Plasma physics has recently opened up new vistas in astronomy based on the interaction of electric and magnetic fields in contrast to gravitational interactions. Yet the magnitude of these electric and magnetic interactions is dependent upon the strength of the Zero Point Energy (ZPE) which controls the properties of the vacuum. The evidence indicates that the ZPE strength has increased with time. This has had the effect of reducing the voltages, current strengths and speed of plasma interactions as time increased. Research indicates that a weaker ZPE in earlier times had the ability to account for some otherwise inexplicable astronomical phenomena. In particular, it gives a new understanding of the role played by electro-magnetic processes earlier in the history of our solar system. Several examples are discussed.

1. Exploring Plasma Behavior

1.1. Introducing Plasma

In 1879, the English physicist, Sir William Crookes, discovered what turned out to be a new fundamental state of matter. In 1923, Nobel Laureate, Irving Langmuir, gave this state of matter the name plasma. Plasma is now considered to be the fourth and most fundamental state of matter. Most people are familiar with the other three states of matter, namely solids, liquids and gases. For example, when we see H2O in its solid state we call it ice. When it is in liquid form it is called water. When that liquid is heated until it boils to a gas we call it steam. However, if that gas is heated to very high temperatures, so that electrons are stripped off the atomic nuclei, this causes the gas to become ionized and we then have plasma. Even a 1% ionized gas may be considered as plasma since it will behave in the same way as fully ionized plasma. Plasma exists in three states, or modes: dark, in which it cannot be seen; glow, such as we see in the auroras; and arc, such as we see in lightning.

Because of ionization, plasmas are better conductors of electricity than metals. Indeed, their conductivity and response to electric and magnetic influences mark them as being distinctly different from a gas. Even weakly ionized plasma has a strong reaction to electric and magnetic fields. In *Physics of the Plasma Universe* [16, p. 17], A. L. Peratt points out that electromagnetic forces are 39 orders of magnitude stronger than gravitational forces. This means that plasmas can act much more rapidly and strongly over vaster distances than any gravitational phenomena can.

Astronomers use an instrument called a spectroscope which can readily discern ionized gases. We have found that about 99% of the cosmos is comprised of these ionized gases, which by definition are plasmas. As it turns out, the Sun and stars are gravitationally bound plasmas. Many of the beautiful photographs from the Hubble Space Telescope have revealed formations of gas clouds out in space, which are plasmas. The electric current in fluorescent lights generates plasma by ionizing the gas in there. Neon signs glow because an electric current excites plasma in the tube. Very weak electric currents in plasma, normally do not glow; they remain in dark mode. It is only when the current is stronger that the plasma begins to emit light.

Extremely strong currents, cause the plasma to go into arc mode as in a welder’s torch, or a lightning bolt. In a terrestrial lightning bolt, the lightning streamers are atoms in the atmosphere that are about 20% ionized and act as channels of plasma for an electric current that may reach a strength of 200,000 Ampers and expend an energy of $6 \times 10^8$ Joules. In contrast, lightning bolts on Jupiter release about 4,000 times as much energy [16, p. 3].

In our near-space environment there is plasma also. We are all familiar with the aurora borealis. In 1908, Birkeland found that luminous rings and streamers were produced around the poles of a magnetized metal globe into which a current was flowing in a near vacuum. He concluded from this classic experiment with his “terrella” that auroras are the result of plasma in our upper atmosphere being excited by electrical currents from the Sun [1]. The Triad satellite confirmed this in 1973 and 1974 [2, 3]. Indeed, the earth is encased in this protective shell of plasma. It begins at our ionosphere and extends some distance into space. The whole structure is called the plasmasphere or magnetosphere. This structure shields life on earth from the high energy radiation that comes from space. Most recently, data from the Themis mission, a quartet of satellites that NASA launched in late 2006, has confirmed Birkeland’s proposal and added more detail. They have found that “a stream of charged particles from the sun flowing like a current through twisted bundles of magnetic fields connecting Earth’s upper atmosphere to the sun” abruptly released the energy to produce the aurora borealis. The comment was made that “Although researchers have suspected the existence of wound-up bundles of magnetic fields that provide energy for the auroras, the phenomenon was not confirmed until May, when the satellites became the first to map their structure some 40,000 miles above the earth’s surface.”[4]

1.2. Plasma & Controversy

However, beginning about 1913, Birkeland’s ideas of electric currents in plasma were vehemently opposed by Sydney Chapman, who had a high standing in the scientific community as a professor of mathematics at Cambridge and Manchester Universities, England. As a result, the history of currents in plasmas then became mired in scientific politics [5]. NASA summarized the situation as follows:
Theories about plasmas, at that time called ionized gases, were developed without any contact with laboratory plasma work. In spite of this, the belief in such theories was so strong that they were applied directly to space. ... The dominance of this experimentally unsupported theoretical approach lasted as long as a confrontation with reality could be avoided. ... Although the theories were generally accepted, the plasma itself [in the laboratories] refused to behave accordingly. Instead, it displayed a large number of important effects that were not included in the theory. It was slowly realized that new theories had to be constructed, but this time in close contact with experiments.”

The second confrontation came when space missions made the magnetosphere and interplanetary space accessible to physical instruments. The first results were interpreted in terms of the generally accepted theories or new theories built up on the same [old] basis. However, when the observational technique became more advanced it became obvious that these theories were not applicable. The plasma in space was just as complicated as laboratory plasmas. Today, in reality, very little is left of the Chapman-Ferraro theory and nothing of the Chapman-Vestine current system (although there are still many scientists who support them). Many theories that have been built on a similar basis are likely to share their fate.”

Because of this controversy, the term “Birkeland current” was not used until 1969. In that year, Birkeand’s prediction of the existence of these currents in auroras was being experimentally verified [7]. Those middle years of the 20th century also involved Hannes Alfvén in the controversy. In 1942 he calculated that if a plasma cloud passed through a cloud of neutral gas with sufficient relative velocity, the neutral gas would itself become ionized and thereby become plasma. This “critical ionization velocity” was predicted to be in the range of 5 to 50 kilometers per second. In 1961 this prediction was verified in a plasma laboratory, and this cloud velocity is now often called the Alfvén velocity. This is one reason why gas clouds in space are usually ionized.

Alfvén’s approach was to build from experiment to theory and then apply it to astronomical phenomena. His work included the prediction in 1963 that the large scale structure of the universe was filamentary [8]. This was proven to be correct in 1991, and came as a shock to many astrophysicists. Earlier, again in 1961, Alfvén also explained the Sun’s visible features in terms of current filaments and sheets [9]. This explanation is currently being verified as a result of photographs obtained in July 2004 from the Swedish one-meter Solar Telescope (SST) at La Palma in the Canary Islands, and from the Japanese Hinode space telescope in March 2007. In 1970, Alfvén was awarded the Nobel Prize in Physics for his work. On 16th June that same year, Chapman died and the vigorous opposition he led against the plasma pioneers slowly began to wane.

By the late 1980’s and early 1990’s, the work of Anthony Perrat came to the forefront in plasma physics. His work at Los Alamos National Laboratories laid the foundation for a much more complete understanding of a wide variety of astronomical phenomena including the formation of galaxies, stars and planets. This foundation is being built on today by scientists like Wal Thornhill, Don Scott, Eric Lerner and many others. As a result of the progress made by these scientists, many astrophysicists are becoming more conscious of the role of electric currents and magnetic fields in astronomical phenomena in general.

1.3. The Origin of Magnetic Fields

The presence of a magnetic field necessarily implies that there is an electric current since this is the only known mechanism whereby magnetic fields are produced. This is just as true in space as it is true for a bar magnet on earth. In the case of the bar magnet, the electric current is produced by the motion of electrons in their orbit and/or by them spinning on their axes. In either case, the negative charge of the electron is in motion, and a charge in motion constitutes an electric current. In the case of a bar magnet, the atoms are aligned so that the respective electron currents are also aligned.

Experimentally we know that an electric current will always produce a magnetic field. The same is true for the motions of positive ions or negative electrons in plasma out in space. These charged particles in motion constitute an electric current, and this current will, in turn, produce a magnetic field whether or not the direction of the current is linear or circular. Plasma is the only state of matter in space where atoms are ionized and can form the electric currents that give rise to magnetic fields. It follows, therefore, that the existence of either an electric current or a magnetic field in space necessarily implies that plasma is present with the ions and electrons in motion. Up until recently, astronomers have often considered a magnetic field to be intrinsic to some local part of space without looking for the larger scale current circuit that produced it.

1.4. Plasma & Magnetic Constriction

Astronomically, magnetic fields are often present in plasma due to electric currents on a scale much larger than the object with the magnetic field. However, the charged particles which make up plasma, namely the positive ions (atomic nuclei) and negative electrons, will tend to follow these magnetic field lines. The reason is that any ion or electron in a magnetic field will experience a force in all orientations except when it is moving parallel to the magnetic field. The movement of these ions and electrons along the magnetic field lines then constitutes a secondary electric current.

Because the existence of such field-aligned currents in space was first anticipated by Birkeland, they are now called Birkeland currents by those involved in space plasma physics [10, 11]. Any such field-aligned current will, in turn, generate its own magnetic field. This secondary magnetic field wraps itself around the current circumferentially and constricts the plasma into a filamentary cable, or fiber, or a stringy, rope-like structure. With an electric current of high intensity, this filamentary cable will itself often twist, producing a pinch that spirals like a corkscrew or a twisted, braided rope. These varieties of rope-like structures are very typical characteristics of Birkeland currents in plasma.

The twisting and pinching of plasma filaments was not generally understood in the early 20th century. It was not until 1934 that an analysis was performed by Bennett of the radial pressure exerted in such instances [12]. These pinches are now called Bennett pinches, or Z-pinches. They are a characteristic of the circumferential magnetic field which surrounds the electric currents in the plasma filaments. Any instability in the current flow
or in the magnetic field will cause the field to pinch the filament inwards. As it does so it will compress the plasma and dust in the pinched region, tending to make a ball. We can see a variety of filamentary structures throughout space where this has happened. The standard Bennett pinch due to the gradient of magnetic pressure $p_m$ is given by

$$p_m = \frac{B^2}{2\mu}$$

(1)

where $B$ is the magnetic flux density or magnetic induction, and $\mu$ is the magnetic permeability of the vacuum. Bennett also noted that compression of the material always occurred whether or not it was fully ionized. Since then, a variety of other pinch effects have been discovered that differ in their geometry and/or operating forces. By 1985, Birkeland currents had become well-known and a discussion of their role in astronomy was opening up [13]. Since then, Peratt and others have shown how Bennett pinches in galactic plasmas and filaments can easily form stars.

### 1.5. The Size Range of Plasma Phenomena

In the laboratory, plasmas commonly display the typical filamentary, rope-like, structure mentioned above, as well as occurring as thin current sheets. On a cosmic scale, plasmas exhibit the same filamentary structures and are associated with field-aligned Birkeland currents. There are many examples in nature of such electric currents aligned with magnetic fields. To begin with, there are those in our atmosphere and the near space environment of our own earth. As Scott points out, “The strange ‘sprites’, ‘ELVES,’ and ‘blue jets’ associated with electrical storms on Earth are examples of Birkeland currents within the plasma of our upper atmosphere” [14]. Again, as Peratt notes, auroras have been observed that have filaments parallel to the magnetic field with dimensions that range from about 100 meters up to 100 kilometers [15, 16]. In auroras, these Birkeland current filaments are often called “auroral electro-jets” and carry currents of about $10^6$ amperes [17]. By contrast, current filaments in solar prominences can carry 100 billion amps [18]. Additional images that serve to emphasize the role of Birkeland currents in Solar phenomena can be found in [19].

Peratt also mentions that space probes have found “flux ropes” in the ionosphere of Venus whose filamentary diameters are of the order of 20 kilometers [15, 16]. On a larger scale he lists examples of plasma filaments in the Veil, Orion, and Crab nebula. More recently, a huge “magnetic slinky” was found to be wound around a rod-like cloud that occupied a significant portion of the constellation Orion. This should have come as no surprise because, at the 1999 International Conference on Plasma Science in Monterey, California, the radio astronomer Gerrit Ver- schuur made an important announcement. After high resolution processing of the data from about 2000 clouds of neutral hydrogen in our galaxy, he found that they were actually made up of plasma filaments which twisted and wound like helices over enormous distances. It was estimated the interstellar filaments conducted electricity with currents as high as ten-thousand-billion amperes [20].

Fifteen years earlier, Yusef-Zadeh et al. had pointed out that twisting filaments, held by a magnetic field, extend for nearly 500 light years in the center of our galaxy and were characteristically 3 light years wide [21]. About the same time Perley et al. demonstrated that filaments may exceed a length of 65,000 light years within the radio bright lobes of double radio galaxies [22]. Thus the magnetic pinch of a Birkeland current can maintain filaments of glowing matter over distances of thousands of light years.

Plasma effects can also be seen on galactic scales. One of the first images returned by NASA’s Spitzer space telescope was of the spiral galaxy M81. That telescope detects faint infra-red or heat radiation through clouds of obscuring material. It gave an excellent view of the filaments that form the entire galactic structure of M81 with stars and star clusters forming where its filaments had undergone a series of Bennett pinches. Galaxies like this can extend to 150,000 light years in diameter. These examples clearly demonstrate that plasma filaments and Birkeland currents behave in a consistent way from the scale of laboratory experiments up to at least the size of galaxies. That is consistent behavior from about 1 meter up to $10^{20}$ meters or a scale factor of $10^{10}$.

### 1.6. Cosmological Plasma Filaments and Sheets

The whole structure of the cosmos also provides examples of plasma filaments and sheets. There have been numerous surveys of the positions of galaxies, clusters of galaxies and galaxy superclusters. The Cambridge Cosmology group reproduces the diagram from the CfA survey of large-scale structures of the universe and comment that “Galaxy positions are plotted as white points and large filamentary and sheet-like structures are evident, as well as bubble-like voids” (see [23]). They then go on to elaborate saying that “Deep redshift surveys reveal a very bubbly structure to the universe with galaxies primarily confined to sheets and filaments.” The Particle Physics and Astronomy Research Council (PPARC) website states that large-scale surveys of the cosmos “reveal the hierarchical structure of galaxies, galaxy clusters and superclusters linked by filaments and sheets surrounding huge voids.” Their three dimensional diagram showing the filaments can be found at [24] with some comments about it at [25].

These structures trace out the behavior of plasma filaments and sheets on a cosmological scale. This was just what Alfvén had predicted, yet it caught many astrophysicists unprepared. Some still try to account for these structures using gravity, but they require the invented and very finely tuned action of “dark matter” to produce the desired result.

If these cosmological structures are taken at face value and compared with typical plasma behavior, one cannot avoid the conclusion that the earliest moments of the universe involved plasma sheets, filaments and Birkeland currents. Furthermore, they demonstrate consistent plasma behavior from the laboratory to cosmos-wide scales. Additional proof was provided recently when it was found that the spin axes of spiral galaxies were all aligned along filaments. This cannot be reproduced by gravitational physics, but is a natural consequence of plasma physics and galaxy formation as outlined by Peratt.

### 1.7. Plasma Physics and the Early Universe

Herein lies one of the advantages of the plasma model. Many astronomers agree that the universe started off as a hot plasma. Gravitational astronomers then have to wait for the universe to cool and for neutral atoms to form (a process called decoupling)
and then attract each other gravitationally before galaxies and stars and planets can even begin to form. Plasma astronomers do not have to wait for these developments; the processes can start immediately. This is advantageous because the most distant galaxies that we can see already have a degree of maturity and are exceptionally close to the Big Bang event itself.

The galaxy closest to this event is UDFy-38135539, and the image of this galaxy, at a redshift of 8.55, "shows the galaxy as it was when it was 100 million years old ... just 600 million years after the Big Bang..." [26]. There is a huge problem with this. It is the same problem that exists with the lines of the element iron found in the spectra of these distant objects. They are too near to the inception of the Big Bang process, as it is usually understood, for these to exist on the standard model.

James Trefil put it this way: "Galaxies cannot begin to form until after radiation and matter decouple. If, however, the only mechanism at our disposal is gravitational instabilities of the Jeans type, all the matter will be carried out of range before anything like the present galactic masses can collect. There is a narrow window in time between decoupling and the point where matter is too thinly spread, and any galaxy-formation mechanism we can accept has to work quickly enough to fit into this window." [27]. But the data show galaxies and mature galaxy clusters in existence very soon after the Big Bang. Since plasma processes act more immediately and quickly than gravitational processes, plasma physics has a very obvious answer to the gravitational astronomers’ problem. To understand why plasma interactions are so rapid, consider the following points.

1.8. Plasma Interactions and Galaxy Formation

First, two or more parallel Birkeland currents can interact with each other. Two parallel Birkeland currents moving in the same direction will attract each other. This attractive force is inversely proportional to the distance between them [28]. This contrasts with the gravitational force which is inversely proportional to the square of the distance. In fact, in plasma, electromagnetic force can exceed gravitational force by a factor of $10^{39}$. Even in neutral hydrogen regions of space where the ionization is as low as 1 part in 10,000, electromagnetism is still about $10^7$ times stronger than gravity [28].

Not only is this electromagnetic attraction much stronger than gravity, the attractive force is also proportional to the strength of each current multiplied together [28]. Thus stronger currents result in even stronger attractive forces. The same holds true for electric currents in parallel wires as Ampere first demonstrated in 1820. This can be expressed mathematically. If the attractive or repulsive force is $\delta F$, on a length $\delta l$ of either current whose distance apart is $r$, with the currents being $I_1$ and $I_2$ respectively, then we can write [29]:

$$\frac{\delta F}{\delta l} = \frac{I_1 I_2}{r} \mu \frac{\mu}{2\pi}$$

In this equation, the quantity $\mu$ is the magnetic permeability of the vacuum.

These laboratory filament interactions form an entire sequence of objects starting with the various types of double radio galaxies, then quasars and active galactic nuclei, then the various elliptical galaxies and finally, at the end of the sequence, a variety of spiral galaxy types are formed. Which object is formed depends either on where the interaction ceases or at what stage we are viewing the interaction out in space, and the number of filaments involved.

As the process continues, the Bennett pinch first forms stars in the cores of these galaxies and then, a little later, in the spiral arms. This accounts for the two main distributions of stars, Population II and Population I. The process has been described in a number of scientific papers and books which have resulted from plasma laboratory experimentation and computer simulations. For key examples see [15, 16, 30].

1.9. Sorting of Elements by Plasma Currents

When currents flow in ionized or partially ionized plasma filaments, a separation of elements may occur. When there are a variety of ions in a filament, there tends to be a preferential, radial transportation of ions. The elements with lowest ionization potential are brought closest to the current axis. Peratt points out that the most abundant elements found in cosmic plasma will be sorted into a layered structure within the plasma filaments. He states that "Helium will make up the most widely distributed outer layer; hydrogen, oxygen and nitrogen should form the middle layers; and iron silicon and magnesium will make up the inner layers. Interlap between the layers can be expected and, for the case of galaxies, the metal-to-hydrogen ratio should be maximum near center and decrease outwardly" [30]. This process is called Marklund convection after its discoverer [31].

The Bennett pinch, coupled with the sorting of elements in plasma filaments, which follows ionization sequences, explains not only the predominant composition of the members of the solar system as we go out from the sun [32], but it also gives us the answer to a problem the standard model has with the earth’s geology. That model states the earth became completely molten at the time of an ‘iron catastrophe’ which resulted in the layering of the earth’s interior. However, zircons from the Jack hills area of Western Australia reveal that the earth was cool with an ocean and hydrological cycle operating during the time it was meant to be molten [33]. Marklund convection overcomes the problem.

2. The Zero Point Energy (ZPE)

2.1. Concepts of the Vacuum

The electric and magnetic effects observed in plasma are dependent upon the properties of the vacuum. If these properties should alter, the rate of plasma processes may well alter also. In order to discover exactly what will happen, these vacuum properties need to be examined.

During the 20th century, our knowledge regarding space and the properties of the vacuum took a considerable leap forward. The vacuum of space is popularly considered to be a void, an emptiness, or just ‘nothingness.’ This is the definition of a so-called bare vacuum. However, as science has learned more about the properties of space, a new and contrasting description has arisen, which physicists call the physical vacuum.

To understand the difference between these two definitions, imagine you have a perfectly sealed container. First remove all solids, liquids, and gases from it so no atoms or molecules remain. There is now a vacuum in the container. This gave rise to the 17th century definition of a vacuum as a totally empty volume
of space. Late in the 19th century, it was realized that the vacuum could still contain heat or thermal radiation. If we insulate our container with the vacuum so no heat can get in or out, and if it is cooled to absolute zero, or about -273°C, all thermal radiation has been removed. It might be expected that a complete vacuum now exists within the container. However, both theory and experiment show this vacuum still contains measurable energy. This energy is called the Zero-Point Energy (ZPE) as it exists even at absolute zero.

The ZPE was discovered to be a universal phenomenon, uniform, all-pervasive, and penetrating every atomic structure throughout the cosmos. It is composed of electromagnetic waves of all wavelengths down to the Planck length cutoff at 10⁻³⁵ centimeters. The existence of the ZPE was not suspected until the work of Max Planck in the early 20th century for the same reason that we are unaware of the atmospheric pressure of 15 pounds per square inch that is imposed upon our bodies. There is a perfect balance within us and without. Similarly, the radiation pressures of the ZPE are everywhere balanced in our bodies and measuring devices. However, the world of atoms is like a ship supported by a vast sea of electromagnetic waves that comprise the ZPE.

2.2. Planck and Einstein infer the ZPE

The work of Planck in discovering the existence of the ZPE is vital to our understanding of the development of the topic. In 1901, after a number of physicists had failed, Max Planck derived a mathematical expression that fitted the most recent experimental curves for black body radiation. Planck achieved his derivation by hypothesizing that the energy states of charged point particle oscillators came in discrete units rather than being continuous. Thus radiation is not emitted in continuous amounts but in discrete bundles of energy described by the product of the new constant ‘h’, and the frequency, ‘f’. Kuhn noted Planck was skeptical of the physical significance of his mathematical assumption and his constant ‘h’ for over a decade [34]. At best, Planck felt it only applied to particle oscillators and their emitted radiation. This was only a slight modification of Maxwell’s classical theory of radiation.

Because of his dissatisfaction, Planck in 1910 formulated his so-called second theory where he again derived the blackbody spectral formula but with an excellent reason for the presence of his constant ‘h’. His equations, published in 1911, pointed directly to the existence of a zero-point energy [35]. Planck’s equation for the radiant energy density of a black body had the same temperature-dependent term as derived in his first theory, plus an additional (½)hf term which was totally independent of temperature. It indicated a uniform, isotropic background radiation existed.

Albert Einstein and Otto Stern published an analysis in 1913 of the interaction between matter and radiation using simple dipole oscillators to represent charged particles – an approach based firmly on classical physics [36]. Very significantly, they remarked that if, for some reason, dipole oscillators were immersed in a zero-point energy, that is, if there was an irreducible energy of hf at absolute zero of temperature in the vacuum, the Planck radiation formula would result without the need to invoke quantisation at all. This important point has been proven correct, since Timothy Boyer and others have made just such derivations [37]. These calculations show the irreducible energy of each oscillator is (½)hf, as Planck and Nernst correctly deduced, rather than Einstein and Stern’s hf. However, Einstein and Stern’s comments are still very pertinent.

2.3. Observational proof for the ZPE

In 1916, Walther Nernst examined the ZPE’s existence from Planck’s second theory along with Einstein and Stern’s proposal, and suggested that the universe may actually be filled with vast amounts of this zero-point radiation (ZPR) [38]. Nernst noted both of these developments required an intrinsic cosmological origin for the ZPE. In 1925 the existence of the ZPE was confirmed. The chemist Robert Mulliken found this proof in the spectrum of boron monoxide. As he analyzed the wavelengths of these spectral lines, he discovered a slight shift from the theoretical position that these lines would have had if the ZPE did not exist. The ZPE waves slightly perturb an electron in an atom so that, when it makes a transition from one state to another, it emits light whose wavelength is shifted slightly from its normal value. Some years later, a similar shift of wavelength in the microwave region of the hydrogen spectrum was seen experimentally by Lamb and Retherford using a method developed for radar. Today, the Lamb shift of spectral lines, as it is now called, is quoted as an observational proof for the existence of the ZPE. Lamb stated the experimental results were “a proof that the [perfect] vacuum does not exist” [39].

2.4. Choices for Physics

It is at this point, in the mid-1920’s, that the direction of physics hung in the balance. Physics could have adopted the approach of Planck’s second theory, plus the contributions from Einstein, Stern and Nernst that indicated the ZPE existed. Classical theory plus a real, intrinsic cosmological ZPE could then account for all the observed phenomena, backed by Mulliken’s observational proof that the ZPE actually existed. The alternative was to follow Planck’s 1901 approach that used a purely theoretical concept of ‘h’ without a physical cause, except that it gave the right results. Four major papers were then published in four years using mathematical explorations of Planck’s first theory without the intrinsic ZPE. These four papers swung the balance and set physics on a course that led to present-day Quantum Electro-Dynamics or QED.

However, in 1962, Louis de Broglie noted that serious consideration of Planck’s second theory, embracing classical theory with an intrinsic cosmological ZPE, had previously been widespread until around 1930 [40]. His book initiated a re-examination of the alternative. This re-examination showed that the quantum processes mentioned in the four papers, which had swung physics in the direction of QED, actually had viable explanations in classical physics using the ZPE.

Since then, a steady line of papers has been published using the ZPE approach, which is called Stochastic Electro-Dynamics (SED) in contrast to the more standard QED. SED physics, based on the existence of an all-pervading ZPE, has been able to derive and interpret classically the black-body spectrum, Heisenberg’s Principle, the Schroedinger equation, and explain the wavenature of matter (see details in reference [41]). These were the
very same four factors that, interpreted without the ZPE, gave rise to QED concepts. In listing some of the successes of SED physics, it was stated that “The most optimistic outcome of the SED approach would be to demonstrate that classical physics plus a classical electromagnetic ZPF could successfully replicate all quantum phenomena” [42]. This requires SED physics to overhaul a 60-year head-start of QED physics, with millions of man-hours involved. But good progress is occurring, despite the few physicists working in the field.

2.5. Evidence for the ZPE

After Planck’s 1911 paper, experimental evidence accumulated pointing toward the existence of the ZPE, although its fluctuations do not become significant enough to be observed until the atomic level is attained. This explains why cooling alone will never freeze liquid helium. Unless pressure is applied, ZPE fluctuations prevent helium’s atoms from getting close enough to permit solidification. In electronic circuits, such as microwave receivers, another problem arises because 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.

There are other physical evidences for the existence of the ZPE. One is the surface Casimir effect. 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. The explanation 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 with 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% [43]. The Casimir effect therefore demonstrates the existence of the ZPE in the form of electromagnetic waves.

2.6. Introducing Virtual Particle Pairs

Since ZPE waves go in all directions, they impact each other in somewhat the same way as waves in the ocean. Where ocean waves meet, due to a boat passing or strong cross-currents, they crest and form whitecaps which then die down quickly. When ZPE waves meet, they create a concentration of energy that results in the formation of a positive and negative pair of particles, which flash into existence momentarily, then re-combine and annihilate. For this reason they are referred to as virtual particles. It has been estimated that today, at any given instant, there are about \(10^{42}\) virtual particles flashing into and out of existence in the volume of any cubic meter. SED physics predicts a veritable zoo of all kinds of virtual particles inhabiting the vacuum.

These virtual particles must be navigated by every photon of light. As a photon moves through the vacuum, it will be absorbed by a virtual particle. However the particle pair will recombine and annihilate extremely rapidly, releasing the photon to continue on its way. The more virtual particles a photon of light must navigate, the longer it takes to reach its final destination. Because of the extreme numbers of virtual particles, there will be huge numbers of photon/particle interactions even over very short distances.

This means that, if the strength of the ZPE changes over time, there will be a corresponding and directly proportional change in the numbers of virtual particles in a given volume of space. Thus, if the ZPE strength increases, the vacuum will become "thicker" with virtual particles. Since Planck’s constant is a measure of the speed of light will decrease in inverse proportion. It has been demonstrated that there are a number of atomic constants, in addition to these two, which are linked with the ZPE strength. They include the electrical permittivity and magnetic permeability of free space. These quantities individually and collectively have shown that the ZPE strength has indeed increased over time. For a full discussion of the data and their link with the ZPE see [44-47].

2.7. An Increasing ZPE Strength

There are good physical reasons for the strength of the ZPE to increase with time. It can be shown that the ZPE originated with the expansion of the universe. It is generally agreed the universe was rapidly expanded out at its beginning. This is supported by the cosmic microwave background radiation. It is also supported by evidence from the distribution of hydrogen clouds, but they also strongly imply that the cosmos became static later [48]. Some models accept these data, but other models insist on continuing expansion.

Whichever model is chosen, this initial expansion resulted in an enormous amount of potential energy being invested in the fabric of space. In a similar way, a stretched rubber band has potential energy invested into its fabric. When released, the rubber band will fly quickly at first, and then slow down as the potential energy converts to kinetic energy. Similarly, the fabric of space converted the potential energy of the expansion into the kinetic energy which manifested as the ZPE. The process is detailed in [32, 47, 49]. This conversion happened quickly at first, then slowed. However, it still continued for some time, and while it was continuing, the electro-magnetic ZPE field was becoming stronger as evidenced by astronomical data [47]. Therefore, even in a universe which may currently be in a static state after original expansion, the ZPE strength would have continued to build for a significant time.

2.8. ZPE Variation and Atomic Constants

Changes in the strength of the ZPE will mean that the vacuum’s electrical permittivity, \(\varepsilon\), and magnetic permeability, \(\mu\), are also changing. As these change, the speed of light, \(c\), will also change since they are related as in equation (3) here:

\[
c^2 = \frac{1}{\varepsilon\mu}
\]

But with these changes in vacuum properties, the vacuum must remain a non-dispersive medium otherwise photographs of distant astronomical objects would appear blurred. This requires the ratio of electric energy to the magnetic energy in a traveling wave to remain constant. In turn, this means the intrinsic imped-
ance of free space, $\Omega$, must be invariant. It then follows from the
definition of intrinsic impedance and (3) that:

$$\Omega = \left[ \frac{\mu}{\varepsilon} \right] = \text{invariant} = \mu c = \frac{1}{\varepsilon c}$$

(4)

Thus $\Omega$ will always bear the value of 376.7 ohms. From (4) it
follows that, with all these changes, $c$ must vary inversely to
both the vacuum permittivity and permeability, so that

$$\varepsilon \sim \mu \sim \frac{1}{c}$$

(5)

where the symbol $\sim$ means "is proportional to" in this paper.
Therefore, at any given instant, $c$ would have the same value in
all frames of reference throughout the cosmos. It can then be
shown as in reference [47] that if the ZPE strength is given
by $U$, then as $U$ varies so do $\varepsilon$ and $\mu$ such that:

$$U \sim \varepsilon \sim \frac{1}{c}$$

(6)

Because experimental evidence indicated $c$ was declining, an
ongoing discussion occurred in scientific journals from the mid
1800’s to the mid 1940’s. In 1927, M.E.J. Gheury de Bray was re-
sponsible for an initial analysis of the $c$ data [50]. Then, after four
new determinations by April of 1931, he said “If the velocity of
light is constant, how is it that, INVIABLY, new determinations give
values which are lower than the last one obtained. … There are twenty-
two coincidences in favour of a decrease of the velocity of light, while
there is not a single one against it” [50].

As Planck’s analysis showed in 1911, the strength of the ZPE
is given by Planck’s constant, $h$, so we can write:

$$h \sim U$$

(7)

Faced with increasing values for $h$, J. H. Sanders noted that
the increase could only partly be accounted for by the improve-
ments in instrumental resolution. One reviewer commented on
this very point saying that it "may in part explain the trend in the
figures, but I admit that such an explanation does not appear to be
quantitatively adequate." [44] A complete discussion with all the
data can be found in [44]. It also follows from (6) and (7) that for
all ZPE variation

$$h c = \text{invariant}$$

(8)

The conclusion from (8) that $hc$ is invariant is supported to an
accuracy of parts per million by observations out to the frontiers
of the cosmos, including studies of the fine structure constant, $\alpha$
[51]. This constant is a combination of four physical quantities
such that $\alpha = \left[ \frac{e^2}{\varepsilon} \left[ 1/(2hc) \right] \right]$, where $e$ is the electronic charge.
From (8), $hc$ is cosmologically invariant, but this observational
evidence for $\alpha$ means throughout the cosmos that

$$\frac{e^2}{\varepsilon} = \text{constant}$$

(9)

Since (6) shows the permittivity is proportional to ZPE
strength, $U$, then it follows from (9) that

$$e^2 \sim U$$

(10)

The variation in $e$ has been experimentally verified and dis-
cussed in [44]. It has also been shown there and in [47] that atom-
ic masses, $m$, behave such that

$$m \sim U^2 \sim h^2 \sim \frac{1}{c^2}$$

(11)

2.9. The ZPE, Electricity and Magnetism

Equation (9) leads to an expression for the electrostatic force, $F$, associated with ions and electrons, and it is given by the
standard equation:

$$F = \left[ \frac{e^2}{\varepsilon} \left( \frac{1}{4\pi r^2} \right) \right] = \text{constant}$$

(12)

since $r$ is unchanged. The electrostatic force $F$ is also given by:

$$F = eE = \text{constant}$$

(13)

where $E$ is the magnitude of the electric field strength. Thus, from
(10), we have the magnitude of the field strength of an electron or
ion given as

$$E \sim \frac{1}{\sqrt{U}}$$

(14)

Now field strengths of ions and electrons can also be written as
$E = V/r$ in volts per meter, and since distances, $r$, are un-
changed, it then follows that

$$V \sim \frac{1}{\sqrt{U}}$$

(15)

This also means that capacitance, $C$, behaves as follows:

$$C = \frac{e}{V} = 4\pi r - \frac{1}{c} \sim U$$

(16)

Since forces are constant in electro-magnetics, we have:

$$\frac{\delta F}{\delta I} = \left( \frac{l_1 l_2}{r} \right) \left( \frac{\mu}{2\pi} \right) = \text{const} ; \quad \mu l_1 l_2 = \text{const}$$

(17)

Let us assume that two ion currents are of equal magnitude.
Then, applying (5) to (17), means current, $I$, in amperes goes as:

$$I \sim \frac{1}{\sqrt{U}}$$

(18)

So from (18), the electric current $I$ is proportional to $\sqrt{e}$. This
may be similarly derived from reference [15] equation (6). Thus all
electric currents, $I$, will be intrinsically higher when the strength of the ZPE is lower and $c$ values are higher.

Since power, $P$, equals current, $I$, multiplied by the voltage, $V$, then from (15), (17) and (18) it behaves as follows:

$$P = IV = c \sim \frac{1}{U}$$

(19)

So the power in watts is inversely proportional to the strength
of the ZPE. In contrast, the resistance, $R$, in ohms is given by:

$$R = \frac{V}{I} = \text{constant}$$

(20)

So resistances remain unchanged with ZPE variation. Now
the magnetic field strength is defined as $(H = I/r)$ in units of am-
peres/meter. Since \( r \) is unchanged, this means that \( H \) is proportional to \( I \) which from (18) gives us
\[
H \sim \sqrt{\mathcal{E}} \sim \frac{1}{\sqrt{U}}
\]  
(21)

The magnetic flux density or magnetic induction \( B \) from [52] is:
\[
B = \mu H \sim \frac{1}{\sqrt{\mathcal{E}}} \sim \sqrt{I}
\]  
(22)

Let us now examine the equations elucidating plasma behavior and the effects of a changing ZPE. The standard equations used in this next section all come from [15, 16, 30].

2.10. Examining Plasma Equations

The Bennett pinch, due to the gradient of magnetic pressure, is governed by the effects of (5) and (22) so that:
\[
p_m = \frac{B^2}{2\mu} = \text{constant}
\]  
(23)

The drift velocity of ions in a plasma filament, which is linked with Marklund convection, is given by the relationship
\[
v = \frac{E}{B} \sim c \sim \frac{1}{U}
\]  
(24)

which follows from (14) and (22). Thus drift velocities were higher when the ZPE strength was lower in the early universe. As a consequence, matter could accumulate in plasma filaments much more readily than they do now, and this mechanism is certainly much more efficient than gravity. This contention is reinforced by the rate of accumulation of material in filaments which is given by:
\[
\frac{dM}{dt} = (2\pi)^2 \rho \frac{E}{\mu} \sim c \sim \frac{1}{U}
\]  
(25)

where \( \rho \) is the number density of ions. This result follows from applying (6), (14) and (18) and confirms that such processes were much more efficient in the earlier days of our cosmos.

The potential difference that builds up on a grain or particle of dust in a plasma is given by:
\[
V = -2.51 \frac{kT}{e} \sim \sqrt{\mathcal{E}} \sim \frac{1}{\sqrt{U}}
\]  
(26)

Here \( T \) is the temperature of the ions and electrons and \( k \) is Boltzmann’s constant. Thus voltages on dust grains were greater when the ZPE strength was lower.

The axial component of the vorticity, \( \mathcal{W} \), which forms current bundles or filaments when instabilities occur has the following proportionality:
\[
\mathcal{W} = \frac{c(N_e - N_i)}{e} \sim \sqrt{\mathcal{E}} \sim \frac{1}{\sqrt{U}}
\]  
(27)

where \( N_e \) and \( N_i \) are the numbers of electrons and ions respectively. So it can be seen that this component was more effective in forming filaments when the ZPE strength was lower and the value of \( c \) was higher.

Thus, when the cosmos was younger, plasma processes, including instabilities, formed filaments and accumulated material more readily than now because the ZPE strength was lower. In contrast, gravitational processes were much more leisurely. These results establish basic principles when dealing with the formation of the various types of objects seen out in the cosmos.

3. ZPE Variation & Plasma Effects

3.1. A New Scenario Opens Up

With intrinsically stronger electric currents, higher voltages, lower capacitances, faster ion drift velocities, faster filament formation, more rapid accumulation of material and more efficient Marklund convection, the whole plasma universe scenario takes on a new aspect. To begin, the problem of the time it takes for galaxy formation, that James Trefil so clearly enunciated, completely disappears. A similar situation applies to star and planet formation times as well. In that scenario, dust grains could attain a significant size and still be more easily moved by electric and magnetic interactions than gravitation. For example, it seems that the spherical chondrules in meteorites, which can attain 1 centimeter diameter, could easily have been agglomerated in the early universe by electromagnetic means, rather than gravitational.

3.2. The Sun and its Output

With a lower ZPE strength, the output of the sun is often thought to be a cause for concern. If nuclear sources are considered for stellar output of light, the result is the same as for an electric power source. In the latter case, equation (19) shows that the power output is greater in inverse proportion to the ZPE strength. The same result is obtained from more elaborate reasoning in the nuclear case. The result is that the number of light photons or waves emitted per unit time is greater, proportional to \( c \), when the ZPE strength, \( U \), is less.

However, several other factors are also at work. First, the energy, \( E \), of each photon or wave remains unchanged. This occurs because it can be shown that, as the ZPE increases, the wavelengths, \( \lambda \), of light remain fixed. So we can write
\[
E = \frac{hc}{\lambda} = \text{constant}
\]  
(28)

since \( hc \) is invariant from (8). Unchanged photon energy means the color of light photons remains the same. This is because a photon’s energy determines its color.

The second point is crucial. The energy density of a wave or photon determines its amplitude squared [53]. It can be shown that these energy densities are proportional to \( h \) or \( 1/c \) and are lower when the ZPE strength is lower. The reason is that energy density (and hence the square of the amplitude) is affected by the vacuum permittivity and permeability, which are proportional to \( h \) or \( 1/c \). So the amplitudes of all radiation will be lower with lower ZPE. This leads on to point three.

The intensity, or brightness, of light is determined by two factors multiplied together: the square of the amplitude (or the energy density), and the velocity, \( c \) [53]. Thus a wave train whose energy density is proportional to \( 1/c \) has \( c \) times as many waves (or photons) passing a given point in the same time interval. As a result, the radiation intensity, or brightness, of the sun and stars remains unchanged as the ZPE varies. A lower ZPE thus means a greater flux of photons for the same brightness. The effect of this on fossil plants is explored in [56].
3.3. Planets and Plasmaspheres

One of the most important outcomes of a low ZPE in earlier times was the effect on the plasmaspheres and/or magnetospheres of the planets. Planetary plasmaspheres have a shape like the 'windsock' which is seen at some airports. The plasmaspheres have a broad hemispherical 'nose' facing the Sun and a long 'tail' which streams away from the Sun and moves back and forth in the solar wind something like a comet's.

Whether a plasma is in dark, glow, or arc mode depends on the strength of the current flowing through it. Today, the planetary plasmaspheres are in dark current mode because the current is relatively low. In the past, however, when currents were higher, the planetary plasmaspheres would have been, at least partly, in glow mode. For this reason, the planet Venus would have given the appearance of a woman's head of hair as the "stringy things" in its plasma tail stream out in the solar wind. This is exactly how the ancients describe the planet. Spacecraft have found these stringy things which form part of Venus' plasma tail in the near earth environment. So we know Venus' plasma-tail crosses our orbit.

The planet Jupiter has an enormous plasmasphere. It extends from 3 to 7 million kilometers (2 to 4.5 million miles) towards the Sun and the windsock tail has been detected by space craft as far out as Saturn’s orbit. This means that its greatest diameter would be up to 14 million km. From earth, this structure would appear to be about 1.5 degrees wide at its closest approach. This is three times the Sun and Moon appear in our skies. Thus, Jupiter’s plasmasphere in glow mode would be visible from earth and be the largest object in the heavens. This may be why it was given the title "the king of the gods" by the ancient observers.

3.4. Electric Discharges

There is also evidence of a potential difference in the solar system. As the positively charged particles from the solar wind move away from the Sun, they accelerate so that they are traveling faster at Jupiter's orbit than they are at Earth’s orbit, and so on towards the outer solar system. This suggests that the outer solar system is at a more negative potential than the inner sector, and that the Sun is at a large positive potential by comparison [54]. This also means there is a voltage difference between planets. As an illustration, the earth's plasma tail extends well beyond the Moon. During a 6 day period around the time of full Moon, the earth’s plasma tail sweeps over the Moon’s surface. At those times, the potential on the Moon changes by over 1000 volts [55]. When the ZPE was lower, this potential difference would have been greater.

A lower ZPE in the early days of our solar system meant the voltage differences were greater. Thus when the tail of planetary plasmaspheres passed over the next planet further out in the solar system, such as Jupiter's tail passing over Saturn, the huge potential difference could result in a violent electrical discharge. This would have been visible from earth and may have given rise to the tradition of Jupiter casting his thunderbolts. Even today, there is an ongoing electrical discharge between Jupiter and its inner Galilean moon Io. Before, this may have been visible from earth. Therefore, Jupiter would present a frightening aspect with a continual, visible electric discharge with its moons. The thunderbolt legend may be testifying that the ZPE was lower then.

The plasmasphere of Venus passes over the earth when the Sun, Venus and Earth are lined up at the time of an inferior conjunction. This may have allowed an electrical discharge to occur from one to the other. Such a discharge may well have caused considerable damage, and give rise to the notion that planetary alignments bode ill for humanity.

There is a possibility that such an event occurred fairly recently. On 6th July 1908 Venus was again at an inferior conjunction. The solar wind can blow the plasma tail of any planet quite wildly, like the earth’s tail across the Moon. So a typical 7-day period should be taken on either side of the precise alignment with Venus. If this is done, we note that at 7:14 am on 30th June 1908, a blue streak was seen approaching in the sky for about 3 minutes before a blast equivalent to 10 to 15 megatons of TNT (or 1000 times that of Hiroshima) affected an area of over 2150 square kilometers (830 sq. miles). This event was accompanied by a Richter 5 earthquake and is known as the Tunguska explosion in Siberia. No fragments that exclusively belong to a comet or meteorite have ever been found. But the description of the event and any fragments do fit an electric discharge between the planets.

If this is indeed the result of an electric discharge from Venus when the ZPE strength is strong, then any similar event in the distant past, when the ZPE strength was lower, would have been more violent. This may give some idea of why planetary alignments were so feared by the ancients, and became the focus of interest in astrology.

4. Conclusion

The initial expansion of the universe put energy into the fabric of space which we call the Zero Point Energy. It can be shown that the ZPE built up with time, and the properties of the vacuum changed. As the ZPE increased, electric currents and voltages reduced, while resistances and forces remained unchanged.

These changes through time affected plasma interactions. Thus a low ZPE in earlier times resulted in filaments approaching each other and interacting more quickly to form galaxies. A more rapid sorting of ions and the faster accumulation of material coupled with instabilities from pinches in the filaments resulted in more rapid star and planet formation. Ionization potential, which caused the sorting of elements, resulted in the layered structures of planets and the differences in their relative compositions out from the sun.

Higher currents and voltages in the earlier days of our solar system may also have made planetary plasmaspheres go into glow mode and allow electrical discharges between planets when alignment occurs. If so, this would account for a number of features of persistent myths and legends. It also increases the possibility of other electric and magnetic effects being responsible for some structures on planetary surfaces.

References

*All websites retrieved 12 Mar 2011.