

Reviewing A Plasma Universe With Zero Point Energy

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ABSTRACT: The first section of this paper reviews recent developments in areas of plasma physics that have relevance to cosmology, astronomy and our solar system. Some important equations that describe the behavior of plasmas in these areas are noted. The second section reviews recent developments that pertain to the vacuum Zero Point Energy (ZPE) and its behavior over time. It is shown that this behavior affects the electric and magnetic properties of the vacuum. The third section elucidates the effects that these changes in the strength of the ZPE have on plasma, and the equations describing them. The final section discusses the implications these changes have for the early universe in cosmologies based on plasma and Big Bang physics. The role played by ion sorting in plasma filaments in the formation of our solar system is examined. The reason for the quantization of the redshift is elucidated from atomic orbit behavior with a ZPE

KEYWORDS: Plasma physics, filaments, ions, electric currents, magnetic fields, Marklund convection, Zero Point Energy, ZPE, vacuum properties, variable constants, quantized redshift, cosmology, galaxy formation.

I. EXPLORING PLASMA BEHAVIOR

A. 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 now heated to very high temperatures, so that electrons are stripped off the atomic nuclei, this causes the gas to become ionized, so that it consists of positively charged nuclei and negatively charged electrons separated from each other and moving rapidly. This is a plasma. Even a 1% ionized gas may be considered as plasma since it will behave in the same way as fully ionized plasma. Because of this ionization, one of the important properties of plasmas is that they are better conductors of electricity than any metal. In fact, 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. A L Peratt in "*Physics of the Plasma Universe*," (Springer-Verlag, New York, 1991, p. 17) states that when comparing the electromagnetic force and the gravitational force, the former exceeds the latter by 39 orders of magnitude. This means that plasma forces can act much more rapidly over vaster distances than any gravitational force can. This has some major implications for both astronomy and cosmology.

Plasma is the major constituent of the universe. Using spectroscopes, which readily discern ionized gases, astronomers have found 99% of the known, visible cosmos is plasma. As it turns out, the Sun and stars are gravitationally bound plasmas. Many of the beautiful photographs from the Hubble Space Telescope reveal formations of gas clouds out in space which are also a plasma. The electric current in fluorescent lights generates plasma by ionizing the gas in there. Neon signs glow because an electric current excites atoms, producing plasma in the tube. Plasma can be in one of three modes. When a very weak electric current is flowing in a plasma, it normally does not glow. This is called the dark current mode. It is only when the current is stronger that the plasma begins to emit light and is in glow mode, as it

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is in neon signs. With extremely strong currents, the plasma goes into arc mode in the same way it does in a welder's torch, or a lightning bolt. In common lightning, the lightning bolts themselves are atoms in the atmosphere that are about 20% ionized and act as channels of plasma for the electric current that may reach 200,000 Amperes and expend an energy of 6×10^8 Joules. In contrast, lightning bolts on Jupiter release about 4,000 times as much energy [Peratt, op. cit., p.3].

Plasma can also be seen with the aurora borealis. In 1908, Birkeland found that if a current was sent through a near vacuum to a magnetized metal globe, luminous rings and streamers were produced around the magnetic poles of the globe. 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]. In fact, it was found that the earth is encased in a protective shell of plasma, called the earth's plasma-sphere, with which the ionosphere and magnetosphere are involved. These shield life on earth from high energy radiation that comes from space. Most recently, data from the Themis mission, a quintet of satellites that NASA launched in late 2006, has confirmed Birkeland's proposed cause for the auroras 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 auroras. 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." See a detailed comment at: <http://www.foxnews.com/story/0,2933,316519,00.html> .

B. Plasma & controversy

Interestingly, Birkeland's ideas about electric currents in plasma were vehemently opposed by Sydney Chapman, a highly respected British physicist. As a result, ideas regarding plasmas became mired in scientific politics [4]. 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.*" [See comment in full at this URL: <http://history.nasa.gov/SP-345/ch15.htm#250>].

Because of the controversy, the term "Birkeland current" was not used until 1969, when Birkeland's prediction of the existence of these currents in auroras was being experimentally verified [5]. The 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

be ionized and thus 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. We see this happening in space, and it is one reason why gas clouds in space are usually ionized.

Alfvén built on Birkeland’s approach, using both experiment and theory, just as Birkeland had. In 1970 Alfvén was awarded the Nobel Prize in Physics for his work in applying plasma physics to space phenomena. Nevertheless, Chapman continued to vigorously oppose Alfvén’s explanations, even though they were experimentally based. One of Alfvén’s explanations included a prediction in 1963 that the large scale structure of the cosmos was filamentary [6]. This was proved to be correct in 1991, to the amazement of many astronomers.

Earlier, in 1961, Alfvén also explained the Sun’s visible features in terms of plasma currents, filaments and sheets [7]. 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 most recent Japanese space telescope, the Hinode, in March 2007. As the NASA quote above indicates, the tide is gradually turning in favor of the new plasma physics which is slowly divesting itself of Chapman’s incorrect approach. Many astrophysicists are now becoming more conscious of the role played by electric currents and magnetic fields in astronomy generally.

C. The origin of magnetic fields

The presence of a magnetic field necessarily implies that there is an electric current since electric currents are the only known mechanism whereby magnetic fields are produced. This is true in space just as it is true for a bar magnet. With a bar magnet, the electric current is produced by the motion of electrons in their orbits 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 is an electric current. Also, in the case of a bar magnet, the atoms are aligned so that the electron currents are also aligned.

Electric currents always produce magnetic fields. If that current is traveling in a loop, such as the electron in its orbit or perhaps in the wire of a cylindrically wound solenoid, it will also produce a magnetic field. The polarity of that field depends on whether the electric charge is positive or negative. The convention established in the 19th century states that if one looks at the current loop, and the current is anticlockwise, that side is a magnetic north pole, while a clockwise loop is the south polarity. Note that this convention defined the direction of the current as the direction of motion of a positive charge. But, in the case of bar magnets, we are dealing with the motion of negative charges (electrons) in atoms. Experiments have shown that an electron current is simply the reverse of a current of positive ions. Thus, for electron currents, or a current of negative charges the polarity of the magnetic field is the reverse of the usual current of positive charges or ions.

The same is true for the motions of positive ions or negative electrons in plasma out in space. Their motion will produce an electric current, and this current will, in turn, produce a magnetic field even if the current direction is linear rather than circular. It should be noted that plasma is the only state of matter in space where atoms are ionized and can form electric currents that give rise to magnetic fields. Thus, 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. In astronomy magnetic fields are often noticed which appear to be far larger than the visible objects being observed. For this reason, many have concluded

that magnetic fields are intrinsic to space. But now, plasma research says we should look for currents on a much larger scale that are in turn producing these magnetic fields.

D. Plasma & magnetic constriction

Primary magnetic fields are often present in plasma due to electric currents which exist on a much larger scale. The charged particles making up the plasma, namely the positive ions (atomic nuclei) and negative electrons, will tend to follow these primary 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 primary magnetic field lines 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 [8]. 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 helical pinch that spirals like a corkscrew or a twisted, braided rope. These varieties of rope-like structures are also typical characteristics of Birkeland currents in plasma.

These phenomena were not generally understood in the early 20th century, even though the first clue was perceived by Pollock and Barraclough in 1905. They investigated a copper rod that had been struck by lightning near Sydney, Australia. The rod had been compressed and distorted by the strike. Their analysis established that the interaction between the large current flow in the lightning bolt and its own magnetic field had produced compressive forces that caused the distortion [9]. It was not until 1934 that an analysis was performed by Bennett of the radial pressure exerted in such instances [10]. This characteristic constrictive action, which is the product of the circumferential (or azimuthal) magnetic field, pinches the plasma into filaments and has now been called the Bennett pinch or Z-pinch [11]. This pinching or bunching is usually accompanied by the accumulation of matter. This explains why interstellar matter displays such a variety of filamentary structures. The standard Bennett pinch due to the gradient of magnetic pressure p_m is given by

$$p_m = B^2/(2\mu) \tag{1}$$

where B is the magnetic flux density or magnetic induction, and μ is the magnetic permeability of the vacuum. Bennett also noted that the compression always occurred whether or not the material was fully ionized. Since then other pinch effects have been discovered that differ in their geometry and/or operating forces. All such pinched-current filaments are given the name 'Birkeland currents.'

By 1985, Birkeland currents had become well-known and discussion of their role in an astronomical context was opening up. In that year, Fälthammer made an important comment. He wrote, "*A reason why Birkeland currents are particularly interesting is that, in the plasma forced to carry them, they cause a number of plasma physical processes to occur (waves, instabilities, fine structure formation). These in turn lead to consequences such as acceleration of charged particles, both positive and negative, and element separation (such as preferential ejection of oxygen ions). Both of these classes of phenomena should have a general astrophysical interest far beyond that of understanding the space environment of our own earth*" [12].

E. 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. This is also true on a cosmic scale. Plasmas exhibit the same filamentary structures that 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”* [13]. 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 [14, 15]. In auroras, these Birkeland current filaments are often called “auroral electro-jets” and carry currents of about 10^6 amperes [16]. By contrast, current filaments in solar prominences can carry 10^{11} amps [see, <http://www.thunderbolts.info/tpod/2005/arch05/051031plasma.htm>].

Photographs of the Sun by the Swedish Solar Telescope revealed Birkeland currents called *“spicule jets [that measure] about 300 miles in diameter, and a length of 2000 to 5000 miles”* [17]. During March 2007, the Hinode Space Telescope sent back solar images that also confirm Alfvén’s analysis and reveal Birkeland currents 8000 kilometers long. At a NASA Press Conference, Leon Golub from the Harvard-Smithsonian Center for Astrophysics (CfA) said, *“We’ve seen many new and unexpected things. Everything we thought we knew about X-ray images of the Sun is now out of date”* [18]. Additional images emphasizing the role of Birkeland currents on the Sun are in [19].

As far as plasma filaments and the rest of our solar system is concerned, Peratt mentions that space probes have found “flux ropes” in the ionosphere of Venus whose filamentary diameters are of the order of 20 kilometers [14, 15]. On a larger scale he lists examples of plasma filaments in the Veil, Orion, and Crab nebulas. Indeed, at the 1999 International Conference on Plasma Science in Monterey, California, the radio astronomer Gerrit Verschuur made an important announcement. After high resolution processing of the data from about 2000 clouds of so-called ‘neutral hydrogen’ in our galaxy, he found they were actually made up of plasma filaments which twisted and wound like helices over enormous distances. It was estimated that the interstellar filaments conducted electricity with currents as high as ten-thousand-billion amperes [20]. Fifteen years earlier, Yusef-Zudeh 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.

However, some more recent examples are also appropriate. Space probes have shown that Jupiter’s rings and moons exist within an intense region of ions and electrons trapped in the planet’s magnetic field. These particles and fields comprise the Jovian magnetosphere and plasmasphere which extends 3 to 7 million kilometers towards the Sun and stretches in a windsock shape behind Jupiter, past Saturn’s orbit, and Saturn sometimes passes through it. If this plasmasphere were in glow mode, it would appear larger than the full moon to us. Indeed, the Sun itself would fit within its limits [see a complete discussion at this URL: http://www.windows.ucar.edu/tour/link=/jupiter/upper_atmosphere.html&edu=high]. NASA’s Spitzer space telescope gives us an entirely different example. One of the first images it returned after launch was of the spiral galaxy M81. The Spitzer space 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 the galaxy M81. This image can be viewed in detail at the following URL:

http://www.nasa.gov/images/content/54346main_m81_highres.jpg or alternatively, with comments here: <http://www.thunderbolts.info/tpod/2006/arch06/060602plasma-galaxy.htm>. Galaxies like this can extend to 150,000 light years in diameter. With these examples in mind, it can be seen 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 on a scale factor of 10^{20} .

F. Plasma sheets and double layers

While discussing plasma phenomena, it might be mentioned that, in the laboratory, as well as in space, plasma current sheets and double layers frequently occur. When an electric current flows through part of the volume of extensive plasma, magnetic forces tend to compress the current into thin layers that pass through the volume. Thus, electrical currents are confined to a surface within the plasma rather than spread throughout a volume of space. The presence of a plasma sheet that extends throughout the Solar System was first verified in 1965 [23]. It is now called the Heliospheric Current Sheet, is about 10,000 kilometers thick and is known to extend from the Sun to the regions beyond Pluto. In the Sun's corona there are plasma current sheets that typically have an aspect ratio, or breadth divided by thickness, of 100,000:1. However, the Heliospheric Current Sheet has an aspect ratio that is significantly greater than that. An illustration of this current sheet along with appropriate comment and discussion can be found on the web at the following URL: <http://www.thunderbolts.info/tpod/2005/arch05/051031plasma.htm>.

A related phenomenon is the formation of a Double Layer in plasma (usually abbreviated as DL). Irving Langmuir discovered that current-carrying plasmas isolate themselves electrically. Wherever there is a significant voltage difference between sections of plasma, it will be largely confined by the formation of two parallel layers with opposite charge. One layer will have an excess of positive ions while the other layer will consist of an excess of negative charges. Because this protective double layer formed so readily and spontaneously in ionized gases, it appeared as if it almost had a life of its own. As a result, Langmuir was moved to call this ionized gas "plasma" as it was reminiscent of blood plasma. He then invented his ingenious probe that measures DL voltage differences.

Since most of the voltage drop within a given section of plasma will be contained in the DL, it follows that this is where the strongest electric field will be found. It also means that these double layers can accelerate charged particles to very high energies. Thus, with the DL in earth's magnetosphere, kilovolt energies are common for charged particles [24 – 27]. In space, the energies are even higher. It is also of importance to note that Birkeland currents are usually sheathed in a double layer. Therefore such currents can be associated with very high particle energies and velocities.

Several mechanisms exist whereby a DL can be formed. One such mechanism occurs if plasma is divided into two regions with, for example, temperature or density differences, and a surface, plane or interface separating them. If we take the example with temperature differences, we find that electrons from the hot plasma will travel at a higher velocity than the cooler plasma. Now electrons may stream freely in either direction. But the flux of electrons from the hot plasma to the cooler plasma will be greater than the flux of the electrons from the cooler plasma to the hot plasma. This occurs because the electrons from the hot side have a greater average speed. Since more electrons enter the cool plasma than exit it, part of the cool region becomes negatively charged as the number of electrons there increases. The hot plasma, conversely, becomes positively charged. This results in a potential difference between the two regions. Therefore, an electric field builds up, which starts to accelerate electrons towards the hot plasma, reducing the net flux. In the end, the electric field increases until the fluxes of electrons in either direction are equal, and further charge build up in the two plasmas is prevented. The

DL which has formed has a drop in electric potential that is exactly balanced by the difference in thermal potential between the two plasma regions. In general, the oppositely charged DL are usually maintained because their electric potential difference is balanced by a compensating pressure which may have a variety of origins.

G. Cosmological plasma filaments and sheets

Surveys have shown that cosmos-wide examples of plasma filaments and sheets occur. 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 all the comments in full at the following URL: http://www.damtp.cam.ac.uk/user/gr/public/gal_iss.html]. They state *“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 of the filaments can be found at the following URL: <http://192.171.198.135/Ps/aac/images/box.jpg> while further comments can be found at: http://192.171.198.135/Ps/aac/aac_evuniv_iss.asp. 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 very finely tuned action of “dark matter” to produce the desired result. Nevertheless, if these structures are compared with typical plasma behavior, one cannot avoid the conclusion that the inception of the cosmos involved plasma sheets, filaments and Birkeland currents. They also show consistent plasma behavior from the laboratory to cosmos-wide scales.

H. Sorting of elements by plasma currents

Some properties of plasmas with field-aligned currents now assume importance. Where currents flow in ionized or partially ionized plasma filaments, a separation of elements may occur. With 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 in plasma filaments. He states: *“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”* [28].

The order of elements going from the center of the filament outwards using the approximate first ionization potential in electron volts (eV) is then as follows: the radioactive elements Rubidium, Potassium, Radium, Uranium, Plutonium and Thorium (4.5 to 6 eV); Nickel, Iron and metals (7.7 eV); Silicon (8.2 eV); Sulfur and Carbon (10.5 to 11.3 eV); Hydrogen and Oxygen (13.6 eV); Nitrogen (14.5 eV); Helium (24.5 eV). As Peratt points out, this mechanism provides an efficient means to accumulate matter within a plasma [29]. This property of plasma filaments, which causes different chemical elements to distribute themselves radially according to their ionization potentials, was initially studied in detail by Marklund, and is now called Marklund convection [30].

Marklund states “In my paper in *Nature* the plasma convects radially inwards, with the normal [predicted] velocity, towards the center of a cylindrical flux tube. During this convection inwards, the different chemical constituents of the plasma, each having its specific ionization potential, enter into a progressively cooler region. The plasma constituents will recombine and become neutral, and thus no longer be under the influence of the electromagnetic forcing. The ionization potentials will thus determine where the different species will be deposited, or stopped in their motion” [see the comment in context at the following URL: http://www.plasma-universe.com/index.php/Marklund_convection]. Ionization potential charts show where, in a layered filament, the highest concentration of any element will probably be found. The velocity, v , with which the various ions will drift towards the center is given by [28]

$$v = (E \times B) / B^2 \quad (2)$$

Here, E is the electric field strength, B is the magnetic flux density or magnetic induction, and the electromagnetic force on ions causing them to drift is given by $(E \times B)$. It is generally true that the ion drift velocity in a system is given by the ratio of the electric field to the magnetic field, that is:

$$v = E/B \quad (3)$$

For electromagnetic waves, $v = c$, where c is the velocity of light. In plasma out in space, the typical drift velocity of ions can often approach the speed of light, or at least a significant fraction of it. The formula for the rate of accumulation of ions in a filament is given by dM/dt which is defined as [31]:

$$dM/dt = (2\pi r)^2 \rho [E/(\mu I)] \quad (4)$$

where r is the radius of the filament, E is the electric field strength, I is the electric current, μ is the magnetic permeability of the vacuum and ρ is the number density of ions.

1. Interactions between plasma currents

Another important property is that Birkeland currents interact with each other. Two parallel Birkeland currents moving in the same direction will attract each other with a force that is inversely proportional to the distance between them [32]. This contrasts with the gravitational force which is inversely proportional to the square of the distance. In fact, in plasma, electromagnetic forces can exceed gravitational forces by a factor of 10^{39} . Furthermore, even in neutral hydrogen regions of space where the ionization is as low as 1 part in 10,000, electromagnetism is nevertheless still about 10^7 times stronger than gravity [32]. Not only is this electromagnetic attraction much stronger than gravity, the attractive force is also proportional to the strength of each current multiplied together [32]. Thus stronger currents result in even stronger attractive forces. If the currents are moving in opposite directions, the same proportionalities hold but the force is repulsive. 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 δF , on a length δl of either current whose distance apart is r , with the currents being I_1 and I_2 respectively, then we can write [33]:

$$\delta F / \delta l = (I_1 I_2 / r)(\mu/2\pi) \quad (5)$$

In equation (5) the quantity μ is again the magnetic permeability of the vacuum. For a comment on this, please refer to the discussion following equation (14) and the preamble to equation (51).

J. Dusty plasmas

The role of dust in plasmas was initially discussed by Irving Langmuir in 1924 [34]. He described the result when minute drops of tungsten vapor were inserted into plasma. He concluded that the experimental results indicated that electrons from the plasma attached themselves to the minute drops causing them to become negatively charged and so move about under the influence of the electric fields in the plasma. In 1941 Lyman Spitzer discussed a similar process whereby interstellar dust particles acquire a negative charge because they are immersed in an ionized gas or plasma [35]. The negative charge is imparted because the electrons in plasmas move more swiftly than ions, and so the number of encounters with electrons is greater than with positive ions. This results in a net negative charge even if the plasma is in an electrically neutral state overall. In 1954, Hannes Alfvén considered how this process could build up large bodies in the early Solar System [36]. Peratt has discussed the size of particles that have become electrically charged and can be influenced by that charge rather than by gravity [28]. Under the conditions indicated by equation (49) below, this size may be significantly increased for charged particles in the early universe.

A discovery about the rings of Saturn by Voyager 2 in the early 1980's gave the impetus needed to open up discussion on dusty plasmas in the scientific literature. The images of Saturn revealed a pattern of nearly radial "spokes" rotating around the outer portion of the dense B ring. This was something that observers on earth had glimpsed for decades when conditions were favorable, but the spokes were often dismissed as illusory. In fact, as the spacecraft approached Saturn, the spokes appeared dark against the bright background of the rings, but as the craft pulled away the effect was reversed. This meant that the material making up the spokes scatters sunlight preferentially in the forward direction, a property of fine dust. Furthermore, the spokes were not stationary structures, but could form in as little as five minutes. Gravitational effects alone could never achieve this whereas electric and magnetic fields could. Goertz and Morfill demonstrated in 1983 that these spokes were a dusty plasma of micron sized particles that appeared to be about 80 km above the plane of the rings [37]. It was later noted that their formation and disappearance coincided with powerful bursts of radio waves originating with Saturn's magnetic field called the Saturn Kilometric Radiation. This radiation is associated with lightning which caused dust particles to gain electrons and become electrostatically suspended above the plane of the rings [38].

At an altitude of 85 km above the earth are noctilucent or 'night-shining' clouds which are also examples of naturally occurring dusty plasma. These clouds, typically seen at high latitudes during early summer, are formed of ice crystals in the polar mesosphere at temperatures around 100 K. Because these crystals are near the ionospheric plasma, free electrons from there attach to the crystals to form a dusty plasma of charged ice crystals about 5×10^{-8} meters across [39]. In general, if it is assumed that the capacitance of a dust grain of radius, a , is that of a spherical charged conductor of the same size, then the charge, Q , acquired by the grain is given by [39]

$$Q = 4 \pi \epsilon a V \tag{6}$$

Here, V is the electrical potential difference between the grain and the plasma and ϵ is the electrical permittivity of the vacuum. In the case of a particle or grain at rest in a dilute plasma, the electron and ion currents will result in a potential difference for the grain or particle of

$$V = -2.51 kT/e \tag{7}$$

Here T is the temperature of the ions or electrons, k is Boltzmann's constant and e is the electronic charge. When this is applied to hydrogen plasma with kT equal to 3 eV (electron Volts), equations (6) and (7) suggest that a particle of radius of 10^{-6} meters will carry a charge equivalent to 5000 electrons [39]. As a consequence, electrostatic forces on dust grains can be seen to be significant.

The depletion of electrons by absorption on dust particles affects plasma waves. For example, sound waves in plasma, also known as ion-acoustic waves, propagate at higher velocities and with significantly less damping in plasmas that contain negatively charged dust particles. The first physics experiment done in the weightlessness of the International Space Station in February of 2001 was with dusty-plasmas to see how they behaved in the depths of space. It was known as the Nefedov Plasma Crystal Experiment [40]. A typical structure formed in this dusty plasma was a sharply defined void surrounded by a dusty plasma region constrained by fluid vortices along the outer edges of the container and along its central horizontal axis [39]. The result was similar to the honeycomb or bubble and filament structure typical of macroscopic galaxy cluster distribution.

K. Plasma instabilities and vortex formation

A final characteristic of plasma now needs to be discussed. We have already mentioned the Bennett or Z-pinch instability that leads to the bunching of currents and magnetic fields in filaments on a cosmic scale. Within these structures, the process also accumulates matter. However, there are a variety of plasma instabilities, and over forty different types have been listed. There are a variety of methods of classification. They may be broadly classified as macroscopic or microscopic instabilities, although the distinction is not sharp. Macroscopic instabilities influence the spatial distribution of the plasma filament and are often classified according to the geometry of the distortion. Using this approach, there are then four sub-categories under this heading [41].

First, there is **sausage mode** in which plasma filaments contract at regular intervals. The filament radius thereby varies along the axis of the filament. There can be standard sausaging by this process or, alternatively, sausaging with either axial hollowing or axial bunching. As in the case of the Z-pinch, this process also accumulates and concentrates matter. Second is the **sinuous, hose or kink mode** in which the filament bends sideways without any change in the form of the filament other than the position of its center of mass. Third, the **filamentation mode** can occur in which the main filament breaks up into a number of smaller filaments. These smaller filaments may have an elliptical cross-section or a pear-shaped (pyriform) cross-section. Fourth is a **ripple mode** where the filament is distorted by small-scale ripples on the surface. Sometimes these macroscopic instabilities are labeled as magnetohydrodynamic, hydrodynamic, or low frequency instabilities.

In contrast, microscopic instabilities usually excite local fluctuations of density and electro-magnetic fields in plasma. These microinstabilities can sometimes grow and be directly linked with a macroscopic counterpart. For example, the filamentation mode can be the macroscopic stage of a growing transverse electrostatic microinstability known as the Weibel instability [41].

When ions or electrons propagate along an axial magnetic field in a filament, a threshold can be passed with the resultant plasma current that causes the break-up of the beam into discrete vortex-like current bundles. This is called a "slipping stream" or **diocotron** instability. This type of instability may also arise if charge neutrality is not locally maintained such as when electrons and ions separate. There then arises a shear velocity which azimuthally results in vortex phenomena which axially form current bundles or filaments. On earth, this azimuthal vortex can be seen as auroral curtains [42]. The instability can occur in

solid or annular filaments as well as in sheet beams. The axial vorticity component is given by W which is mathematically described as [43]

$$W = e (N_e - N_i) / \epsilon \quad (8)$$

Here e is the electronic charge and ϵ is the permittivity of free space while N_e and N_i are the numbers of electrons and ions respectively. These instabilities result in profound cosmological effects when coupled with other plasma phenomena and the behavior of the Zero Point Energy.

II. EXPLORING THE ZERO POINT ENERGY

A. What is a vacuum?

In addition to plasma phenomena, our knowledge of space and the vacuum also took a major leap forward in the 20th century. The vacuum is more unusual than is often realized. If we take a perfectly sealable flask, pump out all solids, liquids and gases, and cool it to absolute zero Kelvin, so there is no heat radiation in it, we might think a complete vacuum existed in the container. Yet theory and experiment show this vacuum still contains a measurable energy called the Zero-Point Energy (ZPE). It exists at absolute zero and comprises electro-magnetic waves of all wavelengths. It is universal and penetrates every atomic structure in the cosmos. Its existence was not suspected until the work of Max Planck in the early 1900's for the same reason we are unaware of atmospheric pressure on our bodies. There is a perfect balance inside and out. The ZPE radiation pressure is also balanced in our bodies and measuring devices. On a scale of meters the vacuum is featureless, but, at an atomic level, it is a turbulent sea of randomly fluctuating electromagnetic ZPE waves.

B. Planck, Einstein, Stern, Nernst and the ZPE

In 1901, Max Planck derived an expression fitting the data for radiation emitted from a perfectly black body. This was done by supposing the energy states of charged point particle oscillators came in discrete units rather than being continuous. Thus, radiation was emitted in discrete energy bundles given by a new constant ' h ', multiplied by the frequency, ' f '. Planck was skeptical of the physical significance of this assumption and the constant ' h ' [44]. Because of this, he formulated his 'second theory' where he derived the blackbody spectral formula, but with a good reason for his constant ' h '. His 1911 paper indicated the existence of a zero-point energy background [45]. His equation for the energy density, ρ , of a black body had the same temperature-dependent term as his first theory, plus a ($1/2$) hf term that indicated the existence of the ZPE thus:

$$\rho (f, T) df = [8\pi f^2 / c^3] \{ [hf / (e^{hf/kT} - 1)] + [hf / 2] \} df \quad (9)$$

Here, f is frequency, c is light-speed, and k is Boltzmann's constant. In (9), the last term is independent of temperature as it remains when T goes to zero. Thus h is only a scale factor to align theory with data and no quantum interpretation is needed. The ZPE strength is then given by h .

In 1913, Einstein and Stern published a classical physics analysis of interactions between matter and radiation with dipole oscillators representing charged point particles [46]. They remarked that if, for some reason, these oscillators were immersed in a ZPE, Planck's radiation formula would result *without the need to invoke quantization at all*. This has proven correct, as many have made these derivations which

show that, immersed in a ZPE, the irreducible energy of each oscillator is $(\frac{1}{2})hf$ [47]. In 1916, Nernst noted that this required an intrinsic cosmological origin for the ZPE [48].

C. Proofs for the ZPE and a choice for Physics

In 1925 the ZPE's existence was confirmed by Mulliken with the spectrum of boron monoxide. He found a shift from the position the spectral lines would have if the ZPE didn't exist. The ZPE perturbs electrons in atoms so, as they transition from one state to another, they emit light whose wavelength is shifted slightly from its normal value. In 1947, a similar shift of wavelength in hydrogen spectra was found by Lamb and Retherford who stated their results were "*a proof that the [perfect] vacuum does not exist*" [49]. ZPE fluctuations explain why cooling will never freeze liquid helium. Unless pressure is applied, these fluctuations prevent helium atoms getting close enough to form a solid. ZPE fluctuations also cause the random 'noise' in electronic circuits which cannot be removed no matter how good the technology.

In 1925, physics had a choice. Planck's 1901 theoretical concept of '*h*,' gave the right results mathematically, but lacked any physical cause for observed phenomena. It was purely theoretical. On the other hand, Planck's second theory could be adopted, supported by Einstein and Stern's, as well as Nernst's papers, and verified by Mulliken's experiments showing that the ZPE was a physical reality. Classical physics plus an intrinsic ZPE could then account for all the observational data. This approach of using classical physics with an added ZPE received wide attention up until 1925. But then four major papers were published in four years using Planck's first theory without the intrinsic ZPE. These four papers swung the balance and set physics on a course that led to Quantum Electro-Dynamics or QED. Then, in 1962, de Broglie pointed out that the choice made almost forty years before ignored both the earlier discussions and the evidence. He indicated that the option of using classical physics and an intrinsic ZPE definitely needed further examination [50].

After de Broglie's book, many papers were published discussing the theory which had been abandoned. This new approach came to be called Stochastic Electro-Dynamics, or SED physics. A number of seminal papers based on an all-pervading ZPE, derived and interpreted classically the black-body spectrum, Heisenberg's uncertainty principle, the Schroedinger equation, and explained the wave-nature of matter [51]. These were the factors that, interpreted without the ZPE, gave rise to QED concepts. In listing some of SED's successes, it was stated that "*The most optimistic outcome of the SED approach would be to demonstrate that classical physics plus a classical electromagnetic ZPE could successfully replicate all quantum phenomena*" [52]. As a result, many phenomena have both SED and QED explanations. In SED physics the uncertainty in a subatomic particle's position is due to intense random battering by the waves of the ZPE. Since '*h*' is a measure of ZPE strength, this uncertainty is also proportional to '*h*'.

D. ZPE characteristics

SED studies indicate the randomly fluctuating waves of the ZPE exist at all wavelengths longer than the Planck length cutoff. At this length, about 10^{-33} centimeters, the vacuum breaks up into a granular structure. So space provides a natural minimum wavelength cutoff for the ZPE, which is thus a huge but finite physical reality. The ZPE energy density is "*about 10^{10} joules per cubic centimetre*" [53]. This energy is greater than all the stars in our galaxy together shining for 10 billion years. At a macroscopic level, the ZPE is homogeneous and isotropic. Since radiation flow averages the same in all directions, there is no net flux of energy. Observation shows this zero-point radiation (ZPR) is Lorentz invariant and

looks the same to all observers despite any relative velocities. Thus its energy density is proportional to frequency cubed up to the cutoff, as in (9).

E. The Casimir effect and virtual particles

Another indication of the ZPE's existence is the Casimir effect, predicted in 1948. It occurs when two large metal plates are brought close together in a vacuum. A small force pushes them together. The SED explanation is that the two plates exclude all ZPE wavelengths except for those which fit precisely between the plates [54]. Thus all the longer ZPE wavelengths are excluded and act on the plates from the outside without any balancing interior waves. This external excess radiation pressure then forces the plates together. Unlike other possibilities, this approach uniquely specifies that the effect is proportional to the fourth power of the plates' distance apart. In 1998, Mohideen and Roy verified this experimentally to within 1% [55]. This strongly indicates the ZPE is comprised of electromagnetic waves.

These electromagnetic waves are of all wave-lengths and in all directions. Thus, the ZPE is like a restless sub-atomic sea, with peaks and troughs in the energy density of its waves. And, like the ocean, its waves collide, peak, and form 'white caps'. In the case of the ZPE, these 'white caps' manifest as tiny virtual particles which briefly appear as positive and negative pairs and then annihilate. Their positive and negative charges maintain the electrical neutrality of the vacuum. By 1955, experimental evidence had shown that such particle/anti-particle pairs will collide and release a pulse of energy upon annihilation. A wide variety of these particles wink in and out of existence so it is often called a virtual particle zoo. There are enormous numbers of them in any given volume. For example, at any instant, the human body has over 10^{20} virtual particles flashing into and out of existence.

III. THE ORIGIN AND BEHAVIOR OF THE ZPE

A. Preliminary matters

SED physics suggests a ZPE origin that allows us to mathematically predict its behavior over time. The ZPE's influence on other physical/atomic quantities can also be predicted with this approach, since Planck's second theory makes the ZPE the source that governs atomic particle behavior. The model accepted here envisages an initial expansion of the cosmos to a stable position about which it then oscillated. Narliker and Arp show a static cosmos is stable against collapse, but it will gently oscillate [56]. The microwave background radiation proves the initial expansion, as it is considered an 'echo' of the original hot super-dense state. Evidence for a currently static cosmos is given in [57], including the quantized redshift, which precludes any current expansion occurring. In fact, atomic data support a static, gently oscillating cosmos.

B. The fabric of space and Planck particle pairs

String theorists claim the fabric of space comprises six other dimensions wrapped up as extremely tiny Calabi-Yau shapes close together [58]. QED physicists look upon it as a quantum foam. Whichever it is, as the fabric of space was stretched by the initial expansion, energy was fed into the vacuum. Gibson, Hoyle and others have shown this expansion energy manifested as showers of Planck particle pairs (PPP), the smallest particles the cosmos can produce [59]. PPP diameters equal both the Planck length and their own Compton wavelength. Each pair is positively and negatively charged so space is electrically neutral. SED physics states quantum uncertainty and subatomic masses only exist because of the ZPE. As the Planck length cutoff applies to the ZPE, the PPP remained unaffected by the ZPE as it built up. So there was no quantum time limit for the existence of these massless, charged PPP.

Gibson notes expansion generates separation and vorticity with PPP [59]. Charge separation gives electric fields and a tension. Vorticity caused PPP spin, which generated magnetic fields, and added further tension. Gibson points out that this vorticity also fed energy into the system, which allowed more PPP production. This inelastic system would have strong vortices and long persistence times [59, 60]. PPP numbers would thus increase along with ZPE strength until all vorticity died away. As PPP numbers increased, so did the tension in the fabric of space until it balanced the expansion force. The expansion then ceased and oscillation began. As the ZPE built up by this process, it would be maintained by the feedback mechanism described in [51, 61].

C. ZPE strength should increase with time then oscillate

The PPP tend to re-combine due to electrostatic attraction. When this occurs, a pulse of electro-magnetic radiation is emitted with the same energy that the PPP had. This energy would augment the primordial ZPE fields. Recombination would eventually eliminate the PPP, but initial production of PPP from vorticity would partly offset that. The ZPE strength would increase until all these processes ceased. The ZPE was then the final manifestation of expansion energy and ever since it has been maintained by the feedback mechanism. The mathematical form of build-up in ZPE strength over time can be derived using standard descriptions of turbulence and recombination, as in [51]. The final equation reads:

$$U \sim [\sqrt{1 - T^2}] / [1 + T] \quad (10)$$

In (10), U is the ZPE energy density. Orbital time, T , is a ratio with $T = 1$ at the cosmos origin and $T = 0$ near the present. The symbol (\sim) means “*is proportional to*” in this paper. The behavior of the ZPE thereby follows basic physics which indicates the ZPE built up rapidly, but its rate of increase slowed with time. Once the cosmos had expanded to its maximum size, this now static cosmos will oscillate about its final position. This will increase the ZPE energy per unit volume when the cosmos was at its minimum position, and decrease its strength at the maximum position. If the cosmos has several modes of oscillation, a graph of the ZPE strength is expected to contain flat points in a manner similar to reference [62]. So even after the ZPE built up to its maximum value, it is expected that there will be cosmological oscillations in its strength. This will be echoed in the experimental values of ZPE-dependent quantities.

IV. ZPE AND ATOMIC CONSTANTS BEHAVIOR

A. ZPE and Planck’s constant

In Planck’s 1911 theory, the ZPE’s existence was revealed and its energy density was measured by h . Thus, if the ZPE strength increased, h would proportionally increase. So we can write

$$h \sim U \quad (11)$$

where U is uniquely the energy density of the ZPE. This relationship may also be expressed as:

$$h_2 / h_1 = U_2 / U_1 \quad (12)$$

In (12), and in this paper, h_1 is the present value, while h_2 is at some distant galaxy at an earlier time. The experimental data indicate h has varied, along with synchronous variations in atomic quantities related by the ZPE. The officially declared value of h has increased systematically until 1970. After this, the data show a flat point, or a small decline (Fig.1). In 1965, Sanders noted that the increasing value of h was only partly due to improvements in instrumental resolution, which was an inadequate explanation [63]. This follows since quantities like (e/h) , where e is electronic charge, or $(h/2e)$ the magnetic flux quantum, and Josephson’s constant, $(2e/h)$ all show synchronous trends centered on 1970 even though

measured by different methods. The officially declared h values are all listed in detail at the following URL: <http://www.setterfield.org/report/report.html>.

B. ZPE and the speed of light

Analysis in [64] noted that light speed, c , was inversely related to ZPE strength since the ZPE produces a zoo of virtual particle/antiparticle pairs which form briefly then annihilate. Photons in transit are briefly absorbed by virtual particles then re-emitted as particle pairs annihilate. The process repeats with every virtual particle encountered, so a photon is like a runner going over hurdles. As ZPE strength increases, virtual particle numbers per unit volume increase, so more photon interactions occur and photons take longer to get through. Thus, our measured speed of light, c , slows as the ZPE increases, since space is getting "thicker" with virtual particles. This indicates that a constant upper limit velocity for c necessarily exists, which is its speed without any impedance from virtual particles. In terms of Relativity, it is the same as light entering a denser medium (such as water) and slowing. The upper limit velocity is still unchanged. Furthermore, since the ZPE is the same throughout the cosmos, the value of c at any instant is also the same throughout the whole universe.

Changes in ZPE strength also mean changes in the electrical permittivity, ϵ , and magnetic permeability, μ , of space. But space is a non-dispersive medium, so the ratio of electric energy to magnetic energy in a wave must remain constant. This requires the intrinsic impedance of space, Ω , to be invariant, so that:

$$\Omega = \sqrt{(\mu/\epsilon)} = \text{invariant} = \mu c = 1/(\epsilon c) = 376.7 \text{ ohms} \quad (13)$$

From (13) it follows that c must vary inversely to both the vacuum permittivity and permeability, so that

$$\epsilon \sim \mu \sim 1/c \quad (14)$$

Thus, at any given instant, c would be the same in all frames of reference throughout the cosmos. Note that (14) can be derived without any assumptions about the behavior of c , ϵ , or μ , just as Maxwell did. His equations support large cosmic variations in c with time provided both the permittivity and permeability of free space varied as in (13) and (14), [65]. Maxwell used CGS units where this variation is allowed, but SI units consider μ to be invariant. This situation arose because c was assumed to be invariant when the SI units were formulated. As a result, μ was also designated as having a constant value.

If the energy density of an electromagnetic field is given by U , with E and H being the electric and magnetic intensities of the waves, proportional to their amplitudes, then the standard equation reads:

$$U = (\frac{1}{2}) (\epsilon E^2 + \mu H^2) \quad \text{so that} \quad U = \epsilon E^2 = \mu H^2 \quad (15)$$

Applying (15) exclusively to the intrinsic properties of the vacuum means the energy density, U , refers to the vacuum Zero-Point Fields with E and H specifically the electric and magnetic intensities of the ZPF. If the ZPE wave intensities, or their proportional amplitudes, remain unchanged, both E and H will also remain unchanged as the ZPE strength varies. Then, as U varies, so does ϵ and μ such that from (14)

$$U \sim \epsilon \sim \mu \sim 1/c \quad (16)$$

This has implications for both radiation intensities and radioactive heating since radiant energy densities are dependent upon the permittivity and permeability of space. So, when ZPE strengths were lower, the energy density of electromagnetic radiation was proportionally lower [66]. But this is offset for stellar and radioactive sources as photon production rates are proportional to c leaving intensities constant [66]. We can then write:

$$U_2/U_1 = c_1/c_2 \quad (17)$$

Experimental evidence indicated c was declining, so ongoing discussions occurred in many journals up to the mid 1940's. Thus, in 1886, Newcomb reluctantly concluded that the values of c obtained around 1740 were in agreement with each other, but were about 1% higher (over 2000 km/s faster) than in his own time [67]. In 1941, Birge made a parallel statement while writing about the c values obtained by Newcomb and others around 1880. Birge conceded that: *"these older results are entirely consistent among themselves, but their average is nearly 100 km/s greater than that given by the eight more recent results"* [68]. Since both scientists held to a constant c , their admission is significant. The c values recommended by Birge in 1941 are plotted in Fig. 2. In all, 163 determinations of c with thousands of experiments using 16 methods over 330 years comprise the data for declining c published in August 1987 [69]. In 1993, Montgomery and Dolphin did rigorous statistical analyses confirming the declining trend was significant, but it had flattened out around 1970 [70]. Changes in c raise queries about $E = mc^2$, but before examining that, another matter must be dealt with.

C. The electronic charge

The mathematical relationship between (11) and (16) indicate that, cosmologically, the quantity

$$hc = \text{invariant} \quad \text{so that} \quad h \sim 1/c \quad (18)$$

Data out to the frontiers of the cosmos support this to parts per million, including the fine structure constant, designated as $\alpha = [e^2/\epsilon][1/(2hc)]$ with e the electric charge [71]. But data show α is constant too, which means

$$e^2/\epsilon = \text{constant} \quad (19)$$

However, (16) has ϵ proportional to U . This means equation (19) requires the following proportionality:

$$e^2 \sim U \quad (20)$$

The difficulty is that many experiments measure e in the context of the permittivity of its environment. Thus changes in e alone often have to be deduced from other quantities such as the ratio h/e . This ratio should be proportional to the square root of U , while h is directly proportional to U . When the h/e data for Fig. 3 are examined as in [66], the proportionality in (20) is supported. We now return to atomic masses.

D. The ZPE origin of mass

SED and QED physics agree that subatomic particles like electrons are massless, point-like charges often called partons. ZPE waves impact on partons causing them to randomly jitter. This "jitter motion", known as *Zitterbewegung*, comprises 10^{20} oscillations per second. It imparts kinetic energy to the parton which appears as mass. Puthoff states *"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"* [72]. The math agrees with this [see: http://www.calphysics.org/sci_articles.html]. For inertial mass a parton accelerating through the ZPE experiences a retarding force [73, 74]. Rest mass is given by

$$m = \Gamma h \omega^2 / (4 \pi^2 c^2) \quad (21)$$

Here, ω is the *Zitterbewegung* oscillation frequency of the parton, with Γ the Abraham-Lorentz damping constant given by $e^2 / (6 \pi \epsilon m c^3)$. Substituting for Γ in (21) and collecting mass terms, m , then gives us

$$m^2 = (e^2 h \omega^2) / (24 \pi^3 \epsilon c^5) \quad (22)$$

From (19) we note e^2 / ϵ is constant [75]. Now Dirac stated the jitter occurs near c and Puthoff shows the jitter frequency is $\omega = kc$, with k inversely dependent on parton size and independent of c . So we have:

$$\omega \sim c \quad (23)$$

All frequencies follow (23), as shown later. When (23) is linked with equations (18), (19), (20) we have

$$m \sim 1/c^2 \sim h^2 \sim U^2 \quad (24)$$

Since atomic masses m are proportional to $1/c^2$, then in $E = mc^2$, energy, E , will be conserved as c varies. Equation (24) is supported by declared values of electron/proton masses which increase until 1970. After that, a flat point or slight decline occurred (Fig. 4). Data are in reference [69]. The Rydberg constant for an infinite nucleus, R^∞ , is a check on trends as it has five varying quantities. They are combined in such away that the result, $R^\infty = [e^2 / \epsilon]^2 [2 \pi^2 m / (ch^3)]$, should be constant. The official values of R^∞ in Figure 5 confirm this.

This discussion on mass suggests we should also look at the Newtonian gravitational constant, G , which is related to m . On SED physics, the ZPE battering of charged particles produces mass. Additionally, charged particles in motion produce secondary electromagnetic radiation which attracts all charged particles in the vicinity, the sign of the charge only altering the phase of the interaction. Analysis shows this attraction is identical to gravity [49, 74]. The SED approach therefore presents the force of gravity as already unified with the other forces in physics. G has units of [meters³/(kilogram-seconds²)]. Since mass is in the denominator of G it cancels out changes in the product Gm . Thus Gm is constant for a varying ZPE as shown in [75].

$$Gm = \text{constant} \quad (25)$$

E. Varying frequencies, atomic clocks, and the ZPE

To achieve accord with Maxwell's equations and a time varying c , frequencies are required to vary as c . Wavelengths will remain fixed because photon energies are conserved in transit [65]. This means

$$E = hf = hc/\lambda = \text{constant} \quad (26)$$

Consider a photon going through space with dropping speed. Equations (18) and (26) require its wave-length, λ , to be fixed, and its frequency, f , dropping with c . It's like a slowing train hauling box cars. The car length (wavelength) is fixed, but the number of cars passing per second (frequency) gets less. Thus we can write

$$f \sim c \sim 1/h \sim 1/U \quad (27)$$

The data forced Birge to the same conclusion. He said "*if the value of c is actually changing with time, but the value of λ in terms of the standard metre shows no corresponding change, then it necessarily follows that the value of every atomic frequency ... must be changing*" [76]. The frequency of light emitted from atoms depends

on the frequency that electrons orbit nuclei, which depends on their velocity [77]. Electron velocity, v , in the first orbit in *Allen's Astrophysical Quantities*, page 9 (Springer Verlag 2000) is given as

$$v = 2\pi e^2 / (\epsilon h) \sim F \sim 1/U \sim c \sim f \quad (28)$$

Thus, atomic orbital frequencies, F , obey the same proportionality as light frequencies do. So when c is higher, F is higher and all atomic time intervals, t , are shorter, so t is proportional to $1/c$. This is discussed in detail in reference [66]. Some atomic time is based on electron revolution times in the first Bohr orbit. So the time, t , an electron takes for $1/(2\pi)$ revolutions in that orbit is given as [*Allen's op.cit.*]

$$t = h^3 \epsilon^2 / (8\pi^3 m e^4) \sim U \sim h \sim 1/c \quad (29)$$

Proportionalities are from (11), (16), (18), (19), (24). Ref. [66, 69] show radiometric time follows (29). Data comparisons between orbital and atomic clocks have been done by several observatories. One analysis stated: "Recently, several independent investigators have reported discrepancies between the optical observations and the planetary ephemerides... [They] indicate that [atomic clocks had] a negative linear drift [slowing] before 1960, and an equivalent positive drift [speeding up] after that date... This study uses data from many observatories around the world, and all observations independently detect the planetary drifts ... [which] are based on accurate modern optical observations and they use atomic time." [78]. The data turnaround again occurred near 1970 (Fig. 6). Comparing radiometric dates with orbital dates for historical artefacts shows the effects of cosmos oscillation recorded from 1650 BC to 1950 AD [66]. It is graphed in Fig. 8. This means the main part of the ZPE curve associated with the redshift data began before about 2600 BC when the Fig.6 curve was again at its current value. A full discussion on this is reserved for a separate paper.

F. ZPE, atomic orbits and the quantized redshift

SED physics shows the ZPE maintains the stability of atomic orbits across the cosmos. Classical physics states an electron orbiting a proton will radiate energy, and so spiral into the nucleus. This does not happen and QED physics invokes quantum 'laws' without an actual explanation. Puthoff calculated the power electrons radiate as they orbit the nucleus, along with the power received from the ZPE [79]. The process was rather like a child on a swing being given resonant pushes by an adult which kept the swing going [80]. He concluded: "...the ground state of the hydrogen atom is defined by a dynamic equilibrium in which the collapse of the state is prevented by the presence of the zero-point fluctuations of the electromagnetic field" [79]. Alternatively, analyses by Boyer [81] and Claverie and Diner [81] reveal that if an electron in its orbit radiates more energy than it receives from the ZPE it will spiral towards the nucleus until a position of balance is reached. But if an electron radiated less energy than it absorbed from the ZPE, it would spiral out until a position of balance was reached.

Therefore atomic stability only exists because of the ZPE. Puthoff demonstrated that the power radiated and absorbed by the electron governed the orbit angular momentum, which is proportional to h . Thus, as the ZPE strength increased with time (and h increased), all orbit angular momenta increased and light emitted from atomic transitions would be more energetic or bluer. As we look back into the past, the light emitted would be redder at earlier epochs. In a static universe, this is why progressively more distant galaxies have their spectral lines shifted to the red end of the spectrum [51]. This redshift, usually designated $(1 + z)$, is thus proportional to $1/h$ and is given by

$$(1 + z) = [1 + x] / [\sqrt{1 - x^2}] \sim 1/h \quad (30A)$$

In (30A), x is distance such that ($x = 0$) near our galaxy while ($x = 1$) at the origin of the cosmos. This overcomes problems with finding an absolute distance scale. Astronomers often substitute the quantity v/c for x where v is the inferred velocity of expansion. Note atomic orbits based on angular momenta [$mvr = nh/(2\pi)$] go in quantized jumps so redshift quantizations are not surprising [57]. Now electrons form a standing wave so the length of their orbit ($2\pi r$) divided by wavelength (h/mv) is a whole number n . Therefore $2\pi mvr = nh$. If n is held constant so r is also a constant, then the angular momentum can only change when h changes by a factor of 2π . Atomic orbit angular momenta then go in jumps of $\underline{n}(2\pi)$ with \underline{n} an integer. Therefore we write

$$(1 + z) \sim 1/h = 1/[\underline{n}(2\pi)] \quad (30B)$$

giving us the quantized redshift. Thus Guthrie and Napier's 37.6 km/s becomes $[c / (2538 \pi)]$ with $\underline{n} = 1269$.

The relationship between $(1 + z)$ and Planck's constant is confirmed by the physics in [57]. That demonstrated the build-up of ZPE strength due to turbulence and recombination actually followed equation (10). Yet (10) is the inverse form of (30A) except in (10) we have orbital time T while in (30A) we have distance x . As looking back in time is the same as looking out further into the cosmos, this is to be expected. Two different approaches thereby show the redshift and ZPE are inversely related so that we can write:

$$(1 + z) \sim 1/U \sim 1/h \quad (31)$$

Redshift data then confirm ZPE behavior back to the origin of the cosmos as in Fig. 7. The behaviour over time of ZPE dependent atomic quantities has thus been elucidated. That behavior has the form:

$$1/U \sim 1/h \sim c \sim f \sim 1/(\sqrt{m}) \sim 1/t \sim (1 + z) = [(1 + T) / \sqrt{(1 - T^2)}] \quad (32)$$

Note that even after $T = 0$, which it did earlier in our history when $z = 0$, the data still show an oscillation which changed direction in 1970. Finally, the years elapsed, t_e , on the atomic clock, or its equivalent, namely the distance in light years that light has travelled, is then given by substituting for T in the integral of (32) which is:

$$t_e = K[(\arcsin T) - \sqrt{(1 - T^2)} + 1] \quad (33)$$

When $T = 1$, the terms in square brackets in (33) total 2.5708. Now the cosmos is 14 billion atomic years old, and light has traveled 14 billion light years. The numerical value of K must accord with that.

V. ZPE AND ITS IMPORTANCE TO PLASMA PHYSICS

A. The behavior of electric and magnetic quantities

Our starting points for the effects of increasing ZPE on quantities in plasma physics are (19), (20). As electrostatic force, F , is given by $(e^2/\epsilon)[1/(4\pi r^2)]$, which is constant as r is constant, then we can write

$$F = (e^2/\epsilon)[1/(4\pi r^2)] = \text{constant} \quad (34)$$

But if E is the magnitude of the electric field strength, then the electrostatic force F is also given by

$$F = e E = \text{constant} \quad (35)$$

Therefore, from (20) and (35), it follows that the magnitude of the field strength, E , is given by

$$E \sim \sqrt{c} \sim 1/(\sqrt{U}) \quad (36)$$

Field strengths can also be written as $E = V/r$ in volts per meter. Since distance, r , is unchanged, then:

$$V \sim \sqrt{c} \sim 1/(\sqrt{U}) \quad (37)$$

There is an alternative derivation, since the potential at a given point is defined in [82] as:

$$V = (e/\epsilon)[1/(4\pi r)] \text{ volts} \sim \sqrt{c} \sim 1/(\sqrt{U}) \quad (38)$$

This means that the energy of a charged conductor, given by $\frac{1}{2} eV$, is constant from (20) and (37). Therefore, from the definition of capacitance, $C = e/V$, and from (38), it will behave as follows:

$$C = e/V = 4\pi \epsilon r \sim 1/c \sim U \quad (39)$$

Since forces are constant in this scenario (see above), then from equation (5) it is required that we have

$$\delta F / \delta l = (I_1 I_2 / r)(\mu / 2\pi) = \text{constant} \quad \text{so that} \quad \mu I_1 I_2 = \text{constant} \quad (40)$$

If the currents are of equal magnitude, and (16) is applied to (40), then I behaves as follows:

$$I \sim \sqrt{c} \sim 1/(\sqrt{U}) \quad (41)$$

From (41) electric currents generally will be proportional to \sqrt{c} . Reference [14] equation (6) supports this. Further, as power, P , equals current, I , multiplied by voltage, V , then from (37), (38) and (41) we have

$$P = IV \sim c \sim 1/U \quad (42)$$

So power in watts is inversely proportional to ZPE strength. Also, the resistance, R , in ohms, is given by:

$$R = V/I = \text{constant} \quad (43)$$

Resistances thus remain fixed as the ZPE varies. This is experimentally supported by Hall resistance values given by the Von Klitzing constant. Therefore, both resistivity and conductivity are also constant. It should be noted that magnetic field strengths have magnitudes defined as ($H = I/r$) in units of amperes/meter. Since r is unchanged, then from (41) it follows that H is proportional to I . We thus have:

$$H \sim \sqrt{c} \sim 1/(\sqrt{U}) \quad (44)$$

This gives uniformity with the magnitude of the electric field strength, E , which bears the same proportionality with c and U , thereby maintaining symmetry between electric and magnetic phenomena. From these results, the magnetic flux density or magnetic induction, B , is given by [83]

$$B = \mu H \sim 1/(\sqrt{c}) \sim \sqrt{U} \quad (45)$$

It should be noted the attractive force in a plasma cosmology is the long range force between two current filaments. This is proportional to $1/r$, while the short-range repulsive force between them is proportional to $1/r^4$. The forces remain unchanged with ZPE variation, but other behavior does not.

B. Examining plasma equations

From all the foregoing discussion and equations, the following results emerge. The Bennett pinch in equation (1), due to the gradient of magnetic pressure, behaves as follows:

$$p_m = B^2/(2\mu) = \text{constant} \quad (46)$$

Equation (3), the drift velocity of ions linked with Marklund convection, is given by the relationship

$$v = E/B \sim c \sim 1/U \quad (47)$$

The proportionality follows from (36) and (45). Thus drift velocities were higher when ZPE strengths were lower in the early universe. Consequently, matter could accumulate in plasma filaments much more readily than they do now, and this mechanism, even now, is much more efficient than gravity. Equation (4) reinforces that contention as the rate of accumulation of material in filaments becomes:

$$dM/dt = (2\pi r)^2 \rho[E/(\mu I)] \sim c \sim 1/U \quad (48)$$

This result comes from (18), (36), (41) and confirms that such processes were more efficient in the early days of our cosmos. The voltage build-up by dust collecting electrons in plasma is given by:

$$V = -2.51 kT/e \sim \sqrt{c} \sim 1/(\sqrt{U}) \quad (49)$$

Here, the last step is from (20). Voltages were thus greater when the ZPE strength was lower. Equation (8) is the axial component of the vorticity, W , that forms current bundles or filaments when an instability occurs. This has the following proportionality:

$$W = e (N_e - N_i) / \varepsilon \sim \sqrt{c} \sim 1/(\sqrt{U}) \quad (50)$$

This component was more effective in forming filaments when the ZPE was lower and c was higher.

Electric and magnetic field strengths are greater when the ZPE is lower from (36) and (44). When two filaments interact, long-range attractive forces result in an approach velocity given by [14]

$$v = I \{ \sqrt{[\mu L / (2 \pi M)]} \} \sim c \sim 1/U \quad (51)$$

In (51), the current is I , while L is the length of the filamental region involved in the attraction and M is the mass of electrons and ions in length L . Peratt showed galaxy sized filaments typically approach each other today at about 1000 km/s [28]. This interaction will be more rapid when the ZPE strength is less.

One final quantity remains to be discussed; the speed of sound in plasma. Sound moves slowly in low pressure, dense gas, while it moves quickly in high pressure, light-weight plasma. At the inception of the cosmos, the initial plasma was intrinsically linked with light photons which have low density but high

pressure. This resulted in plasma that had a sound speed 57% of c [84, 85]. Thus sound waves in plasma traveled much faster when ZPE strength was lower and c was higher.

The conclusion is that, when the cosmos was younger, plasma processes formed filaments, accumulated material, pinched and formed astronomical objects much more quickly than is now possible because ZPE strengths were lower. In contrast, gravitational processes were much more leisurely.

VI. FORMING A PLASMA UNIVERSE

A. The original plasma and its composition

On the model presented here, there was an initial rapid expansion of the cosmos out to its stable size after which there were minor oscillations about this final position. This expansion caused the ZPE which built up over time as elucidated above. Initially, then, the ZPE strength was virtually negligible. Since the ZPE maintains atomic structures, its near absence indicates that no atomic structures existed initially. Thus, all matter must have been in the form of ions and electrons – a plasma. Furthermore, as the universe expanded out, its temperature had to drop due to adiabatic expansion. The data suggest the initial temperature was of the order of 10 billion to 20 billion K. This temperature also demands that the material making up the universe was plasma, as atoms have all their electrons stripped off at that temperature. So an initial plasma universe is indicated on two separate counts.

The composition of this plasma is also important. On the Big Bang modeling the universe was initially filled with a sea of protons, neutrons and electrons in a composition that finally resulted in the formation of about 77% hydrogen and 23% helium. Because a nucleus of mass 5 does not exist, but is needed for the nuclear cookery to continue, the Big Bang process stops there. The remaining elements are envisioned as forming inside stars which explode these elements into space when they become supernovae. These elements then become incorporated into later generations of stars and planets. But quasars from the earliest epochs with redshifts around $z = 6.5$ or greater, show the same iron abundance as pertains at present [see *Nature* 483 (3 November 2005), pp.45-50, and *Astrophysical Journal* 515 (1999) pp. 487-496]. This problem for the Big Bang model is enhanced since neither the equivalent spectral line width nor the Fe II/Mg II line ratio increase from then to now. Furthermore, Population I and II stars from these distant objects all show the same metal enrichment as is currently the case in our galaxy. Since a number of similar observations have noted these facts, the indications are that all the elements up to iron (and probably the rest of the Periodic Table) were in existence in their present abundances when the quasars and early stars were formed. This is a problem for all Big Bang models.

This problem does not exist in plasma physics since fusion occurs easily in z -pinched double layers, and particularly strongly in current filaments in arc-mode plasmas [86]. But fusion is considered to occur only at ignition temperatures of millions of degrees Kelvin, so it may be wondered how this is possible. The reason is that the acceleration energy of a charged particle is given by the particle's charge number (one for an electron or proton) multiplied by the voltage it is accelerated through. This unit of energy is called the "electron-volt," (eV). To equate electron-volts to degrees Kelvin, one multiplies by 11,604.45 [87]. As a result, a 50-million-degree ignition temperature is easily achieved with a mere 4308.7 eV with no restriction on which elements may be formed. Thus elements are formed rapidly enough to be in the first quasars and stars. So plasma physics eliminates the problem of element formation.

B. The Cosmic Microwave Background (CMB) radiation

At a critical point in the cosmological expansion process, the cosmic microwave background radiation was produced. Research on the CMB radiation indicates that sound waves were involved in this process and formed the observed CMB patterns in the plasma [88]. We have seen sound waves form Chladni patterns in dust or sand on a drumhead, the precise pattern being dependent upon the configuration of the drum. An analysis of the pattern gives us information about the shape of the drum. In a similar way, current analysis of the repetition rate and rotation of the CMB pattern suggests that the shape of the universe may be dodecahedral, like a soccer ball [89].

The overall CMB pattern can be shown to be the precursor to the observed pattern of filaments and voids formed by clusters of galaxies. This same pattern is typical of those formed by plasma and was predicted by Alfvén, yet sound waves are implicated in the process. In plasma, it is found the *“presence of sound wave[s] can cause quite large changes in the ionization balance depending on the magnitude and frequency of the waves as well as the atomic parameters”* [90]. Plasma sound waves (ion-acoustic waves) cause ions to move, creating currents which are then confined by their secondary magnetic fields and form filaments. Experimental observations show the sound’s volume and wavelength were both important. Thus, the filamentary pattern, resulting from the action of sound waves, must have formed rapidly as sound velocity was 57% of c , and c was significantly higher with the low ZPE strength.

C. Galaxy formation

These primary cosmological filaments then behaved in the manner similar to those in Peratt’s laboratory experiments and computer simulations. They show that filament interactions due to the action of parallel Birkeland currents form an entire sequence of familiar astronomical objects. The object that finally forms depends on (1) where the interaction ceases; (2) at what stage we are viewing the interaction out in space; (3) the strengths of the Birkeland currents; (4) the number of interacting filaments. Interactions of up to 12 filaments have been studied, but most objects form with just two or three filaments [14, 15, 28].

As two filaments approach, the plasma between them becomes concentrated and the result is a double radio galaxy, with the two current filaments producing the radio lobes. As the interaction continues, and filaments approach more closely, quasars and active galactic nuclei form, followed by the various types of elliptical galaxies. Finally, at the end of the sequence, a variety of spiral galaxy types form as arms develop and lengthen, then thin out as they wind around the elliptical core. This process can be timed in the laboratory and up-scaled to observed galactic dimensions. But galaxy formation rates will be much faster with higher c values and lower ZPE strengths, as the velocity of the approach and interaction of the filaments will then be correspondingly more rapid.

D. The formation of stars

Closely linked with the formation of compressed plasma cores of galaxies are the oldest group of stellar objects, the Population II stars. The Alfvén-Carlqvist Model for the formation of stars in pinched filaments is well-known to plasma physicists [91]. They point out that all magnetic configurations with the Bennett pinch would certainly give rise to contractive forces. Peratt has also given some helpful specifics [28]. He states: *“Star formation in the elliptical [nucleus] is expected to start earlier [than otherwise expected] because of the compressive forces on the dense plasma contained there”* [28]. Furthermore, although the forces causing the compression and collapse in very dense cores are unchanged, the velocity of that compression and collapse is proportional to c or $1/U$. Star formation is thus expected to occur more rapidly than usually anticipated even on plasma models because of a lower ZPE strength in the past.

For the formation of Population I stars in the spiral arms, experiments and simulations show that “*star formation follows closely the morphology of the plasma in the spiral arms that are usually fragmented because of the diocotron instability. The well-known Baade description that stars in spiral arms appear ‘like beads on a string’ is also an equally apropos description for the simulated galaxies. ... The vortex motion of the beads of stars in the arms provides the characteristic $\cot(\psi)$ motion on the rotational velocity curves of spiral galaxies*” [28]. In other words, flat rotation curves for spiral galaxies are a natural consequence of plasma physics, which avoids the need for dark matter or new gravitational physics.

In summary, Peratt states that the experiments and simulations “*show first the formation of elliptical galaxies. Then, as the synchrotron-radiating Birkeland current-conducting outer plasma components move inward on the elliptical core, peculiar galaxies form and in sequence the spiral types Sd, Sc, Sb, and Sa (or their barred equivalents SBd, SBc, SBb, SBa). Stars form first in the densely compressed elliptical core (Population II stars) and then in the pinched plasma that make up the spiral arms (Population I stars).*” Sorting of elements by Marklund convection in filaments, the Population I stars in the spiral arm filaments means they will have a higher metal content than the Population II stars in the core. The Population II stars formed rapidly before the spiral arm filaments developed. The plasma was thus more homogeneous and unsorted than when the Population I stars formed. Similarly, in the spiral arms of galaxies, the plasma pinch rapidly forms the Population I stars like strings of beads along the many lesser filaments there. The plasma spheres formed by the pinch would then undergo rapid collapse gravitationally to their final size ensuring both Population II and Population I stars lit up very quickly.

E. Planet formation

Consider the filament from which our solar system formed. Let us envisage this filament undergoing a filamentation mode instability plus a pinch. There is then a major central filament, which will eventually produce the sun, and some more minor filaments from near the center out to the edge that will form the planets as a result of the pinch and compression. Within this system, there will be Marklund convection for both the major and minor filaments happening simultaneously. The minor filaments will then give rise to layering within the individual planets as the pinch and compression operate. Yet the types of ions which are actually available for this sorting and planetary layering will be mainly determined by the process operating in the major filament. The final result for any planet will be a combination of sorting from the main filament as well as the lesser one from which the planet formed. The sequence of element layering is given just before (2).

This two-fold sorting model of plasma physics for planets is borne out in actual practice. Thus planets near the center of the major filament will be composed of large quantities of nickel-iron and silicates. This is in fact the case. Mercury is predominantly a huge iron core, which occupies about 75% of the planet's diameter, overlaid by a small amount of silicates. The iron core of Earth is less in proportion to that of Mercury, occupying only 55% of the diameter, while that of Mars is lower again at 50% of the planet's diameter. At the same time, the silicate mantles increase in size as we go out from Mercury to Mars. It may therefore be conjectured that the parent(s) of the asteroids were composed of a small amount of nickel-iron, a large amount of silicates with a good percentage of water. The compositions of the various meteorites and asteroids support this as water content ranges up to 20% in some cases.

If we go further out in our solar system, Jupiter and Saturn only have a small quantity of nickel-iron in their cores which are largely composed of silicates surrounded by water ice. Their mantles are mainly liquid metallic hydrogen with atmospheres of hydrogen and some helium with small quantities of nitrogen compounds. Further out again, we have Uranus and Neptune whose basic structure is similar to Jupiter

and Saturn with the significant difference that there is an extensive layer of highly compressed water in which is dissolved a large quantity of nitrogen in the form of ammonia. The main trend is clear. Each planet is layered in a way which follows the ionization sequence and the predominant composition of the planets follows the same sequence as we go out from the Sun. Equations (6) and (7) are also of interest. Depending on the initial strength of the ZPE, dust in plasma could grow to bodies 10^{-2} meters or more and be still be influenced by plasma dynamics instead of the 10^{-6} meters we have today. The small spherical chondrules in meteorites are of this size, yet their origin has usually been considered a mystery.

In overview, then, the planets of the solar system display the effects of this two-fold sorting process, with the major moons representing a third level of filamentation and sorting. This process is expected to operate rapidly compared with gravitational models because both sorting and interaction velocities are more efficient and rapid with lower ZPE strength. This also means that the associated electromagnetic compression on the confined plasma can be expected to rapidly initiate any final gravitational collapse needed to form a planet which would already be differentiated.

It may be thought that any gravitational collapse of a sphere sorted or layered by Marklund convection might result in a high temperature internally and on the surface. However, this does not take into consideration the fact that the properties of the vacuum were different. This difference resulted in the energy density of radiation, including heat radiation, being lower in proportion to the ZPE strength as suggested by (16) above. These facts, and the consequences, are discussed in more detail in reference [66]. The outcome is that planets started off layered with cool interiors and surfaces. They then heated up by rapid radioactive decay deep in their interiors, particularly the short half-life elements. This heating resulted in a predictable series of events in the inner solar system [see an explanation of the entire sequence of events at: <http://www.setterfield.org/000docs/stellarhist.html>].

VII. SUMMARY

Recent developments in plasma physics have given a strong indication of how galaxies and stars have formed out of plasma filaments using known processes. These processes depend on the physical properties of the vacuum, and, as such, are dependent upon the strength of the Zero Point Energy (ZPE). The data indicate that ZPE strength has increased with time, even in a static cosmos. This means that the physical properties of the vacuum have changed, and that this change also affected the behavior of plasmas. With a lower ZPE in the past come stronger electric currents, field strengths and voltages, while resistances and forces remain unchanged. It was shown that these changes result in faster interaction between filaments with faster velocities of approach, more rapid sorting of ions and faster accumulation of material. This makes galaxy and star formation a less time-consuming process. Planet-formation processes using pinch instabilities and a rapid sorting of ions in plasma filaments also results in each planet having a layered structure initially. The planets would start off relatively cool, but since radioactive elements would be concentrated near the centers of planets, the radioactive heating would result in a predictable series of events. This ZPE approach then allows many problems that confront Big Bang cosmologists to be avoided, including dark matter and dark energy, and at the same time emphasizes that plasma phenomena can account for the basic features of the universe.

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FIGURE 1: Recommended values of Planck's constant, $h \times 10^{-34}$ J-s

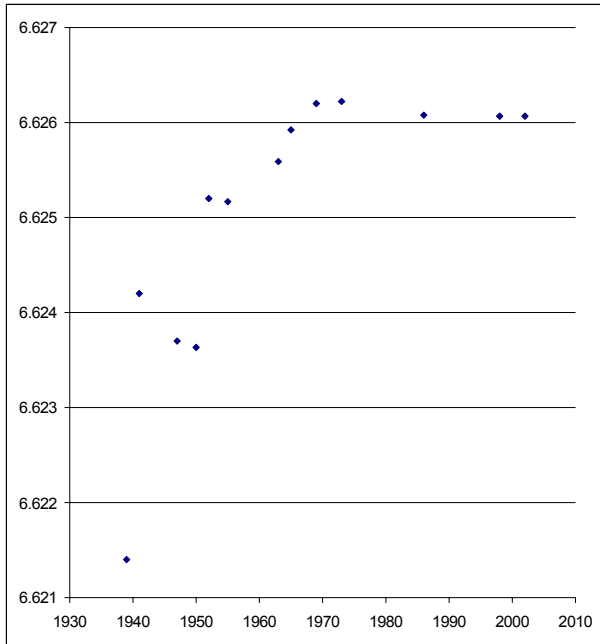


FIGURE 2: Birge's recommended values of light velocity, $c \times 10^5$ km/s

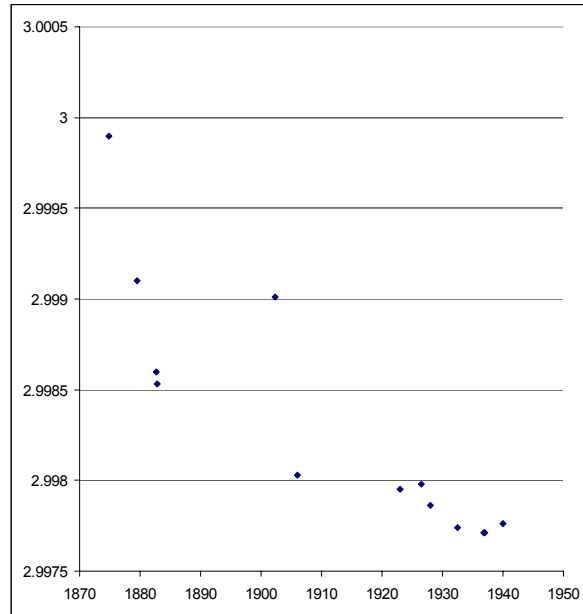


FIGURE 3: Recommended values of $h/e \times 10^{-15}$ J-s/C

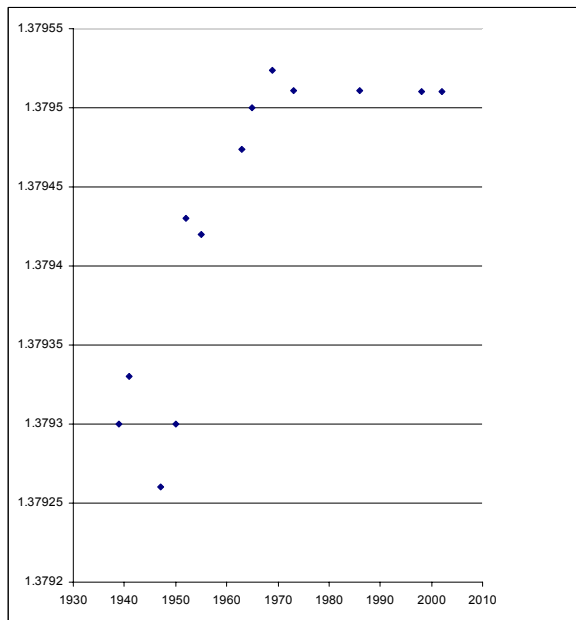


FIGURE 4: Recommended values of electron rest-mass, $m \times 10^{-31}$ kg

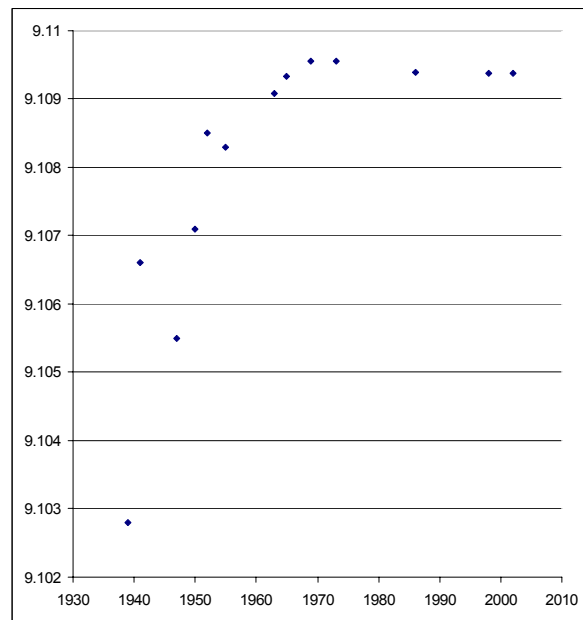


FIGURE 5: Recommended values of the Rydberg constant $R_\infty \text{ cm}^{-1}$

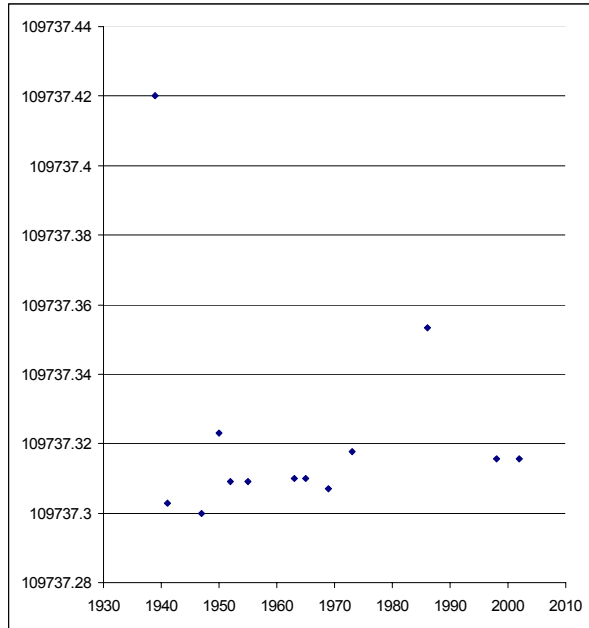


FIGURE 6: Secular variation of corrections to the mean longitude of the planet Mercury in arc-seconds (after Kolesnik)

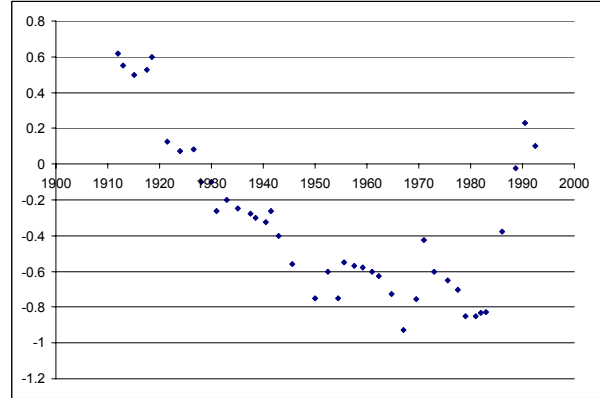
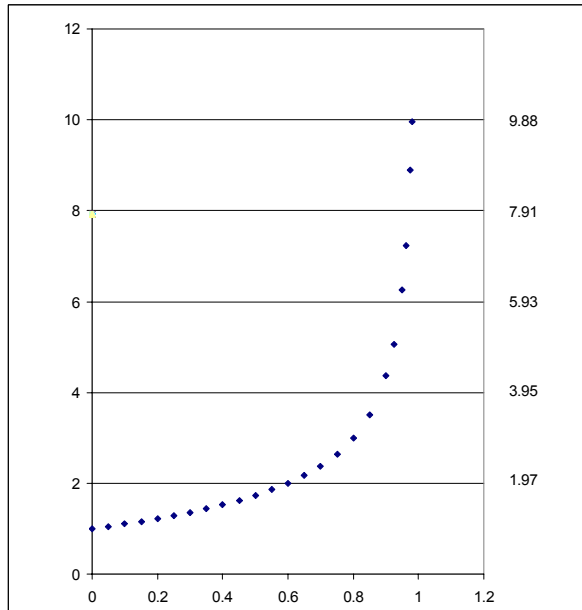


FIGURE 7: Graph of (57) the inverse of ZPE behavior and h . Behavior of $(1+z)$ on left axis and $c \times 10^7$ on right.



Horizontal axis: Time $T = 0$ now, and $T = 1$ at origin of cosmos.

Figure 8: C-14 Atomic Dates compared with Orbital Dates

