Zero Point Energy and the Redshift

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The first section of this paper introduces the concept of the vacuum Zero Point Energy (ZPE) in terms of stochastic electro-dynamics, or SED physics. The effects of the ZPE on atoms and atomic processes according to SED concepts are then summarized. This includes the concept of an increasing ZPE strength due to universal expansion. SED physics has shown that the stability of atomic orbits is dependent upon the strength of the ZPE. Claverie and Diner, Puthoff, Spicka and others have shown that if an electron is emitting more recoil radiation, because of the impacting electro-magnetic waves of the ZPE, than it is absorbing from the ZPE, then it will move towards the nucleus. The reverse is also true. Thus the orbit which results for an electron comes from an equilibrium between the energy radiated and energy absorbed. In the context of a ZPE increasing with time, it is shown that atomic orbits will behave in such a way that light emitted by atomic orbit transitions will become bluer as time moves forward. Thus as we look back into the past by observing increasingly distant astronomical objects the emitted light should be redder with distance. The effect will be the same as the observed redshift of light from distant galaxies. Thus the redshift may well be evidence of a ZPE increasing with time rather than the standard explanation of universal expansion. The effect of an increasing ZPE on atomic orbits may either be happening smoothly or in the quantum jumps, which are a characteristic of atomic orbit behavior. Analysis then indicates that a quantized redshift can occur with an increasing ZPE. The size of the predicted redshift quantum jumps is in exact accord with the data given by Tifft, Arp, Guthrie and Napier and others.

1. Introducing the Zero Point Energy

The vacuum of space is more unusual than is commonly understood. It is popularly considered to be a void, an emptiness, or just 'nothingness.' This is the definition of a so-called 'bare vacuum.' However, as science has learned more about the properties of space, a new and contrasting description has arisen, which physicists call the 'physical vacuum.' To understand the difference between these two definitions, imagine you have a perfectly sealed container. Let us now pump out all solids, liquids and gases so that all atoms are removed, and cool it down to absolute zero Kelvin (-273 ^{o}C) so no thermal radiation exists within it. Normally, one would consider that there is now a perfect vacuum, a complete nothingness, a 'bare' vacuum, inside that container.

However, that is not so. Experiment and theory have both shown that there is an intrinsic energy inherent in the vacuum. This energy is there even at absolute zero Kelvin. For that reason, this energy is called the Zero Point Energy (ZPE). The 'bare' vacuum plus the Zero Point Energy makes up the 'physical vacuum'. This energy was first proposed theoretically by Max Planck in 1911 [1]. It appeared in his equations that derived the energy radiated from a perfectly black body at any given temperature. Even when a black body was at zero Kelvin, an energy intrinsic to the vacuum still remained as the term (hf / 2) in his equation, which had the following form: [1]

$$\rho\left(f,T\right)df=\left[8\pi f^{2}/c^{3}\right]\left\{\left[hf/\left(e^{hf/kT}-1\right)\right]+\left[hf/2\right]\right\}df \qquad (1)$$

Here, f is radiation frequency, c is light-speed, and k is Boltzmann's constant. If the temperature, T, in (1) drops to zero, we are still left with the Zero Point term, which is temperature independent. In (1), Planck's constant, h, in the Zero Point term simply appears as a scale factor to align theory with experiment and no quantum interpretation is needed. This implies that h measures the strength of the ZPE.

According to Kuhn, Planck's 1911 paper was the result of 10 years of dissatisfaction for Planck at the lack of a physical cause in his initial paper on radiation in 1901. [2] The quantity, h, now called Planck's constant, was a purely mathematical construct in the 1901 paper, having no physical reality. The 1911 paper overcame this difficulty well, and inspired Einstein and Stern, [3] Nernst, [4] and others [5] to pursue the matter further. Einstein and Stern in 1913 published an analysis of the interaction between matter and radiation using simple dipole oscillators to represent charged particles, and an approach that was based firmly on classical physics. [3] They remarked that, if the dipole oscillators were immersed in an irreducible energy at absolute zero of temperature, **then the Planck radiation formula would result without the need to invoke quantization at all.** This has since been proven correct by Boyer and others who have made similar derivations. [5] This early work demonstrated the ZPE must be a universal phenomenon, uniform, all-pervasive, and penetrating every atomic structure throughout the cosmos.

2. Experimental Proof that ZPE Exists

As a consequence of this all-pervasive nature of the electromagnetic waves making up the ZPE, we are not aware of its presence. This follows for the same reason that we are unaware of the atmospheric pressure of 14.7 pounds per square inch that is imposed upon our bodies. There is a perfect balance within us and without. Similarly, the radiation pressures of the electromagnetic waves of the ZPE are everywhere balanced in our bodies and measuring devices. It may therefore be surmised that it would be difficult to prove the ZPE exists.

However, the ZPE was first experimentally proven to exist in 1925 by chemist Robert Mulliken who found this proof in the spectrum of boron monoxide. As he analyzed the wavelengths of its spectral lines, he discovered a slight shift from the theoretical position that these lines would have had if the ZPE did not exist. The Zero Point Fields (ZPF) slightly perturb an electron in an atom so that, when it makes a transition from one state to another, it emits light whose wavelength is shifted slightly from its normal value. Some years later, a similar shift of wavelength in the microwave region of the hydrogen spectrum was experimentally established by Willis Lamb and Robert Retherford using techniques developed for radar. Today, the Lamb shift of spectral lines, as it is now called, is quoted as one observational proof for the existence of the ZPE. Lamb stated the experimental results were *"a proof that the [perfect or bare] vacuum does not exist."* [6]

The existence of a physical ZPE is also supported by the Casimir effect where two metal plates are brought close together in a vacuum. According to classical electrodynamics, such an experimental arrangement will exclude all waves except those whose half-wavelength, or whole numbers of that half-wavelength, will fit exactly between the plates. The excluded wavelengths then exert a radiation pressure on the plates which is measurable. The Casimir effect is directly proportional to the area of the plates. However, unlike other possible forces with which it may be confused, the Casimir force is inversely proportional to the fourth power of the plates' distance apart. Experiments in 1998 have verified the theoretical approach to within 1% using an atomic force microscope. [7]

Experimental evidence has continued to accumulate that demonstrates the existence of the ZPE, even though its fluctuations do not become significant enough to be observed until the atomic level is attained. Thus, the ZPE explains why cooling alone will never freeze liquid helium. Unless pressure is applied, these ZPE fluctuations are agitating the helium atoms and preventing them from getting close enough to permit solidification. In electronic circuits, like microwave receivers, another problem arises because ZPE fluctuations cause a random 'noise' that places limits on the level to which signals can be amplified. The 'noise' can never be removed no matter how perfect the technology.

3. Two Papers - Two Branches of Physics

Shortly after Mulliken's experiment proving the existence of the ZPE, four major papers were written on the basis of Planck's 1901 paper with its theoretical approach without an actual, physical ZPE. These papers set the course for QED physics or quantum electro-dynamics which underwent rapid development. It was not until 1962 that de Broglie (who had written one of those papers) pointed out that physics had missed a major opportunity back in the 1920's to follow through with Planck's 1911 approach. He pointed out that serious consideration of Planck's second theory, embracing classical theory with an intrinsic cosmological ZPE, had been widespread. [8] The outcome of de Broglie's suggestion was the birth of a branch of study known today as stochastic electro-dynamics or, SED physics. This accepts the data pointing to the ZPE as being a real physical entity instead of being a mere virtual construct. Furthermore, SED physics involves intuitive concepts and fairly simple mathematics. This makes a contrast with the many counter-intuitive results from QED physics which requires esoteric mathematics, and involves infinities and zeroes.

Although the ZPE exists as electromagnetic waves of all wavelengths, it has a short wavelength cutoff at the Planck length, around 10^{-35} meters. This is the length at which the structure of the vacuum (or the fabric of space) breaks down and prevents transmission of shorter wavelengths. Shorter wavelengths simply become absorbed in the vacuum. This cutoff, indicated by SED research, also gives an upper limit for the ZPE strength of about 10^{107} Joules per cubic centimeter. Paul Davies put the estimate slightly higher at *"about 10^{110} joules per cubic centimeter."* [9] Since the QED approach indicated that the strength of the ZPE was infinite, the existence of the Planck length cutoff now gives QED physicists a reason to accept the ZPE as a physical reality rather than just a virtual construct, or a mere mathematical entity.

4. Properties of the ZPE

The ZPE has been demonstrated as having a frequency cubed spectrum which is Lorentz invariant. This has three consequences. First, it means that velocities through the ZPE cannot be detected. [10] Second, it means that the ZPE is made up of many more short-wavelengths than long wavelengths. This second point has the consequence that, on the scale of meters, the vacuum is almost featureless. But at an atomic level the ZPE is a turbulent sea of randomly fluctuating electromagnetic fields and waves. The third consequence follows on from this turbulence at atomic scales of reference. Sub-atomic particles get "jiggled" by the impacting waves of the ZPE giving rise to quantum uncertainty in their position and momentum. Now Planck's constant, h, is a measure of this quantum uncertainty, and this uncertainty is dependent on the strength of the ZPE. This, therefore, gives another reason why h can be considered to be a measure of the strength of the ZPE in SED physics.

Haisch, Rueda and Puthoff have established that the rest-masses of subatomic particles originate with this jiggling due to the kinetic energy it imparts to these particles. [11, 12] This kinetic energy, imparted to charged mass-less particles, appears as mass on the basis of the energy-to-mass interconversion. [12] Perhaps this should be examined in a little more detail.

5. Mass and the ZPE

There are a number of problems associated with standard models for atomic masses. Many modern theories envisage the sub-atomic particles making up matter as being charged point particles with a form but no intrinsic mass. While this may seem strange initially, it forms the basis of physics research. This concept originated with the long line of investigators, including Planck and Einstein, who developed radiation theory based on the behavior of mass-less charged point-particle oscillators. Since the resulting radiation theory was in agreement with the data, the problem was then to understand how mass was imparted to these mass-less oscillators, and hence to all matter. There were several possible approaches.

Historically, the first line of enquiry emerged from QED and the resulting standard model of particle physics. This has currently developed to the stage where, in order for subatomic particles to have mass, the Higgs boson had to be introduced. The **energy** from a cloud of Higgs bosons around each particle is meant to impart mass to the particle, depending on how well the Higgs bosons "stick" to the particle. No-one knows what governs this "sticking".

These and other problems are basically overcome in the second line of enquiry which opened up post-1962 with the development of the SED alternative. It is true that SED physics uses the same standard foundation as the QED approach. Both are built on the concepts of quantum pioneers Planck, de Broglie and Schroedinger who accepted that these particles are indeed massless, point-like charges. Richard Feynman generically called these particles 'partons' and electrons in order to avoid preconceived ideas about the structure of protons and neutrons.

However, the difference from the QED approach is that SED physics considers the ZPE itself as the agency that imparts mass to the partons and electrons. To this end, Haisch notes that the electromagnetic waves of the ZPE impinge upon all these charged, massless particles. This causes them to randomly jitter in a manner similar to what we see in the Brownian motion of a dust particle bombarded by molecules of air. Schroedinger referred to this "jitter motion" by its German equivalent, *Zitterbewegung*. Dirac pointed out that the *Zitterbewegung* fluctuations occur either at, or very close to, the speed of light.

Hal Puthoff then explains what happens according to SED physics: "*In this view the particle mass* m *is of dynamical origin, originating in parton-motion response to the electromagnetic zero-point fluctuations of the vacuum. It is therefore simply a special case of the general proposition that the internal kinetic energy of a system contributes to the effective mass of that system.*" [13] Calculations by Puthoff and others quantitatively support this view. As a result, it has been stated that, even if it is found to exist, "*the Higgs might not be needed to explain rest mass at all. The inherent energy in a particle may be a result of its jittering motion[caused by the ZPE]. A massless particle may pick up energy from it [ZPE], hence acquiring what we think of as rest mass.*" [11]

In a similar way, inertial mass can be accounted for since an electron accelerated through the electromagnetic fields of the vacuum experiences a pressure, a retarding force proportional to the acceleration, from these ambient fields in a way formalised in 1994 by Haisch, Rueda and Puthoff. [12] Furthermore, different resonant frequencies of different particles will result in different masses. This occurs because "*Photons in the quantum vacuum with the same frequency as the jitter are much more likely to bounce off a particle…Higher resonance frequencies … probably mean a greater mass, as there are more high frequency vacuum photons to bounce off.*" [12] The formulation of Haisch's team then goes on to show that a particle's oscillation in response to the ZPE gives it a rest-mass which is proportional to the square of the ZPE strength. Analysis in [14] confirms this by showing that subatomic particle masses, m, are proportional to h^2 which, in turn, is proportional to the square of ZPE strength. This proportionality will prove useful shortly.

6. Dynamics of the Universe

An analysis of data from the physical quantities dependent on ZPE strength, like h and m, indicate that the ZPE has increased in strength with time [14, 15]. This increase in ZPE strength has been shown to be the result of the initial expansion, stretching, or inflation of the cosmos [14, 16, 17]. The model which is accepted here is that there was an initial rapid expansion of the universe out to a maximum size about which it then oscillated. The initial expansion of the universe is accepted here as being indicated by the Cosmic Microwave Background Radiation (CMBR). The subsequent small oscillations of a now static universe were shown to be a necessary feature by Narlikar and Arp in 1993 [18].

However, this model for the dynamics of the universe is not just a theoretical concept; it is firmly grounded in data. An examination of the average separation and temperature of the hydrogen clouds throughout the cosmos supports this model. As light passes through the hydrogen clouds, selective wavelengths are absorbed and produce a dark line on the spectrum. The one of importance here is the Lyman Alpha line. As the light goes through an increasing number of hydrogen clouds on its journey, an increasing number of Lyman Alpha lines are built up in the spectrum. Since the clouds further away from our galaxy have greater redshifts, the position of the Lyman Alpha line on the spectrum from an individual cloud will be dependent on distance and hence registered by its redshift. As a result of traveling great astronomical distances, light passing through these clouds will arrive at earth with a whole suite of lines. This is known as the 'Lyman Alpha forest.'

The point that emerges from this study is that, if the universe is expanding, the average distance apart of the hydrogen clouds should be increasing as we come forward in time. So as we look back into the past to earlier times, and hence to greater redshifts, the clouds should get closer together. If the universe is static, the average distance apart of the clouds should remain fixed. A detailed study of this matter has been performed by Lyndon Ashmore. The Abstract to one of his papers contains these conclusions:

"*This paper examines the Lyman Alpha forest in order to determine the average temperature and the average separation of Hydrogen clouds over the aging of the universe. A review of the literature shows that the clouds did once become further and further apart (showing expansion?) but are now evenly spaced (an indication of a static universe?). ... Whilst these results do not support any cosmology individually, they do support one where the universe expanded in the past but that expansion has now been arrested and the universe is now static*"[19]. A further discussion of this can be seen in Lyndon Ashmore's paper that is part of this NPA Conference [20]. Inevitably, this also raises the question of the origin of the redshift. Lyndon Ashmore's NPA Conference paper examines one possible answer to this question; this paper looks at another.

So the model accepted here is one of an initially expanding universe that then became static. The data suggest expansion is indicated for redshifts higher than about 2.6. [20] This initial expansion was responsible for the ZPE. However, the means whereby cosmic expansion formed the ZPE now needs to be examined. Then the link with the redshift is elucidated, and we find the two are inversely related via atomic behavior.

7. Cosmic Expansion and Planck Scale Effects

It has been mentioned that the Planck length of 10^{-35} meters is the length at which the 'fabric' of the vacuum breaks down and space assumes a granular structure. For quantum physicists this granular structure consists of a sort of 'quantum foam'. [21] On the other hand, string theorists consider it to consist of rolled up balls of compactified dimensions called Calabi-Yau shapes. [22] However it is structured, it is universally agreed that phenomena at the Planck scale are fundamental to our current cosmos. It is therefore at this scale that we need to consider interactions as the universe initially expanded.

This expansion or stretching of the fabric of space resulted in a tension or force being manifest at the Planck scale. In other words, an energy was being invested into the fabric at its most basic level. In addition, the evidence indicates that extremely high initial temperatures were involved as expansion began.

Parallel conditions in high energy physics laboratories, as well as in supernovas, result in electron-positron pair production as well as the production of other particle-antiparticle pairs. The process is simply one of conversion of the inherent energy into mass on the basis of Einstein's famous equation. Thus the enormous tensional energy in the fabric of space that was being generated by the expansion, coupled with the extremely high temperature, would similarly be expected to result in the formation of particle-antiparticle pairs. These particle pairs would manifest at the Planck scale and be positively and negatively charged so that electrical neutrality of the vacuum would be maintained.

C.H. Gibson [23] as well as Hoyle, Burbidge and Narlikar, [24] have shown that processes operating at Planck scales initially would result in the formation of cascades of pairs of Planck particles. These particles have the unique property that their diameter is the same as both the Planck length and their own Compton wavelength. They are thus specifically a Planck scale phenomenon. As a result, the enormous tensional energy and extreme temperatures at the Planck scale would be expected to manifest as cascades of Planck particle pairs (PPP).

It should be noted that Gibson uses "*Vacuum oscillations to form Planck particles and Planck antiparticles reversibly...*" However, if a pair become misaligned as they collapse, they form a Planck-Kerr particle (P-KP). Gibson states that "*a truly explosive result can occur [when] a Planck-Kerr particle forms, since one of these can trigger a big bang turbulence cascade [of Planck particle pairs]*" in a process which is irreversible. [23] In this way, Gibson uses the vacuum fluctuations or oscillations to initiate Planck pair production.

In the model proposed by Hoyle, Burbidge and Narlikar, a somewhat different process is proposed. They summarize their model by saying that if a particle exceeds the Planck mass, it "*has the ability to 'tear open,' as it were, the structure of space-time, and then it is from such a 'tearing open' that creation events emerge, leading to the generation of showers of particles with masses of the order of the Planck mass.*" [24] Their mathematical modeling supports this proposal. In addition, their calculations suggest that the decay (not annihilation) of a single Planck particle can produce about 5 x 10^{18} baryons, which includes protons and neutrons.

In contrast to both these models, it is proposed here that the extreme temperatures and the enormous expansion energy provide an environment at the Planck scale in which energy is converted to matter as a turbulent cascade of PPP and/or PKP. This is done on the basis of what we see in high energy laboratories, in supernovae and on the basis of $E = mc^2$. The more exotic nature of the other proposals for the generation of PPP cascades and P-KP is thereby avoided, as we are simply dealing with a known physical effect.

There is another point to consider. Because of quantum uncertainty and particle annihilation, Gibson needed the formation of Planck-Kerr particles as a chance event from the quantum vacuum before Planck particle pairs could be irreversibly produced. This process may not be necessary on the current model because, on SED physics, the ZPE is the origin of all quantum uncertainty. Therefore, since PPP are the originators of the ZPE in a manner to be shown below, their existence is not limited in time as virtual particles are. In this way, the stretching of the fabric of space by universal expansion had invested it with energy from which PPP and P-KP were irreversibly produced, along with great turbulence.

8. The Origin of the ZPE

Gibson, Hoyle and others have therefore shown that, as a result of these processes, there would be extreme turbulent vortices and separation among the PPP. The model being followed here would produce similar effects due to the ongoing expansion and the formation of Planck-Kerr particles which trigger additional turbulence. Gibson has shown that this P-KP turbulence starts at the Planck scale and then cascades into progressively larger scales so that the whole PPP 'gas' throughout the cosmos is in a state of extreme turbulence. [23] He points out that this turbulence feeds energy into the system which results in the production of more PPP. In fact, Gibson's analysis reveals that PPP numbers will continue to increase until all turbulence dies away. He has shown that such systems are characteristically inelastic, while Bizon has established that inelastic systems have stronger vortices and longer persistence times. [25]

In this PPP/P-KP system, the separation of electric charges among the PPP would produce electric fields, while their turbulent movement would produce magnetic fields. In addition, the P-KP radiate electromagnetic energy into their turbulent environment. These sources are the origin of the primordial electro-magnetic fields of the ZPE. But that is not all.

After the universal expansion ceases, vortices and turbulence will persist until all the turbulent energy has been converted to PPP as explained in detail by Gibson. [23] Because of the inelasticity and size of the system, the persistence and decay phases of turbulence may be expected to occupy a long time. During this time the ZPE strength will continue to build because PPP numbers are building.

Once both expansion and PPP turbulence have ceased, there will then be ongoing recombination among the PPP. When Planck Particle Pairs recombine, they annihilate and their total energy is converted to electromagnetic radiation. A similar process occurs when electron/positron pairs annihilate. Thus the electromagnetic fields and waves of the ZPE continue to build up after the decay in turbulence until all PPP have recombined. Puthoff and other authors have shown that the ZPE strength is then maintained by a feedback cycle. [26] Nevertheless, an ongoing oscillation will occur in the strength of the ZPE because of the oscillation in the size of a static universe outlined by Narlikar and Arp in [18].

A theoretical and mathematical analysis based on the known physics of turbulence and recombination indicates that the build-up in the ZPE with time may very closely follow the inverse of the function describing the redshift of light from distant galaxies. [16, 17] If this is true, then the mechanism whereby the increasing ZPE causes bluer light to be emitted from sources of radiant energy now needs to be explained.

9. The ZPE and Atomic Orbits

This all-pervasive ZPE 'sea' has been shown to maintain the stability of atomic orbits across the cosmos. Classical physics requires an electron orbiting a proton to be radiating energy, and so spiral into the nucleus. As this does not happen, QED physics invokes the action of quantum laws, but an actual physical explanation is still needed. According to the SED approach, classical physics is still valid, but must be coupled with the effects of the ZPE. Therefore, the energy that electrons radiate as they orbit their protons can be calculated, along with the energy that these electrons absorb from the all-pervasive ZPE. Quantitative analyses were done, and the results summarized by stating that "*Boyer [27] and Claverie & Diner [28] have shown that if one considers circular orbits only, then one obtains an equilibrium [orbit] radius of the expected size [the Bohr radius]: for smaller distances, the electron absorbs too much energy from the [ZPE] field…and tends to escape, whereas for larger distances it radiates too much and tends to fall towards the nucleus.*" [29]

In 1987 Puthoff examined this further in an SED context. His conclusion carries unusual significance. It reads: "*Finally, it is seen that a well-defined, precise quantitative argument can be made that the ground state of the hydrogen atom is defined by a dynamic equilibrium in which the collapse of the state is prevented by the presence of the zero-point fluctuations of the electromagnetic field. This carries with it the attendant implication that the stability of matter itself is largely mediated by ZPF phenomena in the manner described here, a concept that transcends the usual interpretation of the role and significance of zero-point fluctuations of the vacuum electromagnetic field.*" [30] Thus the very existence of atomic structures depends on this ZPE sea. Without it, all matter in the cosmos collapses. New Scientist discussed this in July 1987 and July 1990 under the heading "*Why atoms don't collapse.*"

10. Atomic Orbits with a Varying ZPE

Atomic orbit energies are therefore sustained by the ZPE. But we can go further. The Bohr atom scales all orbit energies according to the ground state orbit. So, if the ground state orbit of an atom has an energy change, all other orbits will scale their energies proportionally. This means that wavelengths of emitted light will also be scaled in proportion to the energy of the ground state orbit of the atom. Thus, if the ZPE strength varied cosmologically, then all atomic structures throughout the cosmos might be expected to adjust their orbit energies simultaneously.

More specifically, if the ZPE increased over time, as indicated here, light emitted from atomic transitions would then become bluer with time. Puthoff's approach demonstrated that the power radiated and absorbed by the electron governed the orbit angular momentum, which is proportional to h. Thus, as the ZPE strength increased with time, h also increased since it is a measure of the strength of the ZPE. As a consequence, an increase in ZPE strength also means that all orbit angular momenta increased, since atomic orbit angular momenta are directly linked with h. Light emitted from atomic orbit transitions would therefore be more energetic or bluer with time. As we look back into the past, the light emitted would be redder at earlier epochs. Therefore, even in a static universe, such as that proposed by Narlikar and Arp [18], progressively more distant galaxies would have their spectral lines shifted further to the red end of the spectrum [16]. This is precisely the effect we see with an increasing redshift of light from progressively more distant galaxies.

However, there is another, more satisfying way in which this process can be explained by SED physics. This was done by V. Spicka et al. in a presentation about the ZPE and its effects at a conference in the Spring of 2006 [31]. Among the items discussed by the conference was the importance of the role of SED physics which traces the origin of all quantum uncertainty to an actual physical cause, namely the Zero Point Energy. In contrast, QED physics, or Quantum Electro-Dynamics, suggests that quantum uncertainty is a property inherent in the very nature of matter itself.

11. Considering An Electron's Path

In that conference presentation, on page 264, Spicka et al. state "*It is an enormously fruitful idea developed in the frame of SED physics that the moving charged particle, electron for example, can be kept on a stationary orbit in consequence of dynamical equilibrium between absorbed ZPR [Zero-Point Radiation] and emitted recoil radiation. In quantum mechanics, the stationary states being defined as solutions ... of Schroedinger's equation may be mathematically represented by a stationary wave-function pattern. Such a pattern is, speaking more physically, a result of constructive interference of electron waves which is compatible with boundary conditions characterizing a given system. The essential features of the just mentioned duality between SED and QED approach to stationary states (ZPR-recoil radiation equilibrium in SED versus constructive interference in QED) may be illustrated by the following simple model of an electron trapped on a closed orbit.*" [31]

The scenario which Spicka et al. then go on to illustrate is that of an electron moving in an orbit around a proton under the influence of its electrostatic attraction. As it does so, the electron undergoes a series of elastic collisions with the impacting waves of the ZPE which perturb this orbit. These impacting waves force the electron to change direction. When it does so, the electron emits recoil radiation, just as classical physics requires.

The whole 'orbit' then becomes composed of a series of essentially straight line segments whose direction is continually being changed by the impact of these ZPE waves. With every change in direction, recoil radiation is emitted by the electron. Calculation then reveals that the electron may receive over 18,700 hits from the ZPE waves for every orbit around the proton. This is obtained by dividing the frequency of the first Bohr orbit by the Compton frequency. The Compton frequency gives the number of hits per second by the ZPE waves on the electron according to the SED approach, and is about 10^{20}.

12. Electron Recoil Radiation and the ZPE

The hits by these impacting ZPE waves are the reason why there is uncertainty in both the position of the electron and its actual orbit around the proton. Both of them are varying due to these collisions. For a stable orbit, the power absorbed by the electron from the ZPE wave collision, P_A, is then equal to the power emitted by the electron's recoil radiation, P_E. Spicka et al. then go on to state that "*Because of changes in its direction of movement, an electron moving in an environment where it suffers only elastic collisions has to emit recoil radiation of power P_E given by Larmor's formula.* [31]

$$P_E = \left(e^2 v^2 \Omega^2\right) / \left(6\pi\varepsilon c^3\right) \quad \text{where} \quad \Omega = \left(\theta\, v\right) / \lambda \tag{2}$$

Here, e is the charge on the electron, v is its velocity in a straight line between impacts, ε is the permittivity of free space, c is the speed of light, and Ω is the angular frequency. Spicka et al. show that this latter quantity can be replaced by the other terms as shown in (2) where v is again the velocity of the electron, λ is the length of the mean free path between collisions, and θ is the angle subtended by length of the mean free path at the center of the orbit.

Spicka et al. then point out that the power absorbed by the electron is given by

$$P_A = \left(h^2 \lambda \Omega^4\right) / \left(12\pi^4 \mathrm{m} c^3\right) \tag{3}$$

where h is Planck's constant and m is the electron rest mass, while λ is the mean free path between collisions. For a stable orbit, power absorbed equals power radiated. This then gives us:

$$P_E = P_A = \left(e^2 v^2 \Omega^2\right) / \left(6\pi\varepsilon c^3\right) = \left(h^2 \lambda \Omega^4\right) / \left(12\pi^4 m c^3\right) \tag{4}$$

Now in a changing ZPE scenario the quantity e^2/ε has been shown to be constant experimentally. [14] Indeed, it has been shown to be constant out to the furthest reaches of the cosmos. [32] If we isolate that quantity, we obtain:

$$e^2/\varepsilon = \left(h^2 \lambda \Omega^2\right) \Big/ \left(2\pi^3 m v^2\right) = \text{constant} \tag{5}$$

We then substitute for Ω from (2) we obtain

$$e^2/\varepsilon = \left(h^2 \lambda \left[(\theta v)/\lambda\right]^2\right) / \left(2\pi^3 m v^2\right) \tag{6}$$

When this is simplified, it then becomes

$$e^2/\varepsilon = \left(h^2 \theta^2\right) / \left(2\pi^3 m \lambda\right) = \text{constant} \tag{7}$$

As the ZPE varies, it was mentioned above and detailed in [14] that m is proportional to h^2. This then means in (7) that (h^2/m) is constant. This further requires that θ^2/λ must also be a constant with varying ZPE. Now θ is the angle subtended at the center of the orbit by the length of the mean free path λ. Furthermore, the angle θ in radians is given by the length of the arc divided by the radius. Here the length of the arc is λ, and the radius involved is the radius of the electron orbit r. Substituting λ/r for θ then gives us the result

$$\theta^2/\lambda = \text{constant} = \left(\lambda^2/r^2\right)\Big/\lambda = \lambda/r^2 \tag{8}$$

This equation (8) has an important consequence. When the ZPE is stronger, there are more ZPE waves per unit volume and so there are more hits per second on the electron as it travels in its orbit. This means that the mean free path λ is smaller. In order for the above equations to be satisfied as the ZPE increases, the requirement therefore emerges that the orbit radius, r, must decrease in such a way that r^2 is always proportional to λ. So the behavior of λ now needs closer inspection.

13. Considering Orbit Radii for Electrons

The number of hits per unit time can be shown by standard physics to be equal to the velocity of the traveling object divided by the mean free path, λ. Therefore we can write that the mean free path

$$\lambda = v / \left(\text{number of hits per unit time}\right) \tag{9}$$

But the velocity, v, of the electron in its orbit is inversely proportional to U, the strength of the ZPE. This follows since the kinetic energy, $0.5mv^2$, of the electron is conserved as the ZPE changes. Since it was shown in [14] and mentioned above that

$$m \sim U^2 \sim h^2 \tag{10}$$

then conservation requires that

$$v^2 \sim 1/U^2 \quad \text{so that} \quad v \sim 1/U \tag{11}$$

Note that in equations (10) and (11), and throughout this paper, the symbol ~ means "is proportional to." In addition to the electron velocity, v, being inversely proportional to U in equation (9), the number of hits per unit time is also proportional to U. This is the case since an electron has a finite radius. Therefore, its travel in its orbit will sweep out a volume. This volume contains the waves of the ZPE, and the number of these waves per unit volume increase directly as the strength of the ZPE increases. Therefore, the number of waves encountered by the electron in its travel is directly proportional to the ZPE strength. This means that the number of hits per unit time by these waves is proportional to U. Inserting this result as well as the result from (11) into equation (9) we obtain the outcome that

$$U^2 \sim 1/\lambda \sim 1/r^2 \tag{12}$$

which means that

$$r \sim 1/U \tag{13}$$

Therefore, as the ZPE gets stronger, the mean free path gets shorter, so the orbit radius also gets smaller. This result also follows from the general principle enunciated above that, when the electron radiates more energy than it absorbs, it moves closer to the nucleus until a balance is achieved. In this context it can be seen that, as the ZPE increases, more impacts on the electron occur each orbit. In turn this means more recoil radiation is emitted by the electron which requires the electron to move closer to the nucleus.

14. Changing Orbit Radii in Atoms

In clarifying what this means for atomic orbits, we note that the outermost orbit of an atom is effectively the series limit for the continuum of the spectral lines where an electron possesses zero energy. Since this limit depends on the quantity e^2/ε, which is unchanging, then the outermost, or zero energy orbit for any given atom is fixed. But since the lowest orbit radius becomes less, and all other orbit radii change proportionally, then all the orbits have increased their distance apart. Therefore, there is a greater energy difference between the orbits as well as each orbit having an energy whose magnitude is intrinsically greater. In turn, this means that electron transitions between orbits will emit more energy. The outcome is that an atom's characteristic spectral lines will all be shifted proportionally towards the blue end of the spectrum as time increases.

This effect is seen in light from galaxies more distant than our Local Group. The further away they are, the further towards the red end of the spectrum their spectral lines are shifted. Thus as we approach our own neighborhood in space the bluer the light becomes. This effect is usually attributed to either a Doppler shift caused by receding galaxies, or by cosmological expansion stretching the wavelengths of light in transit. However, other evidence discussed in detail in references [16, 17] shows that this interpretation does not fit all the data. Since Narlikar and Arp's static, slightly oscillating model for the cosmos is adopted here, the progressive redshifting of light from progressively more distant galaxies can be attributed to the lower energy density of the ZPE in the earlier days of our cosmos. Thus, as the ZPE strength built up with time, atomic orbit radii became smaller. This resulted in bluer light being emitted from atoms as time progressed.

15. Smooth or Quantized Redshifts?

The process whereby all atomic orbit radii get smaller with increasing ZPE strength could potentially happen in one of two ways. First, the change in radii could be a smooth process since the ZPE increases smoothly. In this case a smoothly decreasing redshift would result as time increased. The second option is that it could happen in jumps if orbit radii are quantized. This process would result in quantized redshifts, that is, redshifts which became less with time, but in steps rather than smoothly. Thus the redshift would remain fixed until a threshold was crossed in ZPE strength, and then there would be a step-like drop in the value of the redshift. The process would then repeat resulting in a quantization of the redshift measurements. There is a large amount of data from astronomy that support this contention, some of which has been outlined by Arp [33] and others. [34, 35]

The second option, the possible quantization, now needs to be formalized mathematically. Because the mathematical model of the Bohr atom often gives results that are numerically correct with less complicated procedures than more sophisticated models [36], that model is employed here. The two main equations governing the behavior of this model of the atom are: [37]

$$mvr = n\hbar \tag{14}$$

$$mv^2 r = e^2/\varepsilon = \text{constant} \tag{15}$$

In (14) and (15) we again have the electron rest mass as m, its tangential velocity in orbit as v, and the radius of the orbit as r. Also, h is Planck's constant, e is the electronic charge and ε is the electrical permittivity of free space. It is known that atomic orbits can only change in jumps, or are quantized. One often quoted reason is that the de Broglie wave pattern of the electron must be maintained and not destructively interfere. Only those orbits which maintain this condition are viable. On this basis, let us now assume that, in a varying ZPE scenario, orbit radii, r, can similarly only change in jumps such that

$$r = r_o/N^2 \tag{16}$$

Here, r_o is the original orbit radius, which is a fixed quantity dependent on e^2/ε, and N is the redshift quantum number which is a fixed quantity within the interval between jumps. However, at the jump, when the ZPE has built up sufficiently to allow an orbit radius change, N increases by one integer value, so that N takes on the values of 1, 2, 3, 4, etc. For the period covered by the interval between jumps, then, we substitute (16) in (14). Since h is proportional to the ZPE strength, U, while m is proportional to U^2, we have the result that orbit velocity

$$v \sim 1/U \tag{17}$$

Therefore, as the ZPE strength builds up with time, the velocity of the electron slows down. Substitution of (16) and (17) into (15) shows that the required constancy is also maintained even though m and v are varying.

16. Considering the Quantum Jump

We now need to consider what happens at the quantum jump when the strength of the ZPE has built up sufficiently to allow the orbit radius to change. This ZPE build-up will result in the mean free path of the electron between collisions becoming sufficiently shorter so that a new orbit radius can be adopted. Orbit radii are described by the Bohr quantum number, n, so that n increases for orbits increasingly distant from the nucleus. Therefore, since orbit radii will undergo a discrete decrease at the quantum jump with time increasing, then we can put

$$n = n_0/N \tag{18}$$

where n_0 is the quantum number that applied to the original radius, r_o. At the same time, there will be a discrete increase in the velocity of the electron, so that

$$v \sim v_j N \tag{19}$$

where v_j is the velocity at the instant prior to the jump.

Now at the instant of the jump, there is an infinitesimally small change in the strength of the ZPE and hence infinitesimally small changes in h and m, while e^2/ε remains a fixed quantity. For all practical purposes, this means that h, m, and e^2/ε are unchanged as the jump occurs. Substitution of (16), (18) and (19), which pertain at the time of the jump, into equations (14) and (15) then reveals that the physical conditions match the mathematical requirements.

We can go on from there to note that the energy, E, of any atomic orbit, n, is given by [37]

$$E = -2\pi^2 \left(e^2/\varepsilon\right)^2 \left(m/h^2\right)\left(1/n^2\right) \tag{20}$$

By inserting the results of (18) in (20) we obtain

$$E = -2\pi^2 \left(e^2/\varepsilon\right)^2 \left(m/h^2\right)\left(N/n_o\right)^2 \tag{21}$$

We recall that (e^2/ε) is unchanging in a varying ZPE scenario and that m is proportional to h^2 under these conditions. Therefore, (21) indicates that in the interval between jumps the energy of a given orbit is constant since both n_0 and N remain fixed. At the quantum jump, (e^2/ε) remains unchanged. Furthermore there is only an infinitesimally small change in m and h so that (m / h^2) remains fixed. The only variation that does occur is that N increases by one so that the numerical value of the energy increases at the jump.

17. Photon Energies and Quantum Jumps

In addition, it is the energy difference between orbits that is emitted as a photon of light, with energy E_p, as an electron falls from an outer orbit, s, to an inner orbit, n. This difference is usually written as [37]

$$E_p = 2\pi^2 \left(e^2/\varepsilon\right)^2 \left(m/h^2\right)\left[\left(1/n^2\right) - \left(1/s^2\right)\right] \tag{22}$$

Substituting $(N/n_0)^2$ for $(1/n)^2$, and $(N/s_0)^2$ for $(1/s)^2$, we obtain

$$E_p = 2\pi^2 \left(e^2/\varepsilon\right)^2 \left(m/h^2\right)\left[\left(N/n_o\right)^2 - \left(N/s_o\right)^2\right] \tag{23}$$

which becomes

$$E_p = 2\pi^2 \left(e^2/\varepsilon\right)^2 \left(m/h^2\right) N^2 \left[\left(s_o{}^2 - n_o{}^2\right)/n_o{}^2 s_o{}^2\right] = KN^2 \tag{24}$$

where K is some constant since (m/h^2) is constant, (e^2/ε) is invariant, and both n_0 and s_0 are fixed. Therefore in the interval between jumps, the energy of the emitted photons will remain unchanged. But at the quantum jump, the energy of the emitted photons will increase by the factor N^2.

The energy of emitted photons, E_p, is given by the standard formula

$$E_p = hc/W = KN^2 \tag{25}$$

Here, W is the wavelength of the emitted photon and the second part of the equation follows from (24). In equation (25), the term hc occurs, where c is the speed of light. In a situation where the ZPE is increasing, both data and theory indicate that the quantity hc is invariant throughout the cosmos. Recent experimental evidence supporting this, and the related constancy of the fine structure constant, can be found in [32].

Since it has already been determined that h is varying in proportion to the strength of the ZPE, the invariance of hc carries with it the attendant implication that c must change in inverse proportion to the ZPE strength. This has been examined in detail in references [14, 15, 16, 17, 38]. In those references, the variation in the other main physical quantities affected by the ZPE, including c, and the experimental evidence supporting these changes, has been examined. Thus, in (25), since both hc and K are constant, it follows that emitted photon wavelengths, W, are proportional to $1/N^2$, so that:

$$W \sim 1/N^2 \tag{26}$$

Therefore, in the intervals between jumps, since N is constant, the emitted wavelengths in a wave-train of light will also be constant. A word of additional explanation may be important here. In transit through the vacuum, as the ZPE increases uniformly, the whole emitted wave-train of light slows down uniformly. The wave-trains in transit behave like a locomotive with carriages of a fixed length. As the locomotive slows down (like the speed of light), the carriage length (the wavelength) remains the same, but the number of carriages passing a given point per unit time (the frequency) is lower in proportion to the speed of the train. Thus emitted wavelengths remain fixed in transit. This condition is an observational fact pointed out by R T Birge in 1934 [39] when the experimentally determined value of c had been measured as dropping consistently for over 60 years and was the object of discussion in the scientific literature. [40]

Returning to equation (26) we note that, at the quantum jump, the value of N increases to the next integer. But the standard definition of the redshift of light from distant galaxies is

$$W_b/W_a = (1+z) \tag{27}$$

where W_a is the reference wavelength in our laboratories now, and W_b is the wavelength of light emitted from a distant galaxy. If we substitute the proportionality from (26) into (27) we obtain

$$(1+z) = N_a{}^2/N_b{}^2 = r_b/r_a \tag{28}$$

Here, N_a is the redshift quantum number for the reference wavelength in our laboratories and N_b is the redshift quantum number for the light emitted by the distant galaxy. The second equality then follows from equation (16) where we substitute r_a for the laboratory electron orbit radius in the laboratory and r_b for the electron orbit radius at the distant galaxy.

18. How Many Quantum Jumps?

William Tifft and Halton Arp have provided the data to make calculations using (28). Tifft noted that the smallest redshift change that he could discern from his measurements was 8/3 km/s. [34] Let us now take this as representing neighboring quantum changes of $(N_a = N_b + 1)$ between us and a nearby galaxy. This gives a change in z of (2.667/299792). We therefore have $(1 + z) = 1 + (2.667/299792) = 1.000008896 = N_a{}^2/N_b{}^2$. If we assume that this change represents one quantum jump in our near vicinity, then calculation reveals that this condition will hold for a quantum jump from $N_b = 224815$ to $N_a = 224816$. Thus, it can be seen that the data suggest there have been

224,816 quantum jumps since the inception of the cosmos, since this is the current quantum number for us.

19. Reproducing Arp and Tifft's Results

We are now in a position to see how this approach checks out against the quantized redshift data of Tifft and Arp. Using the above method, two quantum jumps will be about 5.33 km/s when represented as a velocity. In this case our quantum number, N_a, remains the same, but N_b differs from N_a by two and so is 224814. When a difference of three quantum jumps is involved, so N_b = 224813, the 'velocity' is 8 km/s. For a difference of 6 quantum jumps, the velocity will be 16.0 km/s, while 9 jumps is 24.0 km/s, and 14 is 37.34 km/s. It will also be observed that a difference of 27 jumps gives us 72.0 km/s; 54 jumps gives 144 km/s; 81 jumps gives 216 km/s and 108 jumps gives us a velocity of 288 km/s. It is of importance to note that each one of these quantum jumps has been documented by either Arp [33, 41] or Tifft [34] or both, and the sequence has been very difficult to reproduce theoretically.

In addition, Arp [33] has noted that the prominent quantization of 37.5 km/s picked up by Guthrie and Napier occurs 23 times as we go out from our Local Group of galaxies to the Virgo cluster. This is picked up as a systematic difference of 14 quantum jumps with a resultant 37.34 km/s periodicity on the approach used here. The difference of 0.16 km/s is more than covered by the errors in redshift measurement. The highest accuracy for redshift measurements that has been claimed by Tifft [34] was from the work of Brian Murray Lewis. [42] That redshift error was 0.1 km/s, which is smaller than the difference mentioned above. However the more usual figures are the 2 km/s error mentioned on a number of occasions by Arp. [33, 41]

However, it is more compelling than that. The initial result of Guthrie and Napier on 106 spiral galaxies in 1991 was indeed 37.5 km/s. [43] By November of 1992, a further 89 spiral galaxies had been examined and a quantization of 37.2 km/s emerged. [44, 45] If the average of 37.2 and 37.5 is taken, the result is 37.35 km/s, which is very nearly the 37.34 km/s predicted here. In other words, the increasing ZPE approach to redshift quantization is yielding results which are in very close, if not exact, agreement with all the published data.

There is one more point that tends to confirm the approach adopted here. Tifft had observed that in some cases, the redshift of a set of objects had reduced by one quantum jump over a period of time. [34] In other words, the emitted light had become bluer with time by one quantum jump. This is an impossibility on the standard redshift model. However, it fits in very well here with a ZPE increasing with time and the light emitted from atoms becoming bluer as a result.

20. The Behavior of the ZPE with Time

We may make a further deduction. From equation (13), since the ZPE strength, U, is proportional to $1/r$, we can then write

$$(1+z) \sim 1/U \tag{29}$$

Now the equation linking redshift, z, with distance, x, is given by [46]

$$(1+z) = (1+x)\Big/\sqrt{1-x^2} \tag{30}$$

since x is accepted as being proportional to v/c. In (30), the distance x is a fraction designed so that $x = 0$ where the redshift function ends (about 10 million light years out in space away from our galaxy), and $x = 1$ at the distance that corresponds with the inception of the cosmos. Using this method for distance notation overcomes problems with an absolute distance scale, which is still being finalized. The inverse of this equation gives us the build-up of the ZPE strength with time. Since looking out into space at distant galaxies is equivalent to looking back in time, we can substitute orbital time T for distance x so that

$$(1+z) = (1+T)\Big/\sqrt{1-T^2} \sim 1/U \tag{31}$$

In equation (31), U is the strength of the ZPE, and T is in orbital time such that $T = 1$ at the origin of the cosmos while we have $T = 0$ when the redshift function ceases. This is exactly in line with the treatment for x. In terms of distance, $T = 0$ is at a position out in space about 10 million light years away where the redshift function ends. These matters are discussed more fully and explained in detail, along with the data in references [16, 17]. Thus we can state that the behavior of the various atomic quantities which are dependent upon the strength of the ZPE for their magnitude will be related in some way to equation (31). For those quantities mentioned in this paper, we can discern that the proportionalities are as follows:

$$(1+z) = (1+T)\Big/\sqrt{1-T^2} \sim 1/U \sim 1/h \sim 1\Big/\sqrt{m} \sim c \tag{32}$$

21. Conclusion

In conclusion, what we see both observationally and mathematically is first that a Zero Point Energy exists, which is pervasive throughout space. It is responsible not only for the changes in subatomic masses, and their quantum uncertainty of position, but also for the stability of atomic structures. The experimentally measured increase in Planck's constant, h, and atomic masses, m, along with a decrease in the speed of light, c, (all tracked in peer-reviewed literature) indicates an increase in the strength of the Zero Point Energy through time. Changes in the strength of the ZPE will result in changes in the orbit positions and energy of electrons. It is these orbit levels and the energies involved which are responsible for the light emitted from any given atom: the higher the energy level, the bluer the light. Because atoms, like all physical things, resist change, it takes a certain build-up of the Zero Point Energy to force them to adopt a new energy level.

Because the ZPE is essentially homogenous throughout the universe, the response of the atoms is simultaneous throughout the universe. This results in the fact that, when we look at the redshift measurements from ever more distant galaxies, we don't see the measurements progressing smoothly – which is certainly what should be expected if the redshift were due to universal expansion – but we see the measurements clumped into groups. Hubble himself expressed doubts throughout his life that the red shift was due to universal expansion. [47] The data we have today strongly support those doubts, indicating the universe is not now expanding, although it currently appears to be in a gently oscillating mode.

The red shift of light from distant galaxies is therefore not a result of expansion, but, on the contrary, the result of a build-up of the Zero Point Energy through time. This approach allows us to determine from the data that there have been 224,816 quantum jumps since the inception of the cosmos. Given that figure, this approach then predicts, and predicts exactly, all the quantization 'velocities' that Tifft and Arp have discussed, namely 2.667, 5.33, 8.00, 16.0, 24.0, 72.0, 144, 216, and 288 km/s. [33, 34, 41] In addition, the 37.5 km/s and 37.2 km/s quantizations picked up by Guthrie and Napier [43, 44, 45] are predicted as being 37.34 km/s, which is right in the middle of the range. This is also well within the error margins of the data, which may have been as high as 2 km/s in some cases.

Because there was a time when the Zero Point Energy had finished building and has since remained relatively steady on its own feedback cycle, we do not see quantized red shift measurements within our own Local Group of galaxies. Since the further we look out in space, the more we are also looking back in time, then the point outside our Local Group where the redshift ceased represents the time when the ZPE stabilized. It is within our Local Group that we can see Doppler shifts due to motion, and it is those red and blue shifts which seem to change smoothly.

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