{-51}\ kg$.

This link to a layered structure within the ionosphere leads also to a connection with the weather cycle that in turn leads to a connection with biological forms of physics that occur on surface interfaces between terrestrial regions. This interface biophysics depends upon the presence of water, heat and the changes in energy caused in part by the photon's eigenstates. We shall examine this further in a future report on the biology connected with the EM self-field theory and its application to the photon.

4. Photons across the frequency spectrum

Photons can be absorbed or radiated by charged or dipolar particles, in fact by any 'ponderous matter.' In the case of dipolar particles this is a differential form of the EM self-field theory that results in cyclotron 'spins' rather than cyclotron paths [Fleming 2003b]. The observed frequencies of photons vary from extremely low frequency, for example submarine communications, to extremely high frequency gamma rays capable of causing ionisations to occur. The range of frequencies spans many decades and includes optical and ionization frequencies. Higher frequencies have more energy and thus deliver more mass (Eqns 8). Photons are thus a mass transfer mechanism within atomic physics carrying mass to and fro due to their motions. The frequency, number, or density of photons exchanged is very high thus exerting enormous nuclear and gravitational forces.

In the terrestrial macroscopic world only electric fields result in a net transfer of photons; magnetic fields do no work as they are sensed generally as circular. However at the nanoscopic level, atoms, in fact all matter, possess EM self-fields with photons locked into the atomic structure that do no external work but possess internal energy. At the cosmological level, magnetic fields and electric fields are the mutual forces between gravitating bodies and hence are both streams of photons.

Having a dual nature, photons move as particles and act as waves. Photons have a characteristic frequency that defines their wavelength. The wavelength is measured as a distance along a line through the center of its helical motion. Side views of the helix are observed as the sine waves we know as electric and magnetic fields. (Compare Figs 3a and 3b) Photons of low frequency, such as radio waves, are described in wavelength units in meters; high-frequency photons such as gamma particles are described in terms of particle mass energy units of electron volts *(eV)*. Thus, low frequency photons behave more like waves, while high frequency photons act more like particles.

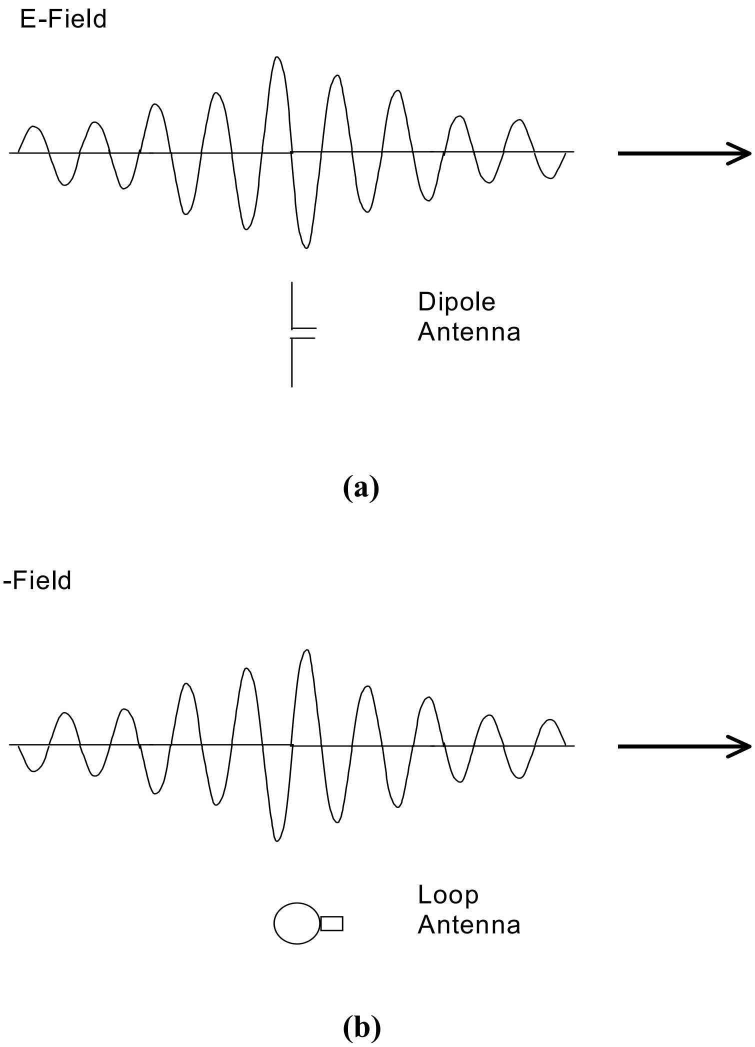

Figure 3. Electromagnetic field, the wave packet, of a single radiating photon as shown in Figure 2. The E-field shown in (a) is shifted in phase by 90º from the H-field shown in (b).

Optical photons have wavelengths within the optical or visible spectrum range of 400-800 nanometers and are sensed by our retinas as light. Optical photons are produced and delivered to the earth by visible objects including stars and super novae, the sun, the moon and the planets. On earth, the star that is the most abundant provider of photonic energy or radiation is the sun. All matter in our universe is in dynamic equilibrium with all other matter, including possible other universes [Rees 2002]. The streams of optical photons that crisscross through the cosmos are intimately involved in this EM balance and are partially responsible for the overall cosmological balance of the universe. So-called empty space is relatively teeming with photonic streams. Not only are there no preferred reference frames, there are no inertial frames whatsoever; all matter including the ubiquitous photons are in perpetual dynamic motion. The photon field of the cosmos moves and changes across the night sky. What is not yet understood is whether so-called 'dark-matter,' including non-optical photons, accounts for the observed cosmological balance. Does the total mass/energy of all photons transiting free-space explain the imbalance? We need to consider self and mutual photonic fields both inside and external to our universe.

What happens at zero-frequency? Zero-frequency in the electrical power industry is a macroscopic concept. It is an averaged value taken across a multitude of electrons and other charge carriers. For instance, direct currents are said to flow in wires and are referred to as zero-frequency in terms of the E-field. But 'direct current' has a spectral content composed of frequency components often referred to as 'noise.' At the photonic level, photons cannot radiate with zero frequency as they are unable to maintain their structure. More importantly, the effect of the rest of the universe means that they always radiate with non-zero energy. In reality they have a minimum energy state that depends on the medium in which they are moving for instance free-space whether on earth's surface or in deep space, or perhaps in some biological tissue. But as we shall see that is *not* the end of the story as far as zero-frequency states allowed by photonic sub-structure.

5. Photons and Bose-Einstein condensates

In 1924 as a young student, Bose sent a paper to Einstein in which he derived Planck's law for blackbody radiation by treating photons as a gas composed of identical particles. Choosing the paper from amongst the multitude he was sent during any given period, Einstein extended the work by generalizing Bose's theory to an ideal gas of atoms or molecules where the particles are conserved. Einstein predicted that at sufficiently low temperatures these particles would become 'locked' together in the lowest quantum state. This state became known as Bose-Einstein condensates. This state only happens for bosons (named after Bose), particles with spin equal to an integer multiple of $\hbar = \boldsymbol{h}/2\pi$.
A BEC is a sudden accumulation of many bosons in a single quantum state. The symmetry of these bosons, all occupying the same state, exhibit correlated properties known as coherence.

Bose-Einstein statistics dramatically increase the odds of finding more than one atom in the same state or coherence, locked together in physical consistency. Coherence defines points on an EM wave (per thermal de Broglie wavelength $\lambda_B = \sqrt{\left(2\pi\hbar^2 / \boldsymbol{k_B m T} \right)}$, where $\boldsymbol{k_B}$ is the Boltzmann constant, $\boldsymbol{m}$ is the atomic mass and $\boldsymbol{T}$ is the temperature of the gas) such that they are separated by a fixed distance and have a constant phase difference.

At a temperature of 170 nK a BEC less than 100 micrometers across (rubidium gas) was achieved at JILA, a group at the University of Colorado [Anderson et al, 1995]. Since the mid 1990's, both at JILA, and at the MIT [Ketterle 1999], BECs in dilute atomic gases have been observed to behave in a 'laser-like' manner, i.e. matter-waves exhibiting coherence. This represents an elementary 'atom laser' that can generate a beam of coherent atoms analogous to the emission of coherent photons by optical lasers.

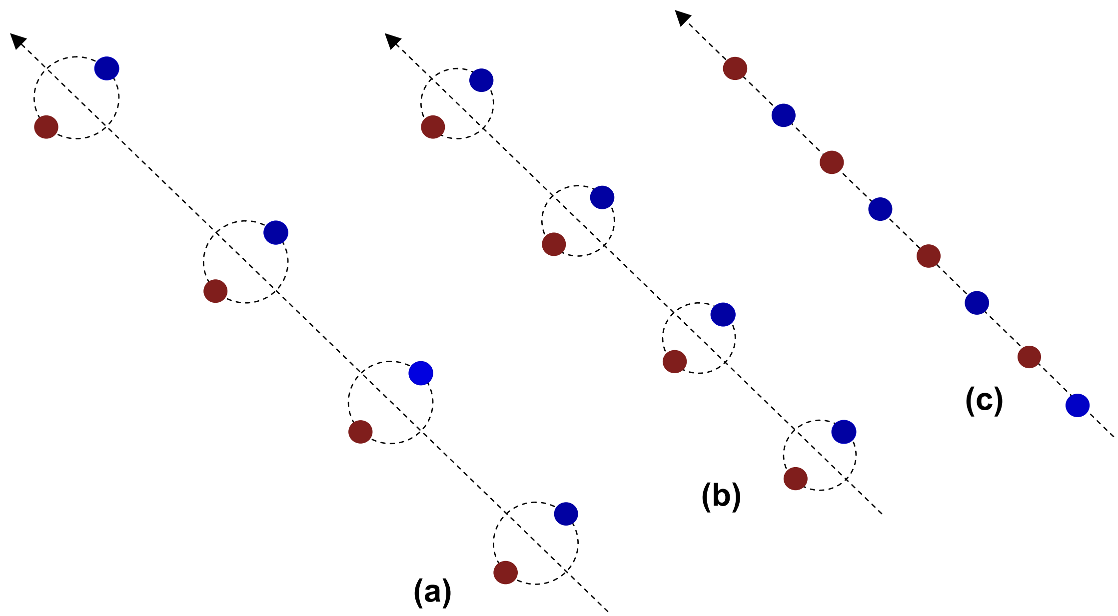

Figure 4. Velocity of photon varies down to zero when string appears (a) c, (b) c/2, (c) $c \approx 0$. At $c \approx 0$, it is possible for 2D or 3D lattices to form between adjacent photons.

In a state near the absolute freezing point (-273 ºC) the velocity of the photon slows down and a form of crystalline matter is observed. In this state, according to the EM self-field theory, the photon can have practically no frequency component and, illustrated in Figure 4c, the translational velocity stops and the cyclotron frequency vanishes. The photon streams become the photonic sub-particles of alternating charge and resemble strings. Strings or photonic structures approximating them may also occur in deep space where the effects of both gravity and temperature are small and where small densities of photon streams exist.

What happens at extremely high energies, above those of gamma particles? Inside the nucleus it appears possible from EM self-field theory that photonic compounds can exist. These compounds are similar to atomic compounds and obey the same field equations [Fleming 2003b] indicating a field may exist at a level below that of the photon. These compounds may also occur inside the cores of complex biological proteins where biophotonic reactions occur. This form of energy may be due to an integration or clustering of photons. We can think of a diffusion process in which photons form the mutual fields between matter. Photons are thus mutually exchanged by matter that moves in a dynamic balance of forces and energy.

A related phenomenon, also revealed by the EM self-field theory, occurs at surfaces between regions of differing phases of matter. For example, as photons emanating from the sun reach earth's ionosphere, their ambient energy increases as the temperature rises from that of deep space. This causes the photonic eigenstates to change as certain discrete energy levels are reached.

6. Photons and their velocities

According to relativity theory, photons can move only at the speed of light, 300,000 km/sec or ~ 186,000 miles/sec. The EM self-field theory is much more flexible in regard the velocity of the photon; photons can have any speed depending on their mass, the ambient temperature, and the presence or otherwise of matter. The edict of relativity as to the constancy of light is really a statement as to the total reaction upon a single photon of the entire matter within the universe when considered isotropic and homogeneous. The photon assumes the measured velocity of light when it is being radiated from matter in a laboratory on earth. When an atom is heated, both the atom *and* the photon are raised to higher states and the photons are subsequently emitted. Such an emission could occur either within the normal terrestrial environment or in deep space where the temperature is vastly different. For each kilometre we go above sea level the temperature drops around 10 K so that at 10,000 m, the temperature will drop by approximately -60 K. The thermal energy of an atomic particle, $\boldsymbol{k_B T}$, (where $\boldsymbol{k_B}$ is Boltzmann's constant and $\boldsymbol{T}$ is the ambient temperature), is due to its kinetic energy and consequently the type of matter. Whether boson (a photon), or fermion (an electron), it will obey either Bose-Einstein or Fermi-Dirac statistics.

In summary, the translational velocity of the photon is due to a gravitational, long distance effect—while the cyclotron effect is due to the energy of its nearby ambient environment. Its translational speed is due to the presence of matter and its cyclotron speed is due to presence of other photons, or other bosons, generally. We may think of the gravitational effect as a form of diffusion where photons follow each other and form clusters of photons inside regions of extremely high energy. For instance clusters form inside the nucleus of atoms, or near large collations of matter as solar EM radiation approaches the earth. We may think of the cyclotron motion of radiated photons as a measure of heat exchange possibly due to the presence of other nearby photons and particles with which it can collide.

7. Photon fields

Vast numbers of photons moving in streams travel along both the electric and magnetic field lines of force. Because the magnetic streams normally appear to move along paths forming circular loops, they are observed as rotating forces, or torques. In reality, both electric and magnetic fields are due to the same physics, streams of photons moving to and fro between charged and dipolar matter.

While electromagnetic fields are composed of photon streams, the correspondence between field and photon is statistically complex. The fields are invariably composed of different frequencies because photons in atoms are emitted and absorbed by electrons and other particles that are in complex motion and undergo complex and rapid transition changes. If an electron is emitting a photon stream while orbiting and spinning, a helical stream of photons can be visualized. Where the motion has orthogonal directions of rotation, both electric and magnetic forces are present, an electromagnetic (EM) field in 3-D space. In practice, even in magnetic media, tiny EM fields are always present due to the rotational motions of electrons. When electric fields are applied, say from batteries, the fields are basically macroscopic 1-D flows within wires. At the macroscopic level the atomic fields can align into magnetic domains producing magnetic fields only. Where magnetic compounds are used, macroscopic rotational fields (2-D) are present. Fully, EM fields are relativistic photon streams in 4-D space-time. For photons the magnetic force equals the electric force. For particles of larger mass, electrons, protons, neutrons, etc. the magnetic force is always smaller than the electric force.

Man-made fields of a single frequency can be generated without too much noise in the laboratory for instance using spectrum analyzers. In nature fields due to radio waves, optics, heat, and acoustics, are much more complex and require statistical methods of analysis.

8. Photons, heat and temperature

Clausius introduced the concept of entropy around 1850 to describe heat transfer: heating of cold matter into hot matter expends external energy and is related mainly to the efficiency of heat engines. In 1876, Boltzmann developed a new definition more related to disorder—entropy of a gas is the amount of information *not* contained in its microscopic properties. Entropy equals the value of all unknown microscopic states. The knowns included pressure and temperature, thus the *unknowns* of the microscopic arrangements existing in a gas were readily determined. Thermodynamic processes can be described in terms of pressure, volume and temperature. After Avogadro formulated his law, energy exchange of heat was seen as a molecular exchange of energy via collisional dynamics. Thermodynamic processes occur because molecules collide. These collisions created ripples in the intervening space—photons were being emitted by the molecules. The size of the ripples depends on the heat difference of the molecules. Thus random motions of hotter molecules induce colder molecules into higher kinetic energy states and vice versa.

The photon's strange quantum behaviour first emerged with the failure of science to provide a single consistent theory for the emitted energy from a blackbody radiator. As discussed by historian and physicist Sir Edmund Whittaker [1953], Wien at short wavelengths and Rayleigh and Jeans at long wavelengths gave differing equations for the radiation. The situation was resolved by Planck who modeled the walls of the blackbody as electromagnetic dipoles using the theory formulated by Hertz along with the concepts of probabilistic thermodynamics. Planck realized that the effect could only be treated as a series involving discrete frequencies rather than a continuous function of frequency [1900]. Via the photo-electric effect, Einstein observed that radiation also acted as discrete quanta of energy $\boldsymbol{E}/\boldsymbol{h\nu}$, or photons. Bohr recognising that the Plank-Einstein equation $\boldsymbol{E} = \boldsymbol{h\nu}$ held for emitted as well as absorbed energy put forward a quantum theory of atomic spectroscopy in which angular momentum must be whole numbers of Planck's quantum number $\hbar = \boldsymbol{h}/2\pi$.

The blackbody theory of radiation integrates Planck's quantum law yielding the Stephan-Boltzmann law for the total radiated energy from a blackbody. In terms of the incremental energy per wavelength $\boldsymbol{E}(\lambda)$, the total energy is given as:

$$\int_0^{\infty} E(\lambda)d\lambda \qquad (9)$$

Wein derived an experimental relationship between the wavelength and temperature at the spectral maximum of any heat. With increasing temperature the photon shifts to smaller wavelengths or higher photon energies:

$$\lambda_m = \frac{\mathbf{2897}}{\boldsymbol{T}} \qquad (10)$$

For a specified temperature (***T***), the total energy over all wavelengths is given by the Stefan- Boltzman law:

$$\boldsymbol{I_{total}} = \frac{\boldsymbol{E_{total}}}{\boldsymbol{AT}} = \boldsymbol{e\sigma T^4} \qquad (11)$$

Thus, the electromagnetic radiation emitted from photons as light is a low entropic form of energy—heat is a higher entropic form of energy. The importance of the entropy theory becomes apparent in both communications theory and thermodynamics as we attempt to design systems that avoid inefficiency or disorganization. For effective communications, the system must reach a state of negative entropy or maximum order. In thermodynamics however, a system will remain at minimum entropy as long as the system remains closed. A closed system consisting of many particles remains within the conservation state constraints of the total energy of that system, and the total number of particles in a number of quantum states. In the presence of heat the number of quantum states within the limits of energy conservation rises, thus an increase in entropy occurs.

As atoms give off characteristic electromagnetic radiation that causes heat, an increase in heat gives rise to an increase in entropy. This concept is basic to the understanding of laser communication systems. In these systems thermal noise is quantum noise, because at the frequencies of light the photon displays quantum properties.

One of the mysteries of modern science is the 'time-arrow' associated with every-day physics and the thermodynamic observation that everything moves towards a mean energy. This is summarised by the concept of entropy and irreversibility [Rees 2002]. Basically, heat flows observed at both the macroscopic and the cosmological level diffuse to a mean fluctuation level where matter is distributed everywhere in a homogeneous manner except for random fluctuations. EM self-field theory suggests otherwise. Given an initial stimulus at the start of time, the 'big bang,' a cosmological dynamic balance has followed in which all matter is in perpetual motion *until* the stimulus is removed by some god-like force. In this way, there is no such thing as an inertial frame of reference. From the atomic to the cosmological there are forces between all particles and this includes the photons which crisscross the universe. If and when the god-like stimulus is removed or perhaps altered, entropy and irreversibility might be overcome. But how can the 'time-arrow' within our universe be overcome by changing the stimulus?

In the next paper in this series, we will discuss how the universe can be viewed in analogy to a living cell. The application of external heat is seen as a very natural process where EM fields applied from outside the universe may provide the energy by which our universe can undergo a type of 'cell-cycle' complete with replication and apoptosis.

9. Discussion

According to modern physics, the photon is the basis of quantum mechanics. Time travel and preposterous anomalies like changing the future by going back in time are seriously considered as possibilities [Barbour 2000]. These paradoxes appear to be a confusion between mathematics and reality (physics). This is prevalent in modern physics where, for instance, relativity is not considered an effect due to the chosen frame of reference but the actual way space-time behaves; in general relativity, space-time warping is thought to actually occur.

This confusion between mathematics and reality is imbedded in our thinking, and goes both ways, reality sometimes being considered 'imaginary mathematics.' The so-called imaginary number system denoted by ***'j'*** is in fact associated with actual distances traveled by photons under the conditions of special relativity. The usual 'real' number associated with this distance is the apparent distance traveled by the photon, whereas the 'imaginary' number is the distance associated with its internal rotation (see Eqns 4-7). This apparent distance is more convoluted where general relativity holds due to the curvature of the so-called 'real' distance. Such confusions when related to elapsed time are a basis for much speculation and mathematical absurdity.

Another common error is to consider probability densities as physical entities. According to quantum mechanics and quantum electrodynamics both are based on conventional EM theory where the electric and magnetic fields are calculated between charge points. In Fleming's EM self-field theory [2000a] the electric and magnetic fields are calculated between centres of motion, an orthogonal pairing of these two vectors that effectively decouples a particle's energy into components mirroring its true motions. Using these components, no probability densities are required and the true motion is yielded by the mathematics.

One of the effects of the particular electric and magnetic fields used within EM self-field theory is that singularities as apparent in Eqn 1 are not mathematically problematic. Now the conditions on the particle's velocity wrt the speed of light are no longer necessary; for the photon, the factor becomes identically ½.

Further, the mystery associated with the speed of light is dispersed. Its constancy is due to its circular rotation; hence acceleration *can indeed* be related to a particle moving with constant speed, rather than recourse to Einstein's equivalence theorem. In addition, this constant speed is related to the mass of the particle indicating that the photon *can indeed* have a non-zero mass *and* have a non-quantum origin.

10. Conclusions

According to quantum theory and modern physics generally, knowledge of the photon is limited by the uncertainty principle, to a constancy of its speed and by an understanding of exactly what the wave-particle duality represents. The EM self-field theory considers the photon as consisting of two sub-particles of equal mass and opposite charge. Its physics concerns the internal and external velocities of its two mass-points, the ambient temperature and its eigenstates. This gives a more comprehensive perception of the photon. Like atomic quantum states, the photon possesses four degrees of freedom associated with the E- and H-fields and another degree of freedom associated with the ambient temperature. Unlike quantum physics requiring integer multiples of angular momentum for atomic and molecular systems, the photon is capable of a continuous spectrum leading to an infinite array of possible states, rather than an infinite number of allowed discrete frequencies.

According to the EM self-field theory, the photon's external velocity can vary from quantum physics' proscribed constancy. This is due to the long-range gravitational effects of the universe varying as a function of position within it. Instead of a constant velocity due to any assumption upon isotropy or homogeneity, variations in the cosmological self-fields within the universe can occur due to variations of matter within it. It is possible the presence of other universes impact upon a photon's velocity at points within our universe. In essence this boils down to differences between self- and mutual fields [Rees 2002].

Although the photon's mass is currently considered negligible as its velocity approaches the speed of light or at zero frequency, the EM self-field theory indicates that this may not be correct. The EM self-field equations as applied to a photon may be used to obtain a theoretical expression in terms of its eigenstates, its mass and the ambient temperature.

Like atomic ground states, the presence of heat or cold alters a photon's energy state. Thus temperature affects the ground state of the photon as it acts as an energy transfer system. This mass transfer mechanism acts both at the cosmological and at the atomic level. This significantly contributes to the dynamic equilibrium with all other matter in the cosmological balance of the universe. Depending on the degree of cold, the photon streams can resemble giant strings across pockets of deep space.

There is a vast range of physical evidence supporting the model of the photon given by the EM self-field theory. Considering the photon's energy states in relation to the ionospheric layers as a function of temperature may allow the mass and charge of the photon's sub-particles to be determined. In addition, the enormous range of energy states within biological cells across the wide range of living species may be similar to the layered structures observed within the ionosphere.

From the vastness of the universe and its gas clouds, down to clusters and single galaxies, suns and solar systems, at the macroscopic level, to the microscopic system of the biological cell, down through atomic and nuclear motions, these various dynamic systems can be modelled as EM self-field systems. More importantly, electromagnetic and other energies derived from the electromagnetic spectrum affecting all these systems, can be studied in relation to what is gleaned from the ongoing study of the photon. The interrelationships between structures observed within biological cells, terraspheres, and the universe, will be discussed in a future report in this series of reports on the humble little photon.

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Review and cite PHOTON ENERGY protocol, troubleshooting and other methodology information | Contact experts in PHOTON ENERGY to get answers.Â Is the photon motionless? Obviously not; it is moving at light speed. Then where 'its magnetic field' might be observed? One mile behind this photon, two miles? Stationary observer should experience time-varying field (electric and/or magnetic) or the energy flux in other words. If so, then the photon's energy should steadily decrease, thus its frequency should tend to null. Nothing like that is observed, although there are some hypotheses about 'tired light'. In conclusion: the amplitude of a single photon magnetic field is exactly zero. The photon transfers a portion of its energy to the electron (assumed to be initially at rest), which is then known as a recoil electron, or a Compton electron. â€¢ All angles of scattering are possible. â€¢ The energy transferred to the electron can vary from zero to a large fraction of the gamma-ray energy.Â â€¢ decreases as the photon energy increases; â€¢ directly proportional to the number of electrons per gram, which only varies by 20% from the lightest to the heaviest elements (except for hydrogen). Compton Scattering Energetics. The energies of the scattered photon hÎ½ ' and the Compton electron Ee, are given by. h. Î½.