# Zero Point Energy and Relativity

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A wide-ranging review of the origins and successes of Relativity, both Special and General, is undertaken. The Michelson-Morley (M-M) experiment is briefly examined, and the properties of the "ether" that this suggested is noted. These properties are then re-examined in conjunction with a developing branch of physics, Stochastic Electro-Dynamics (SED). SED physics emphasizes a real, not virtual, vacuum Zero Point Energy (ZPE). Our knowledge of how the vacuum ZPE behaves fulfils all the criteria required by the M-M experiment. Furthermore, it is shown that the main predictions of Einstein's Special and General Relativity easily emerge using SED physics and the ZPE. These results are obtained with simple mathematics and intuitive concepts rather than the elaborate reasoning and difficult equations that Einstein required. A deeper understanding of the nature of mass and gravity emerges from the SED equations, along with some insights into gravity waves and their speed. A suggested explanation, involving both the SED approach and plasma physics, is given for the lack of gravitational lensing of stars near the object at the center of our galaxy.

## 1. Introduction

### 1.1. Why Relativity was Introduced

At the beginning of the twentieth century, it was assumed that there had to be a medium filling the entire vacuum of space so that light waves could be transmitted. This "light-carrying medium" was called the ether or "aether". It was assumed that the ether was universally at rest. As a result of the orbital motion of the Earth through this stationary ether, it was then thought possible to detect the "ether drift" past the Earth. The simplest way of doing this was to send beams of light in different directions and measure the difference in light speed as it traveled either with or against the ether drift by using fringe shifts in an interferometer. This experiment could be performed since the orbital speed of the Earth is about 30 km/s, and this velocity difference was measurable by the proposed interferometer fringe shifts. Michelson and Morley (M-M) performed this experiment in 1887, and the maximum drift recorded, about 8 km/s, was considered by most to be near the error limits of the equipment. The results of the experiment as plotted by Michelson are shown in Fig. 1 [1].

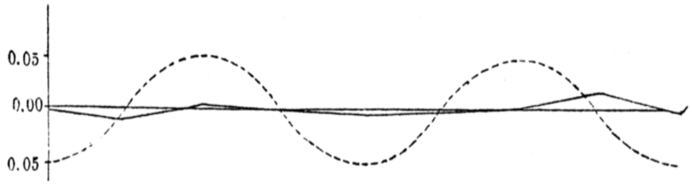

**Fig. 1.** The official results of the Michelson-Morley experiment to detect the presence of an ether (Fig. 4 in their report). The motion of the Earth in its orbit is about 30 km/s. The dashed curve represents one-eighth of this expectation. The experiment itself gave the solid line of small amplitude about the $x$-axis.

Michelson concluded from his experiment in 1887 that:

> *The interpretation of these results is that there is no displacement of the interference bands. The result of the hypothesis of a stationary ether is thus shown to be incorrect, and the necessary conclusion follows that the hypothesis is erroneous.* [2]

In order to account for this lack of motion through the stationary ether, a number of proposals were made by a variety of physicists. These included Lorentz [3] in 1904 and Einstein in 1905, who published their respective theories of relativity in those years.

### 1.2. Lorentz's and Einstein's Relativity Compared

Einstein explained the M-M results in Special Relativity (SR) by proposing (1) that there was no absolute frame of reference anywhere in the universe; (2) that the speed of light was an absolute constant; and (3) that mathematical transformations had to be applied to time, space, and mass and had to be applied both ways when comparing two objects in motion. By contrast, Lorentz (1) did not have the restriction regarding an absolute frame of reference; (2) did not require a constant speed of light; and (3) proposed that mathematical transformations only apply one way and that only clocks, meter sticks, and momentum are affected, not time, space, and matter. There is an important distinction in this latter point. For example, SR requires time itself to be affected by velocity or gravitational potential. By contrast, in Lorentz Relativity (LR) nothing ever happens to time itself, just to certain types of clock attempting to keep time. In a somewhat similar way, an increase in temperature may lengthen the pendulum of some clocks and affect their time-keeping, but not the actual time itself. LR thus accepts that other types of clock exist for measuring time that may be unaffected by speed or potential. In contrast, SR requires not only time itself to be affected by velocity or potential, but mass and length as well. Just recently, an entirely new approach to the problem was attempted and the early results suggest that Lorentz was basically correct [4].

Einstein made use of his required length transformation of space to overcome the problem of the lack of fringe shifts. He claimed that the contraction of the arms of the interferometer in the direction of travel made the interferometer arms shorter by just the amount needed to compensate for what was expected to be a longer travel time for light through the moving ether. Even as late as 1929 and 1931 in the Rhodes Lectures, Einstein claimed that the aether existed, but that his SR overcame the problems with the observations in an aether-filled universe.

However, there is another logical explanation for the lack of fringe shifts in the Michelson-Morley experiment. The absence of the fringes may mean that the Earth apparently has no motion relative to the ether or light-carrying medium. This was a problem in 1905. But if we now exchange the old ether concept for the actual Zero Point Energy (ZPE) which is known to fill the cosmos, and through which light propagates, we can obtain a satisfactory answer to the fringe shift problem. This option first became available through Planck's work, in 1911, but did not really emerge until 1962.

### 1.3. 3. Developments in Physics

In 1911, Planck published his 'second paper' in which the existence of an all-pervasive vacuum Zero Point Energy (ZPE) was shown to be the reason why quantum uncertainty exists.[5] Investigations by Einstein and Stern in 1913 and Nernst in 1916 gave further insights to this proposition, which was appearing very attractive [6,7]. The presence of the ZPE was verified experimentally by Mulliken in 1925. However, these concepts were ignored for a number of years as papers were being written and published using Planck's first paper of 1901, which presented a purely theoretical concept (which Planck himself was unhappy about from the beginning [8]). Planck's first theory, and these resulting papers, led to the birth of Quantum Electro-Dynamics (QED), or Quantum Physics as we know it today, which only envisages a virtual, not a real, ZPE.

Then, in 1962, de Broglie, who had written one of those early papers which gave rise to quantum physics, suggested that, after all, perhaps physics had missed something important. He suggested re-examining the material in Planck's second paper which stated that the Zero Point Energy was a real physical entity which caused the observed quantum effects [9]. In this second paper, the constant $h$ (subsequently called Planck's constant) was a scale factor to bring theory into line with experiment. The result is that $h$ is a direct measure of the strength of the ZPE. Thus, if the ZPE strength, $U$, changed, so did $h$, in direct proportion. This can be written as

$$h \sim U \quad . \tag{1}$$

In Eq. (1) and throughout this paper, the symbol " ~ " means "is proportional to."

This re-examination of the reality of the ZPE is ongoing and has produced the branch of physics known as Stochastic Electro-Dynamics (SED). The SED approach to quantum phenomena holds the promise of explaining quantum effects via the action of a real ZPE. It should also be noted that it has also produced results that unify the four forces of physics.

### 1.4. The Zero Point Energy (ZPE)

The Zero Point Energy exists as all-pervasive electromagnetic waves of all wavelengths throughout the universe. It exists independently of any thermal radiation, even at zero degrees Kelvin, and is composed of many more waves of short wavelengths than long. The precise description is that it has a frequency-cubed spectrum. This means that on the scale of feet or meters there are very few ZPE waves. However, on smaller scales, the number of short-wavelength ZPE waves increases significantly. The smallest of the ZPE's more numerous short waves approaches what is called the Planck length cut-off. The Planck length of $10^{-35}$ meters is the smallest length possible in our universe. Beyond this limit, the vacuum itself breaks down and space assumes a granular structure, like a fabric. Any waves with a shorter wavelength than the Planck length are simply absorbed into the structure of the vacuum.

By the time the scale of atomic size is reached, the characteristic phrase used to describe the ZPE is "the seething vacuum." Every atom is immersed in this turbulent sea of activity. The fact that cooling alone will never freeze liquid helium is one of the strong indications of the existence of the ZPE. Unless pressure is applied, ZPE fluctuations at the atomic level prevent helium's atoms from getting close enough to permit solidification.

In electronic circuits, such as microwave receivers, ZPE fluctuations cause a random "noise" that places limits on the level to which signals can be amplified. This "noise" can never be removed no matter how perfect the technology.

Further evidence comes from what is called the Lamb shift of spectral lines. ZPE waves slightly perturb electrons in atoms so that, when electrons make a transition from one state to another, the atom emits light whose wavelength is shifted slightly from the position that line would have had if the ZPE did not exist.

The Casimir effect also indicates the existence of the ZPE and that it is comprised of electromagnetic waves. This effect can be demonstrated by bringing two large metal plates very close together in a vacuum. When they are close, but not touching, there is a small but measurable force that pushes them together.

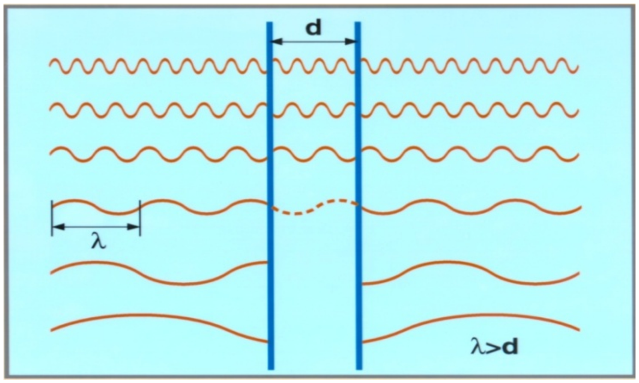

**Fig. 2.** The Casimir Effect. The two vertical blue lines represent the two parallel metal plates in a vacuum. The distance the plates are apart is d. The top three series of waves have wavelengths, λ, which are short enough to fit exactly between the plates. The bottom two series of waves have wavelengths greater than d, and so do not fit between the plates. This bottom two series of waves exert an excess pressure on the plates, which pushes them together. The wave series third from bottom has the largest wavelength that will fit exactly between the plates. All longer waves are excluded and exert a pressure from the outside.

The explanation of this effect comes straight from classical physics. As the metal plates are brought closer, they exclude all wavelengths of the ZPE except those which fit exactly between the plates. In other words, all the long wavelengths of the ZPE have been excluded and are now acting on the plates from the outside. Because there are no long waves acting from within to balance the pressure, the combined radiation pressure of these external waves then forces the plates together. In November 1998, Mohideen and Roy reported verification of the effect to within 1% [10].

### 1.5. Motion through the ZPE is Undetectable

Every source of radiation has a characteristic intensity distribution with frequency. That is to say, every radiation source will have its intensity (the number of waves) rising to a maximum in a given frequency range, producing a characteristic curve. Because of its frequency-cubed distribution, the ZPE has an enormous energy density. In discussing this, Timothy Boyer in his article "The Classical Vacuum", has this to say about the ZPE, explaining why any motion through the ZPE will be undetectable.

> *It turns out that the zero-point spectrum can only have one possible shape…. [T]he intensity of the radiation at any frequency must be proportional to the cube of that frequency. A spectrum defined by such a cubic curve is the same for all unaccelerated observers, no matter what their velocity; moreover, it is the only spectrum that has this property.* [11]

Remember that any motion through the ZPE produces a genuine Doppler shift. Because of this, radiation will appear shifted towards the blue end of the spectrum for an approaching observer or towards the red end of the spectrum for a receding observer. Here is what Boyer goes on to say:

> *The Zero Point Spectrum is independent of the observer's velocity because of compensating changes in frequency and intensity. When an observer is approaching [any] source of radiation, all frequencies are shifted to higher values [that is, become bluer] and all intensities increased; moving away from any source has the opposite effect. Thus a spectrum that has a peak in the green region for a stationary observer has a larger blue[r] peak for an approaching observer and a smaller red[er] peak for a receding observer. The cubic curve that defines the zero-point spectrum balances the shifts in frequency and intensity. Light that appears green in the stationary frame of reference becomes blue to an approaching observer, but its intensity matches that of the blue light seen by an observer at rest. By the same token, green light is shifted to red frequencies for a receding observer, but its intensity is diminished accordingly.* [11]

In this way, the distribution of intensity with frequency for the ZPE remains the same no matter what your velocity is. In other words, because of its frequency-cubed distribution, the ZPE is said to be Lorentz invariant, meaning that the velocity through the ZPE cannot, in itself, be detected. In an examination of this, Davies and Unruh found that, while velocities through the ZPE cannot be detected, acceleration can be detected, but that acceleration has to be of the order of $10^{21}$ times that of Earth's gravity before the effect becomes significant enough to observe. This is called the Davies-Unruh effect. Therefore, for all practical purposes, the motion of the Earth, or any other body, through the ZPE cannot be detected.

There is another reason, also rooted in the ZPE, why the Earth's motion through the "ether" is undetectable. The local gravitational field of the Earth can be shown to be an augmentation of the ZPE in our vicinity brought about by the presence of oscillating point charges. The impacting waves of the ZPE jiggle these point charges or "partons", which make up all matter, and these charges emit recoil or secondary electromagnetic radiation [7]. This secondary field locally boosts the strength of the ambient ZPE around massive objects. This local field of the (augmented) ZPE has no motion with respect to the Earth's center of mass since it originates with the presence of the Earth's mass. Thus, the Michelson-Morley experiment will show no fringe shifts.

However, the Earth does rotate with respect to its own gravitational field, and hence with respect to the augmented ZPE. This motion does produce fringe shifts, known as the Sagnac effect, that were first seen in 1913 when a rotating platform was used for the experiment. It was replicated in the Michelson-Gale experiment of 1925 using the Earth's own rotation. The ZPE approach is thereby shown to be a far simpler explanation for the lack of fringe shifts in the Michelson-Morley experiment than the complication of SR.

### 1.6. The ZPE and the Speed of Light

The Michelson-Morley experiment indicated that the speed of light in any direction through the Zero Point Field is always the same. This experimental result agrees with the SED approach. Because the ZPE is made up of electromagnetic waves of all wavelengths going in all directions simultaneously, the points where these waves intersect result in a concentration of energy. These energy concentrations allow the formation of pairs of virtual particles, such as electron-positron pairs. The virtual particles snap into and out of existence almost, but not quite, instantaneously. During their brief existence they can absorb a light photon, and when the positive and negative of each pair snap back together, the photon of light is released to continue on its way. Even in a very small volume of space, the number of virtual particle pairs is enormous. From the "jiggling" of electrons and their Compton frequency, it can be deduced that one cubic meter contains at least $10^{42}$ virtual particle pairs.

Photons of light must interact with these particles in their path. Thus, the greater the strength of the Zero Point Energy, the greater the numbers of virtual particles that exist in any given volume of space at any given time. As a result, light photons are slowed even more because space has effectively become "thicker" with virtual particles. Thus, in a manner similar to light slowing in water compared to air, light will also slow with a stronger ZPE. In fact, it can be shown that the speed of light, $c$, is inversely proportional to ZPE strength, $U$. This is done in detail in "The Zero Point Energy, Light and Time" [12], which establishes that

$$c \sim 1/U \quad . \tag{2}$$

When Eqs. (1) and (2) are considered together, the inescapable result is that

$$hc = \text{const} \quad . \tag{3}$$

Since the strength of the Zero Point Energy also determines the electromagnetic properties of the vacuum, it was shown in the same paper that

$$\varepsilon \sim \mu \sim U \quad , \tag{4}$$

where $\varepsilon$ is the permittivity of the vacuum and $\mu$ is its magnetic permeability. Therefore, since the standard equation reads

$$c^2 = \frac{1}{\varepsilon\mu} \; , \tag{5}$$

then it follows that the speed of light, $c$, behaves as follows:

$$c \sim \frac{1}{\varepsilon} \sim \frac{1}{\mu} \sim \frac{1}{h} \sim \frac{1}{U} \; . \tag{6}$$

Since the ZPE is uniform through all space at any given time, the speed of light will also be uniform throughout all of space at any given time. In other words, light speed is not dependent on direction of travel. It is the universal changes in the strength of the ZPE which will affect the speed of light, not direction of travel. This explains the result of the M-M experiment, which shows the speed of light to be the same in all directions.

## 1.7. Zero Point Energy Behavior over Time

There are compelling reasons to believe that the strength of the Zero Point Energy has changed with time. Briefly, it can be said that the original expansion of the universe invested an energy into the fabric of space which ultimately appeared as the ZPE. Hydrogen cloud data suggest that the expansion slowed and ultimately stopped so that the cosmos became static. The ZPE built up to its full value after expansion ceased. Narlikar and Arp have shown that a static cosmos will be stable against collapse but will oscillate slightly [13]. This oscillation results in a slightly changing ZPE through the current time, since a fixed quantity of energy in a smaller volume gives a higher energy density. The converse is also true. All these concepts are discussed in more detail in "The Zero Point Energy, Light and Time" [12].

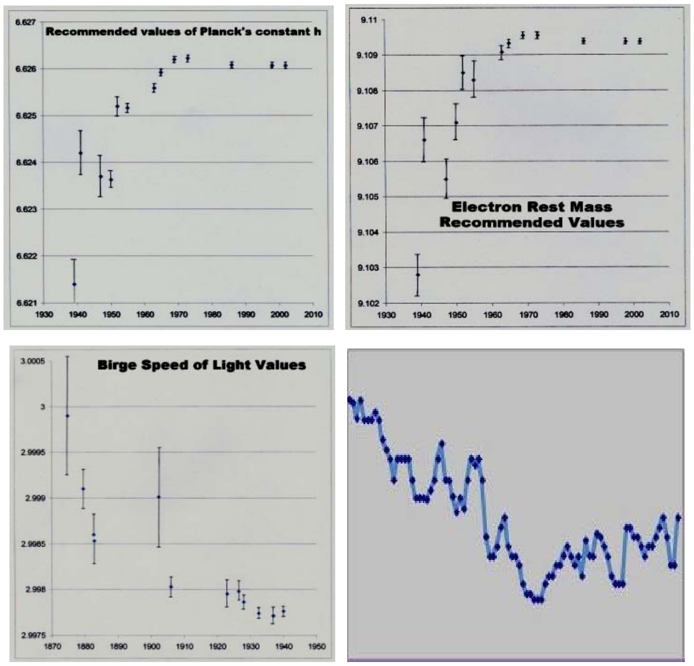

**Fig. 3.** Clockwise from top left—Recommended values of Planck's constant, $h$; electron rest mass, $m$; the run-rate of atomic clocks, $t$, with orbital time horizontally; and light-speed, $c$ [12].

The experimental data support a changing ZPE strength. Data show that atomic masses, $m$, were increasing synchronously with Planck's constant, $h$, up to 1970. Conversely, light speed, $c$, and atomic clock rates, $t$, were decreasing up to 1970. The data are summarized by the graphs in Fig. 3. They suggest that the ZPE strength was increasing until 1970 as part of the oscillation of a static universe which Narlikar and Arp proposed. A reversal of the trend of each of these measurements starting in 1970 indicates the oscillation was also reversing at that time.

Although the speed of light changes with a change in the Zero Point Energy, this does not mean a change in wave lengths. Visualize an extremely long series of waves of fixed wavelength extending to us from some very distant astronomical object in a vacuum in which the ZPE is smoothly increasing. Because the ZPE is increasing homogeneously throughout the whole cosmos, the whole train of waves will be slowing simultaneously although the horizontal distance between the wave crests remains the same. Only the frequency, the number of waves passing a given point in a unit of time, will drop. It is rather like a long train slowing down. The size of the individual cars does not change, but the number of cars passing the observer becomes fewer in any given amount of time.

Therefore, in the wave equation $c = fW$, where $c$ is light speed, and $f$ is frequency, the wavelength $W$ remains constant. This means that

$$f \sim c \; . \tag{7}$$

Martin and Connor point out that there is no refraction or "bending" of the light beam if the wavelengths remain constant or are not "bunched up" in the new medium [14]. This means that there will be no refraction of light in transit with any universal ZPE changes, since wavelengths remain constant with all of them.

## 1.8. The ZPE Replaces the Old Ether

While ZPE provides something like an all-pervasive "ether", it is one whose properties are vastly different from those imagined by physicists when the Michelson-Morley experiment was done. It is this light carrying medium or "ether" that exists in reality. The ZPE is Lorentz invariant, simply meaning you cannot distinguish any motion through it relative to itself, and the speed of light is the same in all directions. If all this had been known then, the results of the M-M experiment could have been readily explained. Interestingly, this would also mean that the necessity for Einstein's theory of relativity would have been eliminated.

Effectively, then, there were three choices when the M-M results came in.

1. The results can be explained by changes in the properties of matter, so that a moving object undergoes length contraction, mass increase, and time dilation. This was the approach of Fitzgerald and Lorentz.
2. Einstein proposed the second option, namely, that instead of physical changes in matter these same effects were due to changes in the properties of space and time. This meant that the absoluteness of space and time, which had been introduced by Newton, had to be discarded.
3. The third option was to conclude that the ether had entirely different properties than those imagined by scientists when the M-M experiment was done.

Although the Fitzgerald and Lorentz propositions (1) were complicated, Einstein's solution to the problem (2) was even more complicated and esoteric. The third option was, and is, far simpler than either of the other two. History, experiment, data, and theory have all shown that the third option would have been the simpler, better way to go. It has been discovered that the "ether" of the ZPE has a frequency distribution which makes it Lorentz invariant, so motion through this "ether" cannot be detected. In addition, the speed of light depends only on the energy density of the ZPE "ether", which is independent of the direction of travel. The mathematical models proposed by Fitzgerald, Lorentz, and Einstein were unnecessarily complex. For that reason alone, they should have been regarded with suspicion and the third option given some serious thought. The existence of the real, not virtual, Zero Point Energy gives good physical reasons why these things happen, without resorting to esoteric mathematics which are not connected to reality.

## 1.9. Special Relativity and Maxwell's Equations

It is customary procedure to derive Maxwell's equations describing electromagnetic phenomena from relativity. This gives relativity additional credibility. Because of this approach, it may be objected that Eq. (5) is obtained on the assumption that $\boldsymbol{c}$ is a constant. But, as shown by Bleany and Bleany [15], (5) can be readily derived without any initial assumptions about the behavior of $\boldsymbol{c}$, $\boldsymbol{\varepsilon}$, or $\mu$, just as Maxwell himself did many years before relativity was introduced. This is done by obtaining a set of four simultaneous partial differential equations based on

1. Gauss's theorem applied to electrostatics,
2. Gauss's theorem applied to magnetic fields,
3. Faraday's and Lenz's law of electromagnetic induction,
4. Ampere's law for magnetomotive force.

It can be shown that the equations from 1. and 2. become [15]

$$\varepsilon \vec{\nabla} \bullet \vec{\mathbf{E}} = 0 \tag{8}$$

and

$$\mu \vec{\nabla} \bullet \vec{\mathbf{H}} = 0 \tag{9}$$

for a vacuum, and so are independent of any variations in $\boldsymbol{\varepsilon}$ and $\mu$. Further, it can be shown that the equations from 3. and 4. eventually become

$$\vec{\nabla} \times \vec{\mathbf{E}} = -\mu \frac{\partial \vec{\mathbf{H}}}{\partial t} \tag{10}$$

and

$$\vec{\nabla} \times \vec{\mathbf{H}} = \varepsilon \frac{\partial \vec{\mathbf{E}}}{\partial t} \ . \tag{11}$$

Provided that $\mu$ varies slowly with respect to $\vec{\mathbf{H}}$, and that $\boldsymbol{\varepsilon}$ varies slowly with respect to $\vec{\mathbf{E}}$, this formulation is still valid. The general wave equation which 1, 2, 3, and 4 reduce to then has the form

$$\nabla^2 \vec{\mathbf{A}} = \frac{1}{v^2} \frac{\partial^2 \vec{\mathbf{A}}}{\partial t^2} \ , \tag{12}$$

where

$$v^2 = \frac{1}{\mu \varepsilon} = c^2 \ . \tag{13}$$

and **A** is some scalar or vector quantity. Again, this equation is valid for describing wave motion provided that $v^2$ varies slowly with respect to **A**. Since a ZPE change manifests as a change in $\varepsilon$, $\mu$, and $c$, as well as proportional changes in atomic clock rates, this condition is always maintained. In addition, another derivation of Maxwell's equations shows an almost infinite variation in $\varepsilon$, $\mu$, and $c$ is permitted in the system of units that Maxwell himself was using [16]. The analysis here therefore indicates that Maxwell's equations can be satisfied with a varying ZPE, $\varepsilon$, $\mu$, and $c$ in a manner independent of relativity.

## 1.10. Einstein's Two Postulates

Einstein's basic postulate, from which the theory of relativity takes its name, is that there is no absolute frame of reference anywhere in the universe. This appeared to be true for some time. However, in 1964 the Cosmic Microwave Background Radiation (CMBR) was discovered by Penzias and Wilson. In contrast with relativity theory, the physical reality of the CMBR has provided an absolute rest frame against which the actual velocity of the solar system, our galaxy, and our Local Group of galaxies can be measured.

In his book **Astrophysical Concepts**, Martin Harwit writes:

> *Current observations indicate that the universe is bathed by an isotropic bath of microwave radiation. It is interesting that the presence of such a radiation field should allow us to determine an absolute rest frame on the basis of local measurement.* [17]

Using the CMBR, the velocity of our Solar System has been measured as 390 km/s towards the constellation of Leo, and our Milky Way galaxy is moving at 600 km/s in the direction of the Centaurus cluster. Harwit then goes on to salvage what he can for relativity by saying

> *[T]he establishment of an absolute rest frame would emphasize the fact that special relativity is really only able to deal with small-scale phenomena and that phenomena on larger scales allow us to determine a preferred frame of reference in which cosmic processes look isotropic.* [17]

Martin Harwit is correct. The work based on the ZPE also shows that Einstein's equations may be valid in the atomic frame of reference but not in the larger world.

Einstein's second basic postulate, stating that the speed of light is an absolute constant, is also called into doubt by the speed of light experiments that were discussed earlier. Relativity cannot account for these variations in *c* and so declares them to be erroneous. Einstein stated that the speed of light was the uppermost possible speed for anything in the universe. A different approach to relativity, based on Galilean concepts, shows that although there is an upper maximum speed for the cosmos, it need not be the current speed of light. This approach received prominence in "New Scientist" for 1 November 2008. The cover page read *"Why Einstein was wrong about relativity: the speed of light is nothing special."* The article on pages 28-31 carried the bolded comment *"Not only is light not necessary in relativity – there's no room in the theory for it."* Then it goes on to state: *"Light's special position in relativity is a historical accident."* [18] Thus the second basic postulate has also been shown to be problematical. It is possible, however, that this upper maximum speed for the cosmos was the original speed of light, which then slowed as the ZPE strength increased.

### 1.11. That Famous Equation

$E = mc^2$, the equation associated with Einstein, is probably one of the most famous equations in the world. Interestingly, however, this equation did not originate with him. It appears to have been scientific "politics" which led to the idea that the equation was his. Many believe this famous equation is a triumph for relativity theory. But $E = mc^2$ does not depend upon relativity nor does it need any relativistic concepts. It can be obtained in a manner which is entirely independent of both, using simple classical physics. Alfred O'Rahilly did this in **Electromagnetic Theory: A Critical Examination of Fundamentals** [19]. Others such as Thomas G. Barnes, late Emeritus Professor of Physics, University of Texas at El Paso, have similarly derived it [20]. In order to understand what happened, let us look at the events as they unfolded historically.

In 1881, J. J. Thomson was working with the mass of the electron in relation to its electromagnetic energy. In his papers, he showed there was a relationship between electromagnetic energy and the masses of subatomic particles. In 1900, before any ideas of relativity, the work of Henri Poincaré mathematically implied the form of the equation we are familiar with today. Within a few years, physicists Wilhelm Wien in 1900, Max Abraham in 1902, and Hendrik Lorentz in 1904 were all working in this area, using a similar equation relating mass and energy. Their equation was the same as the famous one, but, unlike Poincaré, often had a factor of $4/3$ inserted. Then, in 1904 and 1905, F. Hasenöhrl published several papers which specifically derived a mass-energy conversion statement related to $c^2$. In the first paper [21], a factor of $8/3$ was employed, while his second paper [22] had the factor as the (then) more usual $4/3$. If he had used a slightly modified approach in his calculation, he would have eliminated the fraction and the result would have been the equation as we know it today. It was Max Planck who derived the exact equation from classical physics [23]. So Poincaré had essentially derived the relationship in 1900; Hasenöhrl had approximately derived it in 1904 and was awarded the Haitinger prize of the Austrian Academy of Sciences for it; and Planck derived it exactly in 1907. All these pioneers achieved this without the help of relativity.

In contrast, Einstein's derivation occurred in 1905 in a manner which was linked with relativity. However, as a number of commentators have pointed out, Einstein's derivation was not exact, but was only an approximation. Indeed, in 1907, Planck himself wrote a comment that said

> *Einstein has already drawn essentially the same conclusion [Ann. Physik* ***18****: 639 (1905)] by application of the relativity principle to a special radiation process, however, under the assumption permissible only as a first approximation that the total energy is composed additively of its kinetic energy and its energy referred to a system with which it is at rest.* [24]

Thus, an approximation is all that Einstein achieved; it was not an exact relationship. In addition, the suggestion has been made that even this derivation of Einstein contained an error which invalidated his procedure. One such article by R.A. Herrmann points out that [25]:

> *Indeed, there is a fundamental problem with Einstein's derivation. It mixes stationary and moving energy observations without taking into account the required relativistic alterations. Thus, Einstein's derivation does not actually say anything concrete about what the complete energy change would be as viewed from just one [of the two] platform[s].*[1] *Indeed, actual analysis by Ives* [26] *shows that Einstein forced this result to occur from some sort of prior knowledge and did not derive it.* [25]

The aforementioned physicists working in the early part of the 20th century were not the only ones fueling the discussion. Professor R.A. Herrmann [25] points out that

> *Olinto De Pretto published the expression $E = mc^2$ in the science magazine Atti (Atte) in 1903. ... There is considerable evidence that Einstein was aware of the De Pretto speculation and that this was an additional driving force behind his faulty attempt to derive this expression for radiation, at least. There is also very strong evidence that Einstein never gave De Pretto any credit for his great insight. ... There is also no doubt in my mind that Einstein would have known of the last Hasenöhrl paper since it appeared in the principle journal that Einstein used six months later to publish his own claimed (1905) derivation. ... Einstein would thus have been aware of Hasenöhrl's first paper as well. Poincaré was a very well-known mathematician who had won the first Bolyai prize, a prize that Einstein did not win when nominated by Hilbert….*
>
> *Although his radiation derivation of 1905 was incorrect, [Einstein] still considered himself as having priority over all those that suggested an inertial mass-energy equivalence…. In a paper written by Stark (Physikalische Zeitschrift 8 (1907):881) Stark stated that Planck gave the first derivation for $E = mc^2$. Einstein wrote to Stark in 1908: "I was rather disturbed that you did not acknowledge my priority with regard to the connection between inertial mass and energy. (17 Feb. 1908) (Albert Einstein, Vol. 2, J. Stached, Ed.)…. [T]oday proper credit is not being given to the contributions of Hasenöhrl, Poincaré, Planck and De Pretto.* [25]

The reason for this lack of credit can be laid at the feet of those who supported Einstein. Among them was Max von Laue. He sidelined the early physics pioneers by stating that the inertia of electromagnetic energy was known before their time. Laue continued by saying that the credit for establishing the inertia of all forms of energy, the actual mass-energy equivalence of all matter, goes to Einstein, who was the first to understand this in relation to relativity [27]. With this enthusiastic support for both relativistic concepts and Einstein, it is no wonder that the scientific community generally attributed the equation to him as if it was his own unique achievement and a triumph for relativity. The truth is, it is a derivation from classical physics.

It may be objected that Einstein's relativity has made predictions that proved correct. The implication is that the whole theory must therefore be correct. However, it is important to note that all the major predictions of relativity also follow naturally and intuitively from classical physics using the ZPE approach. Furthermore, this approach uses very much simpler mathematics. Let us look at some of these predictions.

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[1] One platform was moving, the other stationary

## 2. Some Predictions of Relativity

### 2.1. Length contraction

Einstein's theory of Special Relativity (SR) deals with the effects of velocities on moving objects. These effects include length contraction and increases in atomic masses (including the resulting slowing of atomic clocks) as velocities become high.

Incredibly for a theory that is so widely accepted, it seems that length contraction has never been seen directly in any experiment but has only been inferred. Regarding the constancy of lengths in SR, Tom Van Flandern concludes in an article: *"[T]he clear implication of our considerations here is that length contraction is not a physical shortening, but is merely an observational consequence of time desynchronization. In SR, physical bodies do not actually change dimensions."*[28] The whole idea of length-contraction is therefore unsubstantiated and has no experimental backing.

### 2.2. Atomic Mass Increases

In contrast to ideas about length contraction, we have solid observational proof that accelerating an electron (or proton) through a linear accelerator results in an increase in its mass. This has been hailed as proof that relativity is correct. However, the SED approach predicts exactly the same effect as a result of the existence of the ZPE.

SED physics considers the Zero Point Energy itself as the agency that imparts mass to all subatomic particles. For the last 100 years or so, all the equations of physicists describing the behavior of matter have started with massless charged point particles. This picture of every subatomic particle being charged, but massless, posed the problem of how to impart mass to these point charges. QED physicists are looking to the postulated Higgs boson to do this.

However, SED physicists note that the electromagnetic waves of the ZPE impinge upon all these charged, massless particles, which Richard Feynman called "partons". This action of the ZPE causes them to jitter in a random manner similar to what we see in the Brownian motion of a dust particle bombarded by molecules of air. Schrödinger referred to this "jitter motion" by its German equivalent word, *Zitterbewegung*. Dirac pointed out that the *Zitterbewegung* jitter occurs either at, or very close to, the speed of light. This conclusion has been sustained by recent studies, and the term "ultra-relativistic" has been used to describe it [29, 30]. The physical reality of the *Zitterbewegung* was demonstrated experimentally in 2010 with calcium ions by Roos and colleagues (Gerritsma was the lead author of the report) [31].

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 zeropoint 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."*[32] 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 [the ZPE], hence acquiring what we think of as rest mass."*[33]

Mathematical calculations by SED physicists quantitatively support this view. The formulations of Haisch, Rueda, and Puthoff show the parton's atomic mass, *m*, of ZPE origin is given by the equation [34, 35]:

$$m = \frac{\Gamma h\omega^2}{4\pi^2 c^2} \sim U^2 \sim h^2 \sim \frac{1}{c^2} \quad . \tag{14}$$

In Eq. (14), $\omega$ is the *Zitterbewegung* oscillation frequency of the particle, $c$ is the speed of light, $h$ is Planck's constant, and $\Gamma$ is the Abraham-Lorentz damping constant of the parton. The proportionalities in (14) hold because the terms $\Gamma h\omega^2$ which make up the numerator can be shown to remain constant in a changing ZPE scenario, even though the individual terms are ZPE dependent [36, 37]. Analysis there shows that the angular frequency of the particle's jitter is given by

$$\omega = 8\pi^2 f \quad , \tag{15}$$

where $f$ is the particle's Compton frequency.

From (14) it can be seen that energy, *E*, will be conserved with any change in ZPE strength since atomic masses are changing as the inverse square of the speed of light. Thus, energy $E = mc^2$ will remain constant, and the equation is valid for SED physics with a changing ZPE.

Since masses for all subatomic particles comes from the "jiggling" of these particles by the impacting waves of the ZPE, consider what happens with a particle in motion. Because of its motion, the particle is running into more ZPE waves than when it is at rest. An increase in particle mass is then the result. The higher the velocity, the more "jiggling" occurs and the greater the resulting mass. This has been mathematically quantified by SED physicists and yields the same results as relativity.

The rate of ticking of atomic clocks is also implicated in this. The reason is that kinetic energy is conserved in atomic processes [37, 12]. Consequently, atomic particles must move more slowly as they gain mass. If kinetic energy is *E*, then it can be written that

$$E = \tfrac{1}{2}\, mv^2 = \text{const} \quad . \tag{16}$$

As a result, since Eq. (14) shows that atomic masses $m$ are proportional to $1/c^2$, then it follows that atomic velocities $v$ in Eq. (16) must go as

$$v^2 \sim c^2 \quad \text{so} \quad v \sim c \sim \frac{1}{U} \quad . \tag{17}$$

Thus, subatomic particle velocities are proportional to the speed of light $c$ or to the inverse of the ZPE strength $U$. This velocity change affects the rate of atomic processes, including the orbit times for electrons and the rate of escape of particles from nuclear orbitals. This means atomic time varies with changes in mass because the square of the velocity of subatomic particle is inversely proportional to the mass. Thus, any increase in mass would result in a slowing of the atomic clock involved. Therefore atomic frequencies $f$ bear the same dependencies as atomic velocities, so Eq. (17) may be written:

$$v \sim c \sim f \sim \frac{1}{U} \ . \tag{17A}$$

It has been experimentally demonstrated that, after accelerating a short-half-life radioactive particle, the mass has increased and the rate of decay has slowed down. This has been used to show Einstein's theory of Special Relativity is right. But exactly the same result is predicted from SED physics because there is increased jiggling of the parton that occurs with acceleration through the ZPE.

### 2.3. Zero Point Energy and Mass

The kinetic energy given to the particle by the jiggling imparted by the ZPE appears as its atomic mass. As a result, this mass depends on the strength of the ZPE. Its mass describes the way the parton or electron behaves in its atomic environment. This is described by Eq. (4). In that equation, the damping constant $\Gamma$ appears. It is made up of the following terms:

$$\Gamma = \frac{e^2}{6\pi\varepsilon}\frac{1}{m^* c^3} \ . \tag{18}$$

In Eq. (18), there appears another form of mass, $m^*$, which might be called the intrinsic mass. Unlike atomic mass, intrinsic mass $m^*$ is due only to the charge which makes up the parton or electron. In other words, the intrinsic mass $m^*$ is purely electromagnetic in origin. An approximation for this mass can be derived from the formula for Classical Electron Radius $r_0$, from which we get

$$m^* \simeq \frac{e^2}{\varepsilon}\frac{1}{r_0 c^2} \ , \tag{19}$$

where $\simeq$ means "approximately equal to." A rigorous derivation results in the formula

$$m^* = \frac{e^2}{4\pi\varepsilon}\frac{1}{r_0 c^2} \ . \tag{20}$$

Since it has been shown that $e^2/\varepsilon$ is a constant out to the limits of the universe, even with a changing ZPE [36, 38], then it follows that the intrinsic mass $m^*$ is inversely proportional to both the radius of the parton or electron $r_0$ and to $c^2$.

Since any changes in the charge radii of partons and electrons are due to changes in the strength of the ZPE, then as the ZPE increases, so, too, do their charge radii. This is because the ZPE produces an inward pressure while an outward pressure is exerted by the presence of the charge itself. As the ZPE increases, so does the electronic charge $e$, because $e^2/\varepsilon$ is a constant and $\varepsilon$ is proportional to ZPE strength $U$. These opposing pressures result in the parton's or electron's sphere expanding until a balance is achieved and a stable radius for the sphere results.

An investigation of this effect was undertaken by Timothy Boyer in 1968 and Hal Puthoff in May of 2007. Puthoff discussed several possible explanatory models [39]. The one which yielded results in accord with data was described in these terms. *"[T]he charge density is taken to be sufficiently dense in a vanishing-radius shell so as to result in the total absence of interior vacuum fluctuation fields as a singularity is approached."* Puthoff also found that *"the outwardly-directed coulomb pressure [was] balanced by the inwardly-directed vacuum radiation pressure."*[39] His equations show that the Coulomb energy component $W$ is given by

$$W_{\text{Coul}} = \frac{e^2}{8\pi\varepsilon}\frac{1}{r_0} \ . \tag{21}$$

In a changing ZPE model, the quantity $e^2/\varepsilon$ is constant. This means that the outwardly directed Coulomb energy is inversely proportional to the radius of the charged sphere or, in the case of partons and electrons, the charge radius. Therefore

$$W_{\text{Coul}} \sim \frac{1}{r_0} \ . \tag{22}$$

In contrast, the inwardly directed energy of the vacuum is given by Puthoff's equation

$$W_{\text{vac}} = -\int \frac{h\omega^3}{4\pi^3 c^3} d\omega \ . \tag{23}$$

In Eq. (23), $\omega$ is the oscillation frequency of the parton or electron. Puthoff then goes on to calculate the result and shows that the outwardly directed Coulomb energy is balanced by the inwardly directed vacuum energy. This leads to a stable radius for the electron of $r_0$. However, in our case, we have a changing ZPE strength to consider. So (23) needs further investigation, as there are a number of terms dependent on the strength of the Zero Point Energy. We note that, in (23)

$$h \sim U; \quad c \sim \frac{1}{U}; \quad \omega \sim \frac{1}{U^3} \ . \tag{24}$$

The last proportionality above follows from the fact that there is a frequency-cubed relationship between the strength of the ZPE and the oscillation frequency of the parton. When these U-dependent proportionalities are substituted into (23), the following situation emerges:

$$W_{vac} \sim -\int \left(\frac{U}{U^9}\right) \Big/ \left(\frac{1}{U^3}\right) dU \sim -\int U^{-5} dU \ . \tag{25}$$

When (25) is integrated, we get the result that

$$W_{vac} \sim U^{-4} \sim \frac{1}{U^4} \ . \tag{26}$$

Because, as stated, the energies are balanced, $W_{\text{coul}} = W_{\text{vac}}$, therefore equating (26) and (22) we obtain

$$\frac{1}{r_0} \sim \frac{1}{U^4} \ , \tag{27}$$

and therefore

$$r_0 \sim U^4 \sim \frac{1}{c^4} \ . \tag{28}$$

So, from (20) we find that

$$m^* \sim c^2 \ . \tag{29}$$

Consequently, comparison with (14) reveals that

$$m \sim \frac{1}{c^2} \sim \frac{1}{m^*} \sim U^2 \ . \tag{30}$$

It follows, then, that for a situation with varying ZPE,

$$mm^* = \text{const} = M^2 , \tag{31}$$

where $M$ is a constant bearing the dimensions of mass. Therefore, as previously stated, we have an intrinsic mass $m^*$ for an electron or parton which comes entirely from the presence of the charge. In addition, there is the atomic mass $m$ which comes from the jiggling of this charged particle by the ZPE.

### 2.4. Introducing the Gravitational Constant, *G*

Although data show that $m$ and $m^*$ have both varied through time, since they have varied inversely to each other, as shown above, their product remains a constant. This has been so throughout the entire time that ZPE related quantities have been measured as varying. Thus, the platinum-iridium standard kilogram bars, kept by the various Bureau of Standards, have not changed mass. This is partly because atomic (and subatomic) masses are measured differently larger masses. In Eq. (31), the term $M$ was defined as "a constant bearing the dimensions of mass." This constant is gravitational mass.

In February 1994, Haisch, Rueda, and Puthoff stated that an atomic particle's inertial mass $m_i$ (which is essentially the same as our atomic mass $m$) is related to the bare mass $m_0$ (which is the same as our intrinsic mass $m^*$) [40]. Their Eq. (111) is found on page 690 of their paper and is our Eq. (32) below:

$$m = \frac{2}{3}\alpha\frac{{m_p}^2}{m^*} . \tag{32}$$

In their Appendix A, they note the discrepancy of a factor of 2 between gravitational and inertial mass in the above equation. To overcome the discrepancy in (32), the right hand side of the equation must be multiplied by 2, which results in

$$m = \frac{4}{3}\alpha\frac{{m_p}^2}{m^*} , \tag{33}$$

where $a$ is the fine structure constant given by

$$\alpha = \frac{e^2}{\varepsilon}\frac{1}{2hc} , \tag{34}$$

and $m_p$ in (33) is the Planck mass given by

$$m_p = \frac{h\omega_p}{2\pi c^2} , \tag{35}$$

and $\omega_p$ is the Planck frequency.

It can be shown that for our purposes here, we require the Compton frequency $\omega_c$, rather than the Planck frequency $\omega_p$. However, using the Planck frequency here has its advantages as it produces some mutually cancelling terms. Therefore we note that $\omega_c = \omega_p / k$. Substitution of (34) and (35) in (33) then gives:

$$m = \frac{4}{3}\frac{e^2}{\varepsilon}\frac{1}{2hc}\left(\frac{h\omega_p}{2\pi c^2 k}\right)^2\frac{1}{m^*} , \tag{36}$$

$$m = \frac{4}{3}\frac{e^2}{\varepsilon}\frac{h}{c^5}\cdot\frac{1}{8\pi}\frac{{\omega_p}^2}{k^2}\frac{1}{m^*} . \tag{37}$$

We now substitute for the Planck frequency $\omega_p$, as noted by Haisch, Rueda, and Puthoff as

$$\omega_p = \left[\frac{4\pi c^5}{hG}\right]^{1/2} , \tag{38}$$

which means we can write that

$$m = \frac{4}{3}\frac{e^2}{\varepsilon}\cdot\frac{h}{c^5}\left[\frac{1}{8\pi^2}\cdot 4\pi c^5\cdot\frac{1}{hG}\cdot\frac{1}{k^2}\right]\cdot\frac{1}{m^*} . \tag{39}$$

When terms are cancelled, the result is

$$m = \frac{2}{3}\frac{e^2}{\varepsilon}\frac{1}{\pi}\frac{1}{k^2}\frac{1}{G}\frac{1}{m^*} . \tag{40}$$

Alternatively, if we re-arrange the equation, we obtain the result that

$$G = \frac{2}{3\pi}\frac{e^2}{\varepsilon}\frac{1}{k^2}\frac{1}{mm^*} = \text{const} . \tag{41}$$

Since every bracketed term in the middle of (41) has been shown to be a constant, $G$ is necessarily also a constant. Since $mm^*$ is a constant and, by definition, is the same as $M^2$, then $M$ also is constant so that we have

$$GM = \text{const} . \tag{42}$$

Therefore, orbit times of planets and other similar gravitational interactions will remain unchanged by changes in the ZPE.

### 2.5. General Relativity, Gravity, and the ZPE

It may be pointed out that the later General Theory of Relativity (GR) was based on Special Relativity (SR) and has many successes to its credit. Because of this, it has been implied that Special Relativity has been validated by these developments. But two points need be noted. First, GR was built on SR by using only one-way mathematical transformations (not both ways as SR requires), and those transformations were relative to the local gravitational field. Essentially, the local gravitational field had become a preferred reference frame, namely the centre-of-mass [41]. This means that GR is more in line with Lorentzian Relativity but is not really consistent with SR [41].

The second point that needs noting is that Einstein's Theory of General Relativity (GR) concerns the effects of gravity on objects and light. Einstein considered gravity to be a bending of space-time, and this is still the standard theory today. His theory is used to explain how the Global Positioning System clocks work in the gravitational field of the Earth. However, GR requires complex mathematics and equations using 4-dimensional geometry to describe how a clock will slow in a gravitational field.

Furthermore, while it may be claimed that GR is a good mathematical model, this is not the same as explaining how gravitational forces originate. The GR model is often presented using the "rubber sheet" analogy (Fig. 4). In this analogy, the picture is often given of a heavy ball-bearing, that represents a massive body like the Earth or Sun, which deforms the surface of a rubber sheet (space-time) and causes it to curve.

The problems with both the mathematics and the physics of the analogy were mentioned in a conference in 2002 entitled **Pushing Gravity**, edited by Matthew R. Edwards, and described as follows [41]:

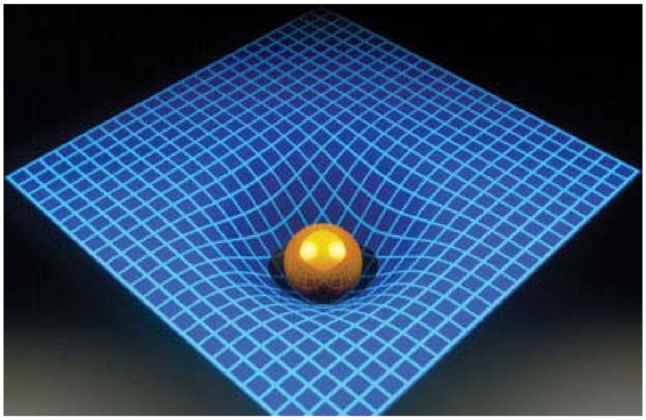

**Fig. 4.** The rubber sheet analogy of gravity; a massive body curves the fabric of space-time like a heavy metal ball on a rubber sheet. General Relativity states that an approaching object or a photon of light is supposed to follow the curve of the sheet rather than travel in a straight line.

> *In the geometric interpretation of gravity, a source mass curves the "space-time" around it, causing bodies to follow that curvature in preference to following straight lines through space. This is often described by using the "rubber sheet" analogy…. However, it is not widely appreciated that this is a purely mathematical model, lacking a physical mechanism to initiate motion. For example, if a "space-time manifold" (like the rubber sheet) exists near a source mass, why would a small particle placed at rest in that manifold (on the rubber sheet) begin to move towards the source mass? Indeed, why would curvature of the manifold (rubber sheet) even have a sense of "down" unless some force such as gravity already existed? Logically, the small particle at rest on a curved manifold would have no reason to end its rest unless a force acted on it. However successful this geometric interpretation may be as a mathematical model, it lacks physics and a causal mechanism.* [p. 94]

Others have also noticed this problem. For example, Haisch and his colleagues at the California Institute for Physics and Astrophysics (CIPA) present the situation like this: *"The mathematical formulation of GR represents spacetime as curved due to the presence of matter and is called geometrodynamics because it explains the dynamics (motions) of objects in terms of four-dimensional geometry. Here is the crucial point that is not widely understood: Geometrodynamics merely tells you what path (called a geodesic) that a freely moving object will follow. But if you constrain an object to follow some different path (or not to move at all) geometrodynamics does not tell you how or why a force arises. … Logically you wind up having to assume that a force arises because when you deviate from a geodesic you are accelerating, but that is exactly what you are trying to explain in the first place: Why does a force arise when you accelerate? … [T]his merely takes us in a logical full circle."*[42]

## 2.6. The Polarizable Vacuum and Gravity

Puthoff, Haisch, and Rueda in an article entitled *"Mass Medium"* [43] help explain the SED approach to gravity in this context. *"[We] can explain away gravity as an effect of electromagnetic forces. Oscillating charges in a chunk of matter affect the charged virtual particles in the vacuum."* This effectively causes the virtual particles in the vacuum to become polarized with a layer of positive charges attracting a layer of negative charges which then attracts a layer of positive charges, etc. They go on: *"This polarized vacuum then exerts a force on the charges in another chunk of matter. In this rather tortuous manner the two chunks of matter attract each other. 'This might explain why gravity is so weak,' says Haisch. 'One mass does not pull directly on another mass but only through the intermediary of the vacuum.'"*

In these circumstances the sign of the charge does not matter. The sign of the charge only affects the phase of the interaction. If the initiating charge is positive, the first layer of the polarization will be negative. If the initiating charge is negative, the first layer of the polarization will be positive. In this way the vacuum polarization results in an attraction. The calculations of Haisch and his colleagues show that this attraction has exactly the same characteristics as gravity. Therefore, they conclude, gravity is due to the attraction exerted by the polarization of the virtual particles in the vacuum.

Does this mean that a changing ZPE results in a change in gravity? No, and there is a reason for this. In a context where the ZPE is increasing with time, this picture of gravity as the result of vacuum polarization can be looked at in the following way. There are two agents governing the polarization of the vacuum and its resulting attraction. In the first case, there is the polarization of virtual particles by the mere presence of the charge on the parton or electron. Since we have shown that the quantity $e^2/\varepsilon$ is constant, then it follows that the polarization of the vacuum due to the charge on the parton (or electron) alone will be constant. This means that the gravitational attraction from this source of polarization will be unchanged.

There is also an additional polarization from the "jitter" itself. This arises because the random acceleration, imparted by the impacting ZPE waves to the jittering partons or electrons, causes them to emit a secondary radiation. This secondary radiation boosts the strength of the ZPE locally, which in turn causes more virtual particle pairs to come into existence per unit volume. The result is a stronger polarization than would occur if the parton or electron was at rest with no jiggling from the ZPE.

This sounds like gravity must be increased locally. However, the increased polarization is offset by the fact that any increase in the ZPE strength, no matter how it is caused, will result in a slower speed of light in inverse proportion. Since the ZPE waves travel at the speed of light, this means they will be traveling more slowly and so cannot accelerate the partons or electrons as rapidly when the waves hit. The result is that the polarization from the acceleration will actually be less, proportional to $c$. This proportionality therefore cancels out the increase in polarization that is due to an increasing ZPE strength. The outcome is that this source of polarization remains constant and therefore gravity itself remains constant.

Therefore, on both counts, it can be seen that the polarization remains unchanged, so the attraction, the pull of gravity, remains unchanged. The force of gravity comes from two different polarization forces acting together: the polarization resulting from the charge in the parton (or electron) itself, and the polarization due to the jitter imparted to the charged particle by the ZPE. In this way, the whole SED approach to gravity is shown to be valid when the polarizable vacuum explanation is employed. Under these circumstances, gravity becomes totally integrated into the SED picture and the four forces of physics are unified. The SED approach which gives the link between quantum phenomena and gravity is something that physicists have been striving to achieve for many years.

### 2.7. Slowing of Light in Gravitational Fields

Relativity demands that light slows down in a gravitational field. The same effect occurs on the ZPE model because of the local increase in ZPE strength around a large collection of particles. In this context a comment about General Relativity (GR) by Sir Arthur Eddington in 1920 is of interest.

> *Light moves more slowly in a material medium than in a vacuum, the velocity being inversely proportional to the refractive index of the medium.... We can thus imitate the [GR] gravitational effect on light precisely, if we imagine the space round the Sun filled with a refracting medium which gives the appropriate velocity of light. To give the velocity* $c(1-2\mu/r)$, *the refractive index must be* $1/(1-2\mu/r)$. … *Any problem on the paths of rays near the Sun can now be solved by the methods of geometrical optics applied to the equivalent refracting medium.* [44]

Since then, others have discussed this proposal. De Felice mentioned nine authors who have looked at this similarity between gravitation and an optical medium [45]. In fact, Hayden of the University of Connecticut (Physics) pointed out that the bending of starlight in the gravitational field of the Sun can be derived, and derived exactly, by this optical medium method *"with a few lines of high school algebra"* [46]. Both ZPE and the secondary fields near massive bodies induced by atomic particle "jiggling" have been shown to be the precise optical medium required, and the purely mathematical modeling of relativity is not required.

### 2.8. Relativity and Varying Constants

Equations used in relativity are consistent internally. That is not the issue here. There are also predictions which have come from these equations which are correct. That being said, two things must also be mentioned. First, SED physics combined with the real Zero Point Energy accounts for all these phenomena more intuitively and with more simple mathematics. Second, in relativistic physics and the equations based on them, the speed of light is made equal to Planck's constant and the Newtonian gravitational constant. So it is often stated at the beginning of their papers that all are made equal to 1, so that $c = h = G = 1$. This may be convenient, but it does not mesh with the reality of the fact that both Planck's constant and the speed of light have been measured as changing.

However, if these "constants" changed proportionally, the equations would still work. In fact, $c$ and $h$ have been measured experimentally as changing inversely, so that the product $hc$ is invariant. The equations of relativity are not designed to cope with this. There is also the problem that $c = h = G = 1$ obscures the colossal mismatch in the magnitudes of these quantities as well as making it impossible to track any changes they might undergo in reality.

At this point there is a choice: go with the data or go with the theory. It does no good scientifically to say that these changes, which have been experimentally verified, do not agree with relativity, and so must be spurious. The issue must be faced that these data in fact show that it is the theory of relativity that must be questioned. In contrast, SED physics with the real ZPE produces results that accord with physical reality, while at the same time producing the major predictions of relativity.

### 2.9. An Interim Suggestion

The conclusion is that the restrictions which Einstein's relativity places on our thinking should be relaxed and a new look taken at the ZPE alternative. Louis de Broglie put the issue at stake somewhat more forcefully in 1962 in his book "New Perspectives in Physics", which started the SED branch of physics. He said:

> *Thus with every advance in our scientific knowledge new elements come up, often forcing us to recast our entire picture of physical reality. No doubt, theorists would much prefer to perfect and amend their theories rather than be obliged to scrap them continually. But this obligation is the condition and price of all scientific progress."* [9]

## 3. Light in Gravitational Fields

### 3.1. Introduction

General Relativity first predicted the bending of light in large gravitational fields and then sought to explain it using the rubber sheet analogy as shown above. If the alternative approach, outlined by Eddington, Einstein, and others is followed, the physical vacuum is considered to be an optical medium whose density increases near any massive object, providing a refraction. The Zero Point Energy does supply the refractive medium needed. This model gives the same mathematical results obtained by General Relativity.

As the ZPE jiggles the electrons and partons making up matter, these jiggled charged particles emit a secondary radiation which boosts the strength of the ZPE locally near massive objects. As light waves enter this locally denser medium, they slow down. However, those waves coming from behind are still traveling at the higher speed. As a result of this higher speed, the wave-fronts "bunch up" as they encounter the interface between the less dense and the denser medium, and refraction occurs. It is in this gravitational case that the locally denser ZPE slows the speed of light waves and simultaneously causes refraction or bending of the light path.

This is in contrast to the change in ZPE strength on a cosmos-wide scale where the slowing of light waves occurs simultaneously along the whole train of waves, which may stretch across the whole universe. In this cosmological case, there is no refraction since there is no bunching up of the wave fronts. But in the gravitational case, the bunching up occurs because of the local variation in ZPE strength. Perhaps an analogy might be useful.

Imagine a large coiled spring on a moving belt. Regardless of the speed of the belt, the distance between the coils remains the same—they are moving uniformly. However, if some force at the front slowed the movement of our spring from the front, but the moving belt was still maintaining its original speed, the coils would start to bunch up near the front. This is what is happening to the light waves near a massive object where the ZPE has increased locally. It is this which produces the bending of light which we see near these objects.

### 3.2. Bending of Light in Gravitational Fields

As noted above, Eddington stated that

> *We can thus imitate the [GR] gravitational effect on light precisely, if we imagine the space round the Sun filled with a refracting medium which gives the appropriate velocity of light. To give the velocity* $c(1-2\mu/r)$*, the refractive index must be* $1/(1-2\mu/r)$. [44]

The effect of the locally increased strength of the ZPE as an "*equivalent refractive medium*" can be justified as follows. The refractive index of a medium $n$ is given by the standard equation:

$$n = \frac{c_0}{c} = \frac{1}{A^2} \tag{43}$$

Here $n$ is the refractive index of the denser medium the light has entered, $c_0$ is the speed of light in a vacuum, and $c$ is the speed of light in the denser medium. "$A$" here simply represents the ratio of the velocities. In this segment of the article, we are considering situations where $0 < A \le 1$. 1 has to be the upper limit since that is where the two speeds of light being measured are equal. An alternative expression for (43) is to say that the speed of light in the medium is given by the speed of light in the vacuum divided by the refractive index, so that:

$$c = \frac{c_0}{n} = c_0 A^2 \tag{44}$$

From Chapters 2 and 3 of this monograph, we have shown that light speed must vary in inverse proportion to both the permittivity and permeability of free space so that we can write as in Eq. (6) above that

$$U \sim \varepsilon \sim \mu \sim \frac{1}{c} \ . \tag{45}$$

But since we have shown that the speed of light is inversely related to the strength of the ZPE, then we can write

$$\frac{c_0}{c} = \frac{U}{U_0} = \frac{1}{A^2} \ . \tag{46}$$

Here we take $U_0$ as the present energy density of the vacuum ZPE away from massive objects and $U$ as the (greater) energy density of the ZPE in the vicinity of such objects.

If we now look at Eddington's statement regarding refractive mediums [44], it requires the refractive index to be given by

$$n = \frac{1}{1-2\mu/r} = \frac{c_0}{c} \ , \tag{47}$$

with the right-hand side following from the standard definition of refractive index as in Eq. (43). Eddington's treatment actually indicates that quantity $\mu/r$ is the same as $GM/r$.

### 3.3. Three Requirements to be Fulfilled

For this condition in (47) to be satisfied, Eddington's approach requires three things. First, there must be a key property of the physical vacuum that increases in density in the vicinity of massive objects. Second, this vacuum property must mimic the behavior of the gravitational field strength, which is proportional to the inverse square of the distance from any massive object. (That also implies this property must mimic the behavior of the gravitational potential $\mu/r$ in Eddington's approach above and so be proportional to $1/r$, where $r$ is the distance from the massive body.) Third, this property of the vacuum must affect the speed of light in an inverse fashion in a way similar to a refractive medium. Let us examine these points.

First, the behavior of the vacuum in the vicinity of massive bodies is in accord with the picture of the vacuum that Haisch, Puthoff, and their colleagues present [47-50]. As noted above, the all-pervasive ZPE has its density increased towards massive bodies due to the secondary fields emitted by the oscillating point-like charges that comprise all matter. The more oscillating charges there are, the more secondary fields there are and hence the greater the total energy density of the ZPE in the vicinity of those charges. This increase in the total energy density of the ZPE towards any massive object can thereby be shown to meet the first requirement for Eddington's alternative model.

Second, the strength of these electromagnetic fields is proportional to the inverse square of the distance from their origin. Furthermore, their potential falls off inversely as the distance from the massive body, so changes in the density of the ZPE medium mimics a gravitational potential. Therefore the second set of requirements is also fulfilled.

The final condition requires the speed of light to slow down as the strength of the ZPE increases. This has been shown above as well as in other articles [12,37,38,51,52], which also demonstrate an inverse relationship between the energy density of the ZPE and the speed of light. Eddington noted that "*the velocity [of light is] inversely proportional to the refractive index of the medium.*" [44] This result means that the increased strength of the ZPE due to the secondary fields of oscillating charges is behaving in the same way as his "*equivalent refractive medium*" requires.

Therefore, Eddington's results can be obtained precisely since we now have

$$\frac{1}{1-2\mu/r} = \frac{U}{U_0} = \frac{c_0}{c} = n \ . \tag{48}$$

Thus the effects of the increased ZPE strength, due to the secondary radiation emitted by oscillating particles, is the same as an equivalent refractive medium. Because of this, the SED approach using the ZPE explains the same bending of light in a gravitational field as General Relativity. However, unlike GR, it gives the mechanism whereby the bending of light occurs. This approach also has the added advantage that it only needs simple mathematics.

GR had predicted the bending of light around massive astronomical objects and later realized this also involved the slowing of light there. In addition, it also predicted the slowing of radar signals in these same fields. This was verified in the

1960's. Irwin Shapiro confirmed this by analyzing radar signal returns from both Venus and Mercury [53]. However, just as the locally increased Zero Point Energy affects the light waves, it also affects radar signals. It is the flip side of the effects of a refractive medium. Both light and radar waves are forms of electromagnetic radiation. Therefore, if light speed slows in these gravitational fields, radar signals will behave the same way. This simultaneous slowing and bending of radar signals and light in the vicinity of massive objects are therefore twin results from an increased density of the ZPE.

## 4. Atomic Clocks Slow in Gravitational Fields

The bending and slowing of light in a gravitational field were only two of the basic observational proofs of GR. Einstein also proposed that the rate of ticking of atomic clocks would be slowed in gravitational fields. This is inevitable with the SED approach using the ZPE as the mechanism. This is because the "gravitational field" in which these atomic clocks are immersed comes from the secondary electromagnetic radiation emitted by oscillating charges that make up all matter. The more charges there are to oscillate, the more secondary radiation will be emitted, and hence the greater the energy density of the ZPE in that vicinity. This local increase in the energy density of the ZPE will cause a drop in the orbital frequency of subatomic particles as outlined in the discussion around Eq. (17A). Thus the slowing of atomic clocks is not an unexpected result but a natural consequence of the SED approach.

The atomic clocks associated with the Global Positioning System reveal that atomic clock frequencies do lessen somewhat in the Earth's gravitational field. The exact equation has the form:

$$f = f_o A \quad , \tag{49}$$

where $f_o$ is the original frequency and $0 < \mathrm{A} \le 1$ as defined above. By way of explanation, we start with the intrinsic mass of the parton or electron $m^*$ as discussed around Eq. (30). There it is shown that the intrinsic mass of the parton decreases when the ZPE is stronger. Using (29) and (44), the relationship may be expressed in terms of the quantity $A$ thus:

$$m^* = m_o{}^* A^4 \quad . \tag{50}$$

The equations relating to the behavior of atomic masses $m$ are given in Eqs. (14) and (18). If (18) is substituted in (14) above, it can be manipulated to show that:

$$m = \frac{1}{24\pi^3} \frac{e^2}{\varepsilon} \frac{1}{c^5} \frac{1}{m^*} \frac{h}{1} \frac{\omega^2}{1} \quad . \tag{51}$$

Applying (24), (46), and (50) to (51), the outcome is that

$$m \sim \frac{e^2}{\varepsilon} \frac{1}{A^4} \quad . \tag{52}$$

However, the behavior of $e^2/\varepsilon$ needs scrutiny at this point. The electronic charge $e$ is not implicated in any changes due to secondary fields. However, the increase in ZPE strength due to the secondary fields will inevitably increase the value of $\varepsilon$ which decreases the magnitude of the ratio $e^2/\varepsilon$. Since $\varepsilon$ is proportional to $U$, then from the definition given in (46) we have

$$\frac{U_0}{U} = \frac{\varepsilon_0}{\varepsilon} = \frac{A^2}{1} \tag{53}$$

Therefore

$$\varepsilon = \frac{\varepsilon_0}{A^2} \quad . \tag{54}$$

As a consequence, when (54) is substituted in (52) it emerges that

$$m \sim \frac{m_0}{A^2} \quad . \tag{55}$$

It has been shown above that kinetic energy is conserved in atomic orbits in the interval between redshift quantum changes. This means that

$$mv^2 = \text{const} \quad . \tag{56}$$

Therefore, putting the results of (55) in (56), we get

$$\frac{m_0}{A^2} v^2 = \text{const} \quad . \tag{57}$$

This means that

$$v^2 = \left(v_0 A\right)^2 \quad . \tag{58}$$

The frequency of revolution of electrons in atomic orbits is directly determined by the orbit velocity $v$. Since this is directly related to the frequency of atomic clocks, then from (58) we have

$$f = f_0 A \quad , \tag{59}$$

which was the required relationship in (49) above. This indicates that atomic processes slow by a factor of $A$ in a gravitational field. As a result, it can be demonstrated that all atomic frequencies, and therefore atomic clocks, will slow in accord with (59) and (49). Alternatively, it can be stated with equal correctness that the time period $t$ between ticks on atomic clocks in these circumstances is lengthened in that gravitational field so that

$$t = \frac{t_o}{A} \tag{60}$$

This prediction of GR can thereby be accounted for on using SED physics and the action of the ZPE in a relatively simple manner. This occurs because the permittivity of the vacuum increases in gravitational fields due to the emission of secondary radiation by oscillating partons. The key point, however, is that this is done without any increase in the strength of the electronic charge. We can thus write that, in strong gravitational fields,

$$\frac{e_0{}^2}{\varepsilon} = \frac{e_0{}^2}{\varepsilon_0} A^2 \quad . \tag{61}$$

In other words, since $0 < A \le 1$, then the ratio $e^2/\varepsilon$ becomes lightly less in a strong gravitational field because $\varepsilon$ increases. Apart from this exception, however, $e^2/\varepsilon$ has shown itself to be a constant.

## 5. The Fine Structure Constant

In 1916, A. Sommerfeld introduced something we now call the fine structure constant $\alpha$ in order to explain why the energy levels of the hydrogen atom appear to be split. These energy levels are indicated by the dark lines in the color spectrum. It would be expected that an energy level from a given orbit would be represented by one dark line. But this is not what Sommerfeld found. The dark line was split into several different lines. This was referred to as the fine structure of the spectral lines. In all of his equations, while working with this, Sommerfeld found he had to deal with the speed of the electron in its orbit $v$ in the first Bohr orbit, divided by the speed of light $c$. So the fine structure constant $\alpha$ equals $v/c$. Since it has been shown that orbit velocities are proportional to the speed of light, this means that the fine structure constant is a true constant.

Today the fine structure constant is defined as being a "coupling constant", which measures the strength of the electromagnetic force that governs how electrically charged particles interact. Its mathematical definition, however, remains unchanged.

When today's astronomers look at the spectral lines in distant galaxies, they are able to see the fine structure and, as a consequence, measure its value. In this more complicated way, the fine structure constant $\alpha$ is defined as [54]

$$\alpha = \frac{e^2}{2\varepsilon hc} = \frac{e^2}{2\varepsilon h_0 c_0} \quad . \tag{62}$$

Since both the product $hc$ and the ratio $e^2/\varepsilon$ are cosmologically constant, it might be assumed that the fine structure constant $\alpha$ might also be invariant under all conditions as well. However, this has recently been called into question by observations at the frontiers of the cosmos. In 2001, this quantity was suspected of being smaller in the early universe as a result of measurements made by John Webb and his associates [55]. Attention was also drawn to this issue in 2002 by Davies and his colleagues [56]. Davies has suggested that varying light speed may the culprit. However, on the basis of the constancy of the product $hc$, this may be considered doubtful. In fact, in 2003, Carlip and Vaidya also disputed that interpretation, but on different grounds. They went on to suggest that a change in the electronic charge $e$ would bring about the observed variation in the measured value of $\alpha$ [57]. The SED approach adopted here tends to discount that option. Nevertheless, in order to see the full range of options available on this matter, we need to examine again the behavior of the Zero Point Energy in a gravitational field.

The change in the ZPE strength is due to secondary radiation emitted by charged particles which are being jiggled. Therefore, the primary equation is (46) which we might re-write as

$$\frac{U_0}{U} = A^2 \quad . \tag{63}$$

The value of $U_0$ in this equation represents the strength of the ZPE in the cosmos, un-boosted by secondary radiation. $U$ is the strength of the ZPE in a gravitational field. Over time, the value of $U_0$ increased as the (un-boosted) strength of the ZPE increased. Therefore, in the early days of the cosmos, any given quantity of secondary radiation that controlled the value of $U$ would have had a relatively greater effect on the value of $A$ in Eqs. (46) and (63) than now. At this present time, the value of $A$ is close to one. However, in the early days of the cosmos, in a gravitational field approximately the same as one now, $A$ could have been significantly less. So it is to the early cosmos that we must look to find the evidence any change in the fine structure constant. In particular, the presence of the $A^2$ term in gravitational fields would cause a decrease in the value of the fine structure constant at large cosmic distances.

Since both $hc$ and $h_0 c_0$ are invariant in (62), the only possibility for variation in $\alpha$ comes from the behavior of the ratio $e^2/\varepsilon$. As noted above, this ratio seems to be constant cosmologically, but the specific prediction here is that it should vary in strong gravitational fields, so that from (61) we can write

$$\alpha = \frac{e^2}{2\varepsilon hc} = \frac{{e_0}^2}{2\varepsilon_0 A^2 h_0 c_0} = \alpha_0 A^2 \, . \tag{64}$$

Therefore, at great cosmic distances, where the ambient ZPE is lower, the value of the fine structure constant is expected to be marginally less than today. This is in agreement with all the early work that Webb et al. did with the Keck telescope in Hawaii. It might therefore be concluded that the observational evidence supports the SED approach. However, it disagrees with their latest results from the Very Large Telescope in Chile [58]. As a result, questions have been raised about possible flaws in either the VLT or the Keck [58]. The alternative suggestion was that the fine structure constant varies in a north-south manner in space, but not in time. Obviously, further work is needed. Nevertheless, if later observations converge to agree with (64), this would favor the ZPE approach over General Relativity.

We have therefore shown that three of the main predictions of Relativity are easily reproduced by the SED approach using simple mathematics and intuitive concepts. However, the fourth prediction of Relativity concerns the advance of the perihelion of the planet Mercury.

## 6. The Perihelion Advance of Mercury

### 6.1. The Basic Formula for Perihelion Motion

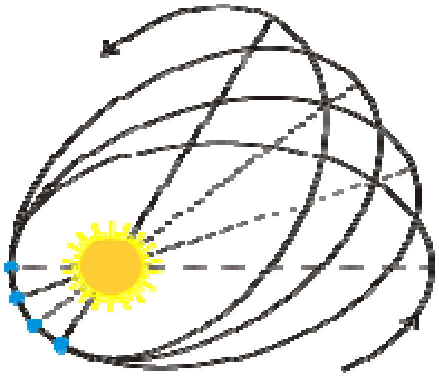

**Fig. 5.** The perihelion advance of the planet Mercury.

The planet Mercury traces an elliptical path around the Sun. The closest point of that ellipse to the Sun is called the perihelion. However, Mercury does not trace exactly the same path each time. Rather, the path swings around over time. When the path is plotted out, it can be seen that the perihelion position rotates around the Sun. Mercury's actual orbit therefore looks something like the situation shown in Fig. 5.

For all orbits that are essentially elliptical, the basic formula for the motion of the orbit perihelion is always the same since it is governed by the properties of motion of an astronomical body in an ellipse. In 1999, the late Tom Van Flandern, an astronomer with the US Naval Observatory in Washington, noted that

> *Perturbations that are themselves modulated by the size and shape of the elliptical orbit and by the speed of a body travelling along that ellipse generally change the perihelion motion by simple integer multiples of the basic form…. The nature of this basic form is such that parameter-free perturbations are mostly constrained to produce perihelion motions that are integer (or at worst, half-integer) multiples of it…. This basic form is:*
>
> $$N = \frac{n\mu}{c^2 a\left(1-e^2\right)} \quad , \tag{65}$$
>
> *where $n = 2\pi/P$ is the orbital mean motion of the planet, P is its orbital period, $\mu$ is the product of the gravitational constant and the mass of the Sun [GM], a is the semi-major axis (mean distance) of the orbit, e is orbital eccentricity, and c is the speed of light. The observed perihelion advance for Mercury is three multiples of the basic form, 3N, to within the error of observations.*
>
> *In GR, the correct multiplier of N is arrived at by combining three contributions. The first is the effect of "time dilation", which contributes $+4N$. The second is the effect of "space contraction", which contributes $-2N$. The third is the effect of mass or momentum increase with speed, which contributes $+1\ N$. The sum of these three contributions gives the observed amount $+3N$ …. It is curious that Einstein required a combination of three effects, with one of them cancelling 40% of the contribution of the other two.*[59]

## 6.2. Discerning an Alternative Approach

By comparison with Einstein's formulation, any approach using the ZPE has less room for maneuver. There is no "time dilation" or "space contraction" which would affect perihelion motion. Furthermore, Eq. (65) reveals that there can be no contribution to *N* that results from any change in mass or change in momentum of the orbiting body, since that quantity does not enter the equation. Also as noted above, *GM* is a constant, so the term designated as $\mu$ in (65) is also constant. This situation is in stark contrast to Einstein's less constrained approach. Nevertheless, on a qualitative basis it is possible to discern the outline of an answer from a suggestion first made in 1999 that appeared in the collection of the "Pushing Gravity" symposium papers of 2002. [60] The symposium noted that if perchance the planets were immersed in a medium that increased in density towards the Sun, then

> *[T]he elliptical motion of orbiting bodies is slowed most by [the medium] at perihelion, where that medium is densest, and slowed least at aphelion, where [the medium] is sparsest. This velocity imbalance (relatively slower at perihelion, relatively faster at aphelion) rotates the ellipse forward, which is what an advance of perihelion means.*

This article indicated that if there was a Newtonian velocity slowing factor $1/\gamma^2$ for a body with actual orbital velocity $v$, when $v_n$ is the equivalent velocity under Newtonian style forces, then the velocity of the orbiting body can be shown as

$$v = \frac{v_n}{\gamma^2} \quad , \tag{66}$$

where $\gamma \geq 1$. It was shown in the above symposium paper that this situation produced the required perihelion advance with the $1/\gamma^2$ slowing factor due to the velocity imbalance caused by the varying density of the medium. This approach, using a single factor, reproduces exactly the observed perihelion advance, as shown below, without the messy juggling of the three factors that GR requires.

This is definitely in line with SED physics and the increased energy density of the ZPE near the Sun, or any massive body. Nevertheless, the question remains regarding how a planet in orbit could experience an imbalance of the Newtonian velocity as a result of changes in the density of the ZPE. Because there are two ways of visualizing ZPE strength, there are also two ways of dealing with this question. The first way is to consider the effects of virtual particles, whose numbers in the vacuum are dependent on the ZPE strength. The second is related to the ZPE waves themselves. Their numbers increase when the ZPE strength increases, and this has an effect on the de Broglie waves which are associated with all moving sub-atomic particles.

## 6.3. The Effects of a Locally Stronger ZPE

In the first case, an increase in ZPE strength also means an increase in the numbers of virtual particles in the vacuum at any given instant. In other words, regardless of the reason for a ZPE increase in strength, the vacuum becomes "thicker" with virtual particle pairs.

In the case under consideration here, the closer we get to the Sun, the greater the number of virtual particles in the vacuum at any given instant. Mercury in its elliptical orbit moves very fast when close to the Sun, then significantly slower further away. At the same time that it is going at its maximum speed, it is also entering and traveling through the area of greatest ZPE strength. This means that it will encounter a much thicker cloud of virtual particles as it moves at high speed near the Sun, and then significantly fewer when further away. As Mercury moves ballistically through a thick cloud of virtual particles when closest to the Sun, this generates a resistance. This occurs because virtual particles are of equivalent size to the subatomic particles which make up all matter and produce a retarding effect on the planet's motion at the atomic level. This is one way of looking at the imbalance induced in the Newtonian velocity.

The second way of viewing the retardation of Mercury in its orbit is to consider the interaction that comes from the de Broglie waves associated with all moving sub-atomic particles. As these matter waves associated with the orbiting planet propagate through the ZPE, the increase in energy density of the ZPE in the vicinity of the Sun will have its effects. It is analogous to the way in which light waves are slowed by the greater number of ZPE waves when the ZPE strength is greater. Therefore, as the de Broglie waves move through a denser (or sparser) ZPE, this slows down (or speeds up) the motion of the entire collection of waves that make up the orbiting planet.

If a particle moves through the ZPE with a velocity $v$, it can be shown that $v$ is also the group velocity of the matter wave [61]. Therefore, a collection of particles, such as a planet made up of their wave equivalents, would also propagate through the ZPE with a velocity $v$ under ordinary circumstances. However, the increase in the energy density of the ZPE slows the propagation speed of the matter waves in a manner inversely proportional to the energy density. As a result, the velocity of the particles making up those waves must also slow since the group velocity of the waves and the particle velocity must remain synchronized [61].

The outcome of this impedance to the motion of the planet, whether considered by either the particle or wave approach, is the same. If the expected velocity is a Newtonian velocity $v_n$, and the actual velocity is $v$, then the slowing factor is given by the ratio $v/v_n$, which must then be proportional to the ratio of the ZPE energy density $U/U_0$. This can be written as

$$\frac{v}{v_n}=\frac{U_o}{U}=A^2\,,\ \text{therefore}\ \ v=v_nA^2\ . \tag{67}$$

But (67) has the same form as (66), which gave the necessary solution to the problem provided we make the identification that the slowing factor

$$A^2=\frac{1}{\gamma^2} \tag{68}$$

This then leads to the required solution in a way outlined by Van Flandern and which is reproduced here with the pertinent amendments and additions [62].

### 6.4. The Perihelion Advance Formula

The change in speed of an orbiting body due to the variation in the factor $A$ stimulates an extra force acting on the body along the velocity vector. The formula for the change in Newtonian velocity is

$$\delta v=v-v_n=v_n\left(A^2-1\right)\ , \tag{69}$$

which follows from (67). However, in the formula given in (65), the term $\mu/r$ is Eddington's gravitational potential. This involves the product $GM$, which, as discussed earlier, is invariant. For an orbiting planet the quantity $Gm/r^2$ equals $v^2/r$ [63]. Therefore, $Gm/r$ is proportional to $v^2$. We can therefore substitute $v^2$ for $Gm/r$ in the expression for $A^2$ and obtain the information that

$$1-\frac{2Gm}{rc^2}=1-\frac{2\mu}{rc^2}\sim A^2\sim 1-\frac{v^2}{c^2}\ . \tag{70}$$

Therefore, if the results from (70) are substituted in the expression in (69) we obtain

$$\delta v=v_n\left(A^2-1\right)\sim v_n\left(1-\frac{v^2}{c^2}-1\right)=v_n\left(-\frac{v^2}{c^2}\right)\ . \tag{71}$$

If we now take the time derivative of $\delta v$, it will give us the extra acceleration needed to produce the required velocity changes. Let us denote this tangential acceleration of the orbiting body by the quantity $T$. This will allow us to compute the perturbing quantity $T$, which can then be introduced into the relevant celestial mechanics formulas to discover what effect it has on the motion of a body in an elliptical orbit.

If we differentiate $\delta v$ with respect to time, we get an expression for $T$. If we further make $v^2$ the chief variable rather than $v$, we obtain

$$T=\frac{d}{dt}(\delta v)=\frac{d}{dt}\left(-\frac{v_n v^2}{c^2}\right)\ . \tag{72}$$

Since we are interested in the primary results from (72), it is not necessary to make a distinction between $v$ and $v_n$ since that would only lead to higher order terms with diminishing effects. Performing the necessary operations then leads to the result that

$$T=-\frac{3v}{2c^2}\frac{dv^2}{dt}\ . \tag{73}$$

In order to make it easier to deal with this derivative, we can substitute from the energy equation for elliptical orbits that gives

$$v^2=\mu\left(\frac{2}{r}-\frac{1}{a}\right)\ . \tag{74}$$

With this information in (74), the derivative can be seen to be

$$\frac{dv^2}{dt}=-\frac{2\mu}{r^2}\frac{dr}{dt}\ . \tag{75}$$

We now need to determine the new derivative for $r$. This can be found in Danby's **Fundamentals of Celestial Mechanics** [64]. The first equation, (6.2.10), gives a necessary definition. The equation that is relevant to our purpose here is his Eq. (6.3.21) which states that

$$\frac{dr}{dt}=e\ \sin f\sqrt{\frac{\mu}{a\left(1-e^2\right)}}\ , \tag{76}$$

where $f$ is the orbital true anomaly (the angle at the Sun between the perihelion and the orbiting body). Making all these substitutions, we obtain the final expression for $T$:

$$T=\frac{3\mu^{3/2}ev}{c^2r^2\sqrt{a\left(1-e^2\right)}}\sin f\ . \tag{77}$$

Danby's Eqs. (11.7.2) and (11.7.4) show that perturbations of the semi-major axis $a$ and eccentricity $e$ are purely periodic and therefore always remain of small amplitude. But Danby's equation (11.7.3) also shows that the perihelion motion contains both small periodic and ever-increasing secular contributions. Applying that equation, where his $\omega$ is the longitude of the perihelion, and substituting for $T$, we obtain

$$\frac{d\omega}{dt}=\frac{2\sin f}{ev}T=\frac{6\mu^{3/2}}{c^2r^2\sqrt{a\left(1-e^2\right)}}\sin^2 f\ . \tag{78}$$

The periodic part gives rise to only small periodic variations that can be neglected here. What is of interest here is the secular variation, which builds progressively with time. It comes from the time average value of $\sin^2 f/r^2$. Time averages over elliptical motion can be found by integrating over one revolution. Using $dr/dt$ from (76) coupled with $df/dt$ from Danby's Eq. (6.3.3), we discover that the required time average is given by the expression $1\Big/\left[2a^2\sqrt{1-e^2}\right]$. If the orbit was circular, the average of $\sin^2 f = ½$, while the average of $1/r^2 = 1/a^2$. If we deal with elliptical orbits, the additional dependence on eccentricity becomes relevant. If we now substitute these results back into (78) and simplify by using Kepler's law for elliptical motion that states that $\mu = n^2a^3$, we arrive at the final formula for perihelion motion, namely that the secular change in perihelion longitude is given by

$$\frac{d\omega}{dt} = \frac{3n\mu}{c^2a\left(1-e^2\right)} = 3N \quad . \tag{79}$$

The final equality of *3N* comes from (65), which is equivalent to Danby's Eq. (4.5.7). When the numerical values of the various parameters are inserted in (79), the quantity *3N* equals 42.98″ per century, well within the 1% measurement error mentioned by Van Flandern [59].

This present result comes solely from the slowing factor presented here and can be derived exactly. By contrast, the GR result comes from juggling three different components using Riemannian geometry and elaborate tensor calculus. Under these circumstances, it appears that the predictions of GR can be reproduced more cleanly by considering a scenario based on the action of the ZPE. This is the fourth major prediction of Relativity that the SED approach has reproduced simply using the presence of a real ZPE. The SED approach to Relativity deserves some serious consideration.

## 7. "Frame Dragging"

General Relativity predicts a number of other more minor effects. One which has recently been verified as actually occurring is called frame dragging. This is also called the Lense-Thirring effect after the two physicists who noticed this outcome of Einstein's equations. The technical GR definition describes this effect as happening when the inertial frame for the axis of a rotating body is dragged by the curvature of space-time. In other words, when a small, spinning object is in orbit about another massive object, a small torque is generated which causes the spin axis of the rotating body to precess. In GR, the greater the curvature of space-time (the more massive the larger object is), the greater the frame dragging (precession) effect.

However, exactly the same effect occurs with the ZPE. Instead of the words "curvature of space-time", we can substitute the words "ZPE strength": the stronger the ZPE is locally, due to the secondary radiation from oscillating charges (that is massive objects), the greater the effect will be. The mechanism by which it works is simple. The small spinning body is moving through the medium of the ZPE as it orbits the massive object. The more massive the body, the stronger the ZPE due to secondary radiation emitted by the oscillating charges. This means that the number of virtual particles in a given volume is correspondingly larger. As a result, the small spinning body in its orbit is moving ballistically through this thick cloud of virtual particles. This generates a resistance which is equivalent to a small torque. The effect of this torque is to cause a precession of the spin axis of the smaller object, in the same way that a small torque applied to a spinning top will cause it to precess.

An experiment was done with the Gravity Probe B in polar orbit. It had the space craft's gyroscopes aligned to point precisely at the star IM Pegasi (HR 8703). The deviations of the gyroscopes, due to precession, were noted. The results were announced in June 2011 by C. W. F. Everitt et al [65]. The results agreed with GR theory to within 10%. The LARES satellite, launched 13 February 2012, is hoped to give results to within 1%, though this accuracy may not be attained.

These experimental results certainly confirm GR theory. However, they also confirm that SED theory, using a real Zero Point Energy, can avoid the complicated dragging of rubbery space-time and account intuitively for these effects. This is a distinct advantage.

## 8. Gravitational Waves

Our solar system is moving through space at about 12 miles per second (or 45,000 miles per hour) in the direction of Lamda Herculis. This movement is rather like a boat on water. In the same way that a boat has a bow shock-wave in front of it, so, too, does the Sun and solar system on two counts. First, the Sun effectively encounters more Zero Point Energy (ZPE) waves and the associated charged virtual particle pairs from this direction than if it had been at rest since it is "running into" them. Thus the ZPE appears stronger in that direction than in the opposite direction. Second, there will be a bow shock-wave from the additional ions and plasma particles that the solar system encounters from that direction. These ions and electrons will augment the charged virtual particle pairs that normally comprise the vacuum, and they, too, will make for a more "viscous" or "thicker" vacuum.

The "bow waves" generated by the solar system motion through the virtual particle pairs inhabiting the vacuum will have their smaller counterparts with any orbiting body. Since the waves are occurring in charged particles which are set in motion, these waves are effectively electromagnetic waves, but they will be of long wavelength. Since this type of wave is generated by all orbiting bodies, it is the ZPE counterpart to the gravitational waves which relativity considers to be "disturbances of space-time". In the ZPE model, the disturbance of space-time is simply a disturbance of virtual particle pairs and/or the waves of the ZPE.

## 9. The Speed of Gravity

One important matter that arises in any discussion of this nature is the speed of gravity. According to Relativity, it is the same as the speed of light. However, the late Dr. Thomas Van Flandern pointed out some inconsistencies in that position [66]. In his analyses, he presented data which suggested that the speed of gravity was as high as $2\text{x}10^{10}$ the current speed of light. In the approach presented by this paper, the speed of gravity is basically the speed at which the virtual particles in the vacuum will polarize. The speed of light and all electromagnetic waves are impeded by these virtual particles and so light speed reduces as their number increases. However, the speed of a light photon may be considered to have always been the same as it moves in the small space between virtual particles.

Gravity, the attraction due to vacuum polarization of the virtual particles, is not inhibited by the virtual particle pairs as light waves are. Rather, it depends on how quickly a negative particle will surround itself with a layer of positive particles and vice versa. There is no reason why this process should be limited to the measured speed of light as Einstein proposed. Rather it is possibly the speed at which light travels in between virtual particle interactions. That would be the speed of propagation through the (pure) vacuum before there were any significant numbers of virtual particles. For this reason, a propagation speed for gravity (and originally for light) of the order of $10^{10}$ times the current speed of light is possible both from the data available and the function describing the behavior of the speed of light.

## 10. Gravitational Lensing

A gravitational lens occurs when there is a large concentration of matter between a galaxy (or a star) and the Earth. This concentration of mass appears to bend the light from the background object as it comes to us in the same way as a lens would.

The explanation for this effect coming from General Relativity is that mass bends light due to gravitation. The more mass, the more bending of space-time, in the same way that the illustration of the rubber sheet would show a deeper "well" with the mass in it. The curve produced by the deformation is what would actually be felt to be responsible for the bending of the light. GR had predicted this effect, and so the scientists started looking for it.

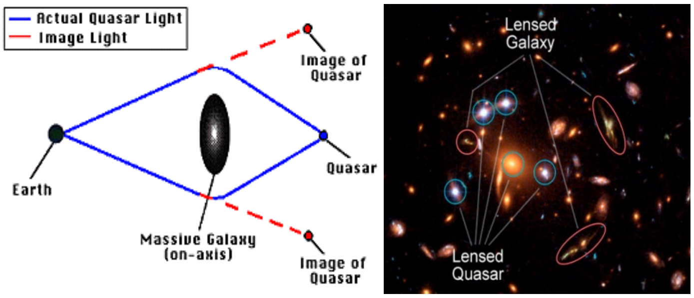

**Fig. 6.** "Gravitational lensing" by massive objects. Left—the prediction based on General Relativity. Right—an actual example of lensing that was found.

The problem that showed up is that there are far too few gravitationally lensed objects compared with what would be expected. In addition, there are examples where the object around which the light is bent does not seem to have enough mass to accomplish that in the GR model.

However, in SED physics with the ZPE, all that is needed is a sufficiently dense collection of matter which gives rise to a large amount of secondary radiation due to the *Zitterbewegung* jitter motion. This concentration of matter will boost the local ZPE strength sufficiently to cause the appropriate bending of light rays. This is one reason why gravitationally lensed objects can be seen when light from a very distant source passes through a cluster of galaxies. However, on this SED explanation, it is not the gravitational field itself which is doing the bending. Rather it is the concentrated amount of secondary radiation from the *Zitterbewegung* jitter that gives a locally denser vacuum that bends the light rays.

As mentioned, GR has a mass problem with its explanation. In a number of cases, it seems as if there is insufficient mass in a given galaxy cluster to give the observed lensing effect. Because of this, dark matter is invoked as an answer for this problem. For example, in Fig. 7 are two images from the Hubble Space Telescope published by NASA, JPL, the Goddard Space Flight Center, and ESA. The left hand image shows the "dark matter ring" around cluster Cl 0024 + 17. The right hand image shows the lensing arcs around the galaxy cluster Abell 2218. In the case of this right hand image, there is indeed a strong gravitational component to the lensing. However, the calculations reveal that there must also be "dark matter" to the extent of 400 trillion solar masses to give the observed effects.

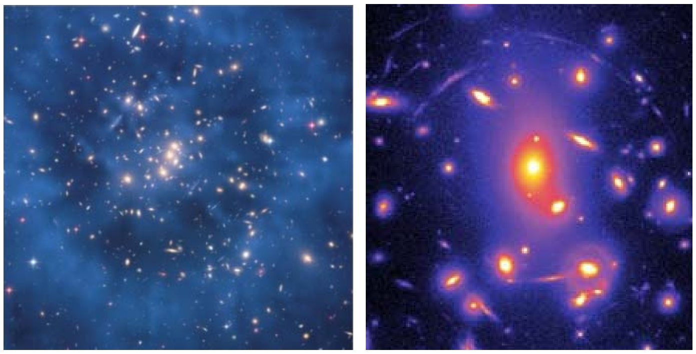

**Fig. 7.** Left—The "dark matter" ring around galaxy cluster Cl 0024 + 17. Right—Lensing arcs around galaxy cluster Abell 2218. The cause of these effects, which are normally attributed to "dark matter," are discussed below.

Dark matter and missing mass were originally introduced because galaxies were observed to have rotation rates that could only be accounted for gravitationally if there were large dark matter halos around the galaxies. (Lab experiments in plasma physics have shown that these rotation rates are the natural results of the interactions between plasma filaments that form galaxies.[67]) Plasma physics, coupled with the SED approach, show that missing mass and dark matter are unnecessary in explaining what we see in space. So what is the actual cause of the effects we are seeing in Fig. 7?

Plasma also bends light. This can be established by looking at the plasma in the near vicinity of the Sun. Starlight which goes through this layer is strongly bent as noted by E. H. Dowdye in "Gravitational Light Bending…" [68]. In both the cases in Fig. 7, we are looking end on at the plasma filament in which the clusters were immersed. These filaments were pinched to form the clusters, and will enhance the lensing effect of the mass already present. The lensing effects are seen most strongly around the outer edge of the filament since that is where the "double layer" in the plasma filament occurs. This double layer is where the charge difference is concentrated and where the change in plasma density is greatest. This allows the plasma filament to form images around this outer edge, which pinches in where the cluster is. Thus light comes to us after traveling down the length of the plasma cylinder, or going through its pinched region, which in some cases will give rise to arc-like distortions. These images have been interpreted in terms of gravitational physics instead of plasma physics.

## 11. Gravitational Lensing, Our Galaxy's Center

At the center of our galaxy, and most other galaxies, there is a fast-spinning disk with polar jets. In the gravitational model, the rate of spin of the disk, and the rate that stars orbit the center, suggests that there must be a super-massive black hole there, exerting tremendous gravitational force. In our galaxy, this object is called Sagittarius A* (abbreviated to Sag A* and pronounced "A Star"). Some 28 stars have been tracked as they orbit around this central object. See for example the orbit of star S2 in Fig. 7.

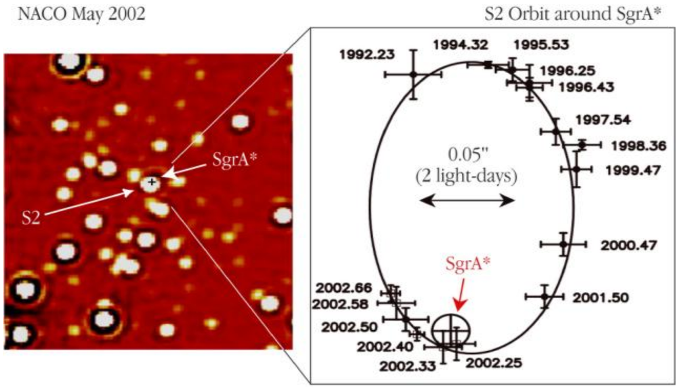

**Fig. 8.** The orbit of the star S2 around the object at the center of our Galaxy, Sagittarius A*. This is one of 28 stars whose orbits have been tracked around Sag A* without any gravitational lensing effect being noted.

The orbits of these stars have shapes and revolution times which suggest a point-like black hole of about 3 million times the mass of the Sun. It would be expected that with a super-massive black hole, at least some of these orbiting stars would be gravitationally lensed. Despite diligent search, no evidence for such lensing has been found [69]. This indicates that the object at the center of our galaxy may not be a black hole. E. H. Dowdye, Jr. expresses it this way:

> *Moreover, the events taking place at the center of our galaxy [have been] under intense observations by astrophysicists since 1992. … This highly studied region, known as Sagittarius A*, is thought to contain a super massive black hole, a most likely candidate for gravitational lensing. The past two decades of intense observation in this region have revealed not a shred of evidence for any gravitational lensing.* [69]

The only viable alternative to a black hole comes from plasma physics, where spinning disks and polar jets are an everyday occurrence with objects like plasmoids. Plasmoids (Fig. 9 left) occur at the focus of electric currents and magnetic fields.

In describing a plasmoid, Wal Thornhill has stated [70]: *"In the powerful magnetic field of a plasmoid, charged particles are constrained to accelerate continuously in the complex pattern of the plasmoid. Like electrons and protons in particle accelerators on Earth, the apparent masses of those particles become enormous as they approach the speed of light. The plasmoid is "quiet" while storing electromagnetic energy. The persistent high-energy flux comes from synchrotron radiation from the circulating charged particles in the plasmoid."*

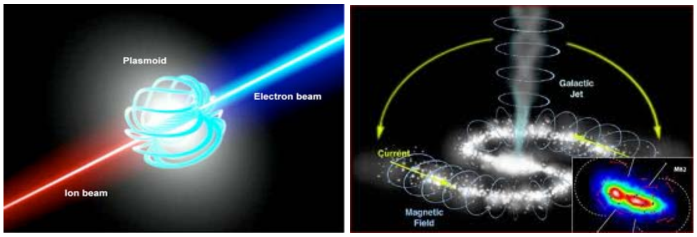

**Fig. 9.** Left—a spherical plasmoid with jets. Right—the typical circuit for a galaxy. The current comes in via the spiral arms and exits at the core where strong currents and high voltages exist. The current exits via the jets (ions in one direction, electrons the other) and circles around back into the spiral arms.

Evidence indicates that such fields and currents exist at galaxy centers as part of the current circuit in every galaxy. (See right image in Fig. 9) Thus plasmoids are expected there.

In plasma physics, the rate of spin of the disk, and the behavior of the polar jets, is entirely dependent upon the strength of the current. If the same applies at the center of our Galaxy, then gravity need not enter the picture. This means that the "black-hole" may not exist either, a conclusion reinforced by the absence of lensing effects from Sag. A*. Rather the galaxy center is a place of strong electric currents and magnetic fields, as well as strong electric charges. The equation for an orbiting star around the central plasmoid must consider both the electric and magnetic effects as well as gravity. Anthony Peratt has done this. The motion of a solid object in such an environment is completely described by his Eq. (2), page 775 in [67]:

$$m\frac{d\vec{\mathbf{v}}}{dt} = m\vec{\mathbf{g}} + q\left(\vec{\mathbf{E}} + \vec{\mathbf{v}} \times \vec{\mathbf{B}}\right) - \eta\vec{\mathbf{v}} + \vec{\mathbf{F}} \tag{80}$$

In Eq. (80), $m$ is the mass of the object, which has a velocity $v$ and carries an electric charge $q$. The electric field strength and magnetic induction are $\vec{\mathbf{E}}$ and $\vec{\mathbf{B}}$ respectively. The term $\eta v$ is due to the viscosity of the medium, and $f$ is the sum of all other forces acting. In the case being considered here, the $\eta v$ and $f$ terms may be omitted, and only the gravitational and electromagnetic forces need to be considered. If Sag. A* is not a black hole, then the $mg$ term will be negligible compared with the electromagnetic terms. This would mean that the electric and magnetic forces, given by $q\left(\vec{\mathbf{E}} + \vec{\mathbf{v}} \times \vec{\mathbf{B}}\right)$, must be imparting an acceleration to the nearby stars equivalent to that of a 3 million solar mass black hole. Plasma physics has already concluded that galaxy rotation rates are governed by electric and magnetic forces. Therefore, it would come as no great surprise that stars in galaxy centers, where these forces are focused, are doing the same thing.

## 12. Conclusion

Relativity is the concept that everything is, literally, relative, and that there is no absolute frame of reference in the universe. The discovery of the CMBR provided that absolute frame of reference, however, and this has negated one premise upon which relativity theory is based. Although quantum physics gained the upper hand in terms of popularity, the investigation of the real Zero Point Energy, started by Planck in 1911, later led to the establishment of SED physics. Ongoing research in this topic has given intuitive solutions, with simple mathematics, to problems posed by both quantum and cosmological phenomena.

This paper, among a number of others, has shown that SED physics using the ZPE can also predict a wide range of phenomena that earlier was considered the exclusive province of Relativity theory. Indeed, it seems that the Zero Point Energy is the common factor linking quantum mechanics with Relativity and gravity. When this is combined with the evidence that the Zero Point Energy has changed through time, explanations for a number of discrepant data also open up.

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