An Aether Model of the Universe

Allen Rothwarf
Electrical and Computer Engineering Department
Drexel University
Philadelphia, Pennsylvania 19104 U.S.A.

Abstract

An aether model based upon a degenerate Fermion fluid, composed primarily of electrons and positrons in a negative energy state relative to the null state or true vacuum, is proposed and its consequences are explored for physics and cosmology. The model provides both insight and quantitative results for a large number of phenomena for which conventional theory provides no answers or unsatisfactory answers. Among the concepts treated are: wave-particle duality, the nature of spin (a vortex in the aether), the derivation of Hubble's law; electric fields (polarization of the aether); Zitterbewegung (a bare particle orbiting within a vortex core); inflation in cosmology; the arrow of time; the Pauli exclusion principle (repulsion between parallel spin vortices); the nature of the photon (a region of rotating polarized aether propagating with a screw-like motion); neutrinos (a spin vortex with no particle in its core); redshifts; γ-ray bursters; and a number of other topics. A key assumption is that the speed of light is the Fermi velocity of the degenerate electron-positron plasma that dominates the aether. As a consequence the speed of light decreases with time on the scale of the age of the universe.

Keywords: Aether, Quantum Mechanics, Cosmology, Relativity, red-shift, Hubble's law, speed of light, vortices, wave-particle duality.

1. Introduction

We live in a universe of interacting fluids. While oceans in which gases are dissolved, and an oxygen-nitrogen atmosphere with water vapor and other trace gases are readily accepted, the third fluid, the aether, which penetrates everything is ridiculed as a relic of a bygone era in science. Yet, while rejecting an aether, the science establishment has no problems swallowing waves in vacuum, mysterious probability waves, ad hoc cosmological constants, vacuum fluctuations that can generate anything, and time and space expanding and shrinking. To the true believer, the fact that "they work" is the only justification for the major theories in physics; Maxwell's equations, the Schrodinger equation, and Relativity, and is used as evidence that we know everything, that "Science is Dead", and humanity's brightest should move on to more challenging tasks. Some of us, however, are heretics. We would actually like to "understand" the physics, rather than just use it as a magic wand to create technology. In this pursuit of "understanding", which is also ridiculed by the establishment as asking meaningless questions, we have found that the aether is not only a useful concept, but that it is a real substance with an origin that coincides with the birth of our universe and whose properties determine the speed of light, the other physical constants, and the missing insight lacking in present theories.

Before expounding upon the aether and how it explains so many phenomena in a simple way, let me point out that contrary to popular belief, science is not logically based. Instead, it, like all human activity is based upon chance and trial and error. The chimp who accidentally cracked the first nut with a stick or the baboon who first cracked an oyster or clam with a rock, didn't ask about how much force needed to be applied or the properties of shells. It was enough for them and those that followed that "it worked". In our text books we mostly read about the approaches that worked. Occasionally failed approaches, such as the aether, are mentioned to show how much better the current approach works.

Once something works there may be all sorts of explanations for why it works, but they are irrelevant since they all necessarily result in what is known to work or they are discarded.

To the modern scientist, Newton's misgivings about his theory of gravitation because it had no medium in which to act and hence was action-at-a-distance, are not a problem, nor does the notion that if light is a wave in what medium is it a wave. For gravity we distort space-time (another mysterious property of the vacuum) and for light we have the concepts of electric and magnetic fields (which have no clear pictures). For the origin of our universe we have a big bang which originated not only all the matter but also space-time itself. It is the expansion of space-time that gives us the expanding universe and the redshift of light from distant galaxies. As to why space-time is expanding or what determines the speed of light, that's just the way it is. Still more mysterious is Quantum Mechanics where the particles are also waves, and waves are also particles (photons, etc), and the wave function is not in a medium but is a probability wave of some sort. The key constant in Quantum Mechanics is Planck's constant, h, and the key constant in Relativity is, c, the speed of light. Conventional physicists wouldn't think of asking what determines the values of these constants; they are God given.

In the subsequent sections we will give our model for the aether and then show how it affords us deeper insight into many areas of physics. In section 2 we give the physical model for the aether and mention some of the conceptual problems it resolves. Section 3 details the mathematical model for the aether and derives the rate of expansion of the universe, the variation of the speed of light with time, Hubble's law, and treats the inflationary period of growth of the universe. Section 4 treats the relation of the aether to Quantum Mechanics. Section 5 relates the aether to electricity and magnetism, gives a detailed description of the photon, a plausible coupling mechanism between particles and the aether, and another possible mechanism for the redshift of light from distant sources.

Section 6 discusses spin and statistics, with a model for spin as a vortex centered on a "pore" in the aether, and shows how the magnetic moment of the electron is related to the Zitterbewegung of the electron. Section 7 discusses our concerns about Relativity and suggests a test of our model using the LIGO apparatus. Section 8 contains a long list of topics ranging from the mechanism for energy production in the early universe, to the arrow of time, the collapse of the wavefunction in Quantum Mechanics, and a possible steady state universe that includes many mini big bangs. In section 9 we summarize our results, and present our conclusion that our aether approach represents a fruitful approach to understanding the universe.

2. The Real Aether Model

While I had never really swallowed Quantum Mechanics, and had harbored the notion of a medium in which the particles moved and created waves that could interact with obstacles and act back on the particle, the nature and origin of such a medium was not obvious. Indeed, this has always been the problem with the aether. In "The Evolution of Physics" by Einstein and Infeld[(1)] at the end of section 2 - The Decline of the Mechanical View, in their summary they state, "Waves spreading in a medium consisting of particles, with mechanical forces acting between them, are certainly a mechanical concept. But what is the medium through which light spreads and what are its mechanical properties? There is no hope of reducing the optical phenomena to mechanical ones before this question is answered. But the difficulties in solving this problem are so great that we have to give it up and thus give up the mechanical view as well". Hence, it is necessary to have a specific model for the aether, if we hope to explain the complex phenomena of electricity, magnetism, radiation, and other phenomena.

It is also of interest to note that Dirac in 1951 published a Letter to Nature titled "Is There an Aether?"[2] in which he showed that the objections to an aether posed by Relativity were removed by Quantum Mechanics, and that in his reformulation of electrodynamics the vector potential was a velocity.[3] He concludes the Letter with "We have now the velocity(2) at all points of space-time, playing a fundamental part in electrodynamics. It is natural to regard it as the velocity of some real physical thing. Thus with the new theory of electrodynamics we are rather forced to have an aether". Others have worked on aether models, some similar to ours in many ways, and we will refer to their work later.

The key insight that our model presents is that it gives a natural origin to the aether and hence links a vast array of phenomena that are often treated in disjointed ways or not at all. In brief, the aether stems from the big-bang origin of our universe. During the period of the big-bang, particles and anti-particles were created in great numbers. Conventional physics asserts that almost all of these annihilated themselves, giving rise to radiation.[4] Our picture differs from the conventional one in that particles and anti-particles do not annihilate one another. Instead they form a bound state which is actually at a lower energy than if they had annihilated. This lower energy results from the collective correlation energy of the particles and anti-particles interacting with many others at high density. An analogous state exists in semiconductors irradiated by a high intensity laser.[5] There, such a high density of electrons and holes (absence of an electron in the bonding states) are created, that degenerate gases of electrons and holes are formed. This "electron-hole drop" shows a much longer lifetime and a large shift in energy, compared to those for an isolated electron-hole pair. Extrapolating the electron-hole state to much higher density one can expect a situation where the electron and hole plasma would be stable relative to recombination and hence would persist after the laser was turned off. While such a state hasn't been realized in semiconductors, we propose that the aether is such a state. We will argue that electrons and positrons dominate the aether plasma, and from this deduce a

number of quantitative and qualitative results that greatly enhance our understanding of the natural world.

At this point it may be occurring to the reader that when particles and antiparticles come together and energy is released that equals the rest mass of the particles, then how can we claim that the particles haven't recombined? Consider an isolated electron or positron. One can show that the energy associated with the electric field around these charges is given by

$$U = \lim_{r \to 0} \frac{e^2}{8\pi \in_0} \frac{1}{r} \tag{1}$$

and hence diverges if $r \to 0$. Here e is the charge on the electron, $\in_0$ the permittivity of free space, and r the distance from the charged particle. In standard treatments of electricity this energy is called the self energy of the particle, and the divergence is avoided by setting this energy equal to the rest mass energy $m_o c^2$, and defining a cutoff distance or radius for the electron $r_0 = e^2/(4\pi \in_0 mc^2)$ or by "renormalizing" the theory to remove the infinity.[6] We will deal with the infinity in another way later. Here, we simply point out that ordinarily as the electron and positron approach one another the field energy is greatly reduced, and at a distance on the order of r_0 the reduction in energy is sufficient for each to emit a γ-ray equal in energy to the particle's rest mass energy $m_o c^2$. Hence there is no contradiction or violation of conservation of energy in our picture, since the electron-positron pair at a distance of $\sim r_o$ would be in a negative energy state relative to the free particles, just as the electron-proton hydrogen atom is in a negative energy state relative to the free particles. For our case we also claim that the electrons and positrons interact with other pairs and reach an energy negative with respect to the null state. The null state is the absence of the aether, is what one would classify as the "true" vacuum.[7]

It is already possible at this point to preview some of the results. First, since the aether is a plasma of particles which obey Fermi-Dirac statistics, they will have a velocity,

and hence the region containing these particles will expand even after new particle-antiparticle production ceases. Hence, in our picture the expansion of the aether replaces the expansion of space-time, and indeed our aether replaces space-time. From the mathematical model of the aether which we will present below, Hubble's law[4] for the expanding universe is easily obtained. Another conceptual problem that the aether removes is the particle-wave duality that arises from Quantum Mechanics. An object moving through the aether creates a wave in the aether just as one moving through air or water creates a wave. The wave also acts back on the object to determine its path. Thus, a flat-faced boat approaching a solid dock has difficulty reaching the dock due to the water it pushes ahead bouncing back, and moving the boat back. For a moving particle in Quantum Mechanics there will be a disturbance in the aether that accompanies the particle and acts back on it. Hence in the double slit experiment the aether waves enter both slits, while the particle passes through only one. This is the approach taken by Bohm[8, 9, 10], but Bohm still considered the waves to be probability waves rather than waves in a real medium. The interference between the components of the aether waves then determines where the particle will strike the detector. Since the particle and its wave disturbance are linked, what affects one affects the other, giving the reason why the particle seems to be simultaneously a particle and a wave. We will give other examples later.

3. Mathematical Treatment of the Aether Model and Cosmology

Having asserted that the aether is a plasma of particles and anti-particles in a negative energy state (relative to the annihilation or null state), we would like to put this picture on a quantitative basis and see what quantitative predictions can be obtained. First we will assume that the aether is dominated by electrons and positrons. This is based upon the standard picture of cosmology (even though we will be changing parts of that picture) in which, as the big-bang cools down, there is a period during which electrons and

positrons dominate the matter in the universe, before annihilating to form γ-rays.[4,7] We envision that the "annihilation" is really a condensation into the aether. While we will be reinterpreting Quantum Mechanics, we accept its mathematical validity. Hence, the electron-positron plasma is subject to Quantum Mechanics, and will for high enough density form a degenerate Fermi fluid, similar to the situation in metals, neutron stars, or liquid He^3.[11]

A universal feature of a degenerate Fermi fluid (gas or liquid) is the existence, due to the Pauli exclusion principle of a highest energy (at zero temperature) for the particles called the Fermi level, and a velocity associated with this level called the Fermi velocity.[11] The expression for the Fermi velocity, v_F, is

$$v_F = \frac{\hbar k_F}{m} = \frac{\hbar}{m}(3\pi^2 n)^{1/3} \qquad (2)$$

where $\hbar$ is Planck's constant divided by 2π, m is the mass of the electron (positron), k_F the wavevector of electrons at the Fermi energy, and n is the density of the electrons (positrons). One thing that becomes apparent from equation (2) is that once particle production ceases as the big-bang cooled, n should decrease as the aether expands, and hence v_F should also decrease. The question arises at this point as to the significance of v_F and our observation that it will be decreasing with time.

We had mentioned in the introduction that others have considered an aether similar to ours. There is a vast literature of recent work, which is most readily accessed through the world wide web, as well as, through conventional journals.[12] We will mention only two of these approaches to give the flavor of what is being considered by others, and because they have some features in common with our model. Meno has an aether composed of particles called gyrons, that are oblong in shape, and matter consists of rotational flows (vortices) involving these gyrons. All phenomena are explained in terms

of various excitations of the aether. Meno's aether satisfies the necessary symmetry and invariance conditions. Sinha et al showed that a particle-anti particle aether would satisfy all the necessary symmetry and invariance relations to be consistent with known physics.[12] They, however, tried to show the relevance of their aether to known phenomena by equating v_F to the critical velocity of a superconductor and exploiting some of the known properties of superconductors to draw analogies to those of the aether. This approach has had some success, but our assumption as to the physical meaning of v_F appears to be more fruitful, namely, we equate v_F to the speed of light, c, and consider the consequences! The rationale behind this assumption is that one can show that excitations in such a system travel at velocities limited by v_F.[13] Using equation (2) and $v_F = c$, we come to some interesting conclusions:

i) c depends upon the density of the particles in the aether, it isn't simply a quantity that one must accept as given.

ii) Since n decreases with time as the aether expands, c will also be a decreasing function of time.

iii) If c is a function of time, e, $\hbar$ and m may also be time dependent.[14, 15]

Taking equation (2) and $v_F = c_0$ the present speed of light, we can calculate n_0 the present value of the density of the aether electrons (positrons). This yields $n_0 = 6 \times 10^{29}/cm^3$. If we compare this to densities in metals of $\sim 10^{23}/cm^3$ or the density of electron and holes in the Electron-Hole Drops,[5, 11] that was the model for our aether, of $2 \times 10^{17}/cm^3$, we see that we are many orders of magnitude denser, and hence, this is at least consistent with the hypothesis that at high density the correlations could increase the binding energy enough to make an electron-positron plasma negative in energy relative to the null state. For the electron-hole plasma in Ge at $2 \times 10^{17}/cm^3$ the added binding energy

is 2 meV compared to the free exciton.[5, 11] To extrapolate 12 powers of ten is not possible, so the true energy diagram for the aether is not available yet. However, we do know that the condensation energy is the present rest mass energy of the electron-positron pair or 2 (0.511 MeV) = 1.02 MeV, and that the kinetic energy of the electrons and positrons in the aether at the top of the distribution (the Fermi level) is $\frac{1}{2}mc^2 \approx 0.25\text{MeV}$. We can thus picture the free electron and positron condensing with each releasing 0.51 MeV and gaining 0.25 MeV in kinetic energy. This suggests that the potential energy of the aether particles at the Fermi level relative to free particles is given by:

$$\frac{1}{2}mc^2 + \langle V \rangle = -mc^2 \text{ or } \langle V \rangle = -\frac{3}{2}mc^2 \tag{3}$$

We will leave this for now and return to it later when we treat the energy balance of the universe.

There are other results that follow from Eq. (2) with $v_F = c$, that have a direct bearing on cosmology. First if we consider that as the aether expands and the big-bang cools, particle production ceases at some point, and leaves a total number of electrons (or positrons) N_o in the aether. If R(t) is the radius of the aether, (also the radius of the universe) then $n = N_0 / \frac{4}{3}\pi R^3(t)$. Since the fastest particles in the aether are moving with velocity c(t) some will always be crossing the outer radius, and thus expanding R(t). The rate of expansion of the aether will be proportional to c(t). Thus, $\dot{R}(t) = \alpha\, c(t)$ and rewriting Eq. (2) as

$$c(t) = \frac{\dot{R}(t)}{\alpha} = \frac{\hbar}{m}\left(\frac{3\pi^2 N_0}{\frac{4\pi}{3}}\right)^{1/3} \frac{1}{R(t)} = \frac{c_0 R_0}{R(t)}, \tag{4}$$

where c_0 is the present speed of light and R_0 the present radius of the universe and $\dot{R}(t)$ is the time derivative of R(t). This gives the differential equation:

$$R(t)\,\dot{R}(t) = \alpha\, c_0 R_0 \tag{5}$$

where α is a geometric factor on the order of one half.

The solution of this equation is, using $R(t)\,\dot{R}(t) = \frac{1}{2}\frac{d}{dt}\left(R^2(t)\right)$:

$$R(t) = \left[2\alpha c_0 R_0\,(t - t_i) + R_i^2\right]^{1/2},\ t > t_i \tag{6}$$

where t_i is the time at which particle production ceased and R_i is the radius of the universe at that time. Since the present time t_0 is much greater than t_i and R_0 is much greater than R_i, Eq. (6) predicts that the universe is expanding with a $t^{1/2}$ time dependence.

Also from Eq. (6) and the second form of Eq (4) we see that the speed of light is decreasing as $t^{-1/2}$. These results have assumed that $\hbar$ and m have values independent of time. The time dependence for R(t) given by Eq. (6) is nearly identical to that found from relativity for an Einstein-DeSitter universe dominated by radiation.[15] Hence, despite our unorthodox assumption of a real aether, our predictions are similar to those of traditional theory at least for some properties. However, the speed of light is not considered as variable in traditional theory, but the expansion rate of the universe does change with time and has a value which just happens to be similar in magnitude to c.[15]

Another result that arises naturally from the aether fluid is Hubble's law.[4, 7] This law which was deduced from experimental observations states that the farther away from us a galaxy is, the greater is its velocity away from us. Mathematically this is

$$v(r) = Hr: \quad \text{where H is Hubbles constant} \tag{7}$$

For a fluid, conservation of the mass of the fluid gives the continuity equation

$$\frac{\partial n}{\partial t} = -\nabla \bullet (n\vec{v}) \tag{8}$$

where n is the density and $\vec{v}$ the velocity of the fluid and $\nabla \bullet (n\vec{v})$ is the divergence of the particle current. The velocity of the fluid is the coherent or drift velocity of the fluid, rather than the velocity of the particles individually. In our treatment so far we have neglected any spatial dependence of the density of the aether. The rationale for this is that the velocity of the particles in the Fermi Dirac distribution range in each volume, from 0 to the speed of light, and hence the fluid is well mixed. This will fail to some extent at the edge of the expanding universe where particles are diffusing into the true vacuum. We will treat n as independent of r in Eq (8). The time dependence of n follows from its definition and Eq. (6). Thus, we can write

$$\frac{\partial n}{\partial t} = \frac{dn}{dt} = \frac{d}{dt}\left(\frac{N_0}{\frac{4}{3}\pi R(t)^3}\right) = -3n(t)\frac{\dot{R}}{R} \tag{9}$$

If we assume that $\vec{v}(r)$ depends only on r, then we need only consider the term in the divergence in spherical coordinates that has the r dependence

$$\nabla \bullet (n\vec{v}) = n\frac{1}{r^2}\frac{\partial(r^2 v(r))}{\partial r} = n\left[\frac{2v(r)}{r} + \frac{\partial v(r)}{\partial r}\right] \tag{10}$$

and (8) becomes

$$3\frac{\dot{R}(t)}{R(t)} = \frac{2}{r}v(r) + \frac{\partial v(r)}{\partial r} = K(t) \tag{11}$$

where K(t) is independent of r. A simpler form for Eq(11) is:

$$\frac{1}{r^2}\frac{d}{dr}(r^2\, v(r)) = K(t) \tag{12}$$

The general solution of this is:

$$v(r) = \frac{K(t)r}{3} + \frac{c_1}{r^2} = \frac{\dot{R}(t)}{R(t)}\, r + \frac{c_1}{r^2} \tag{13}$$

where c_1 is a constant of integration, which from the second form of Eq (13) can be set to zero, since $v(R) = \dot{R}(t)$ satisfies the boundary condition at the edge of the universe. With $c_1 = 0$ we have Hubble's law with H(t) given by:

$$H(t) = \frac{\dot{R}(t)}{R(t)} = \frac{\alpha\, c_0 R_0}{R^2(t)} = \frac{\alpha\, c_0}{R_0} \cong \frac{1}{2t} \tag{14}$$

Where the second form of Eq. (14) is obtained using Eq (5), and the third by setting $R(t) = R_0$ i.e. $t = t_0$ the present time, and the final form using Eq. (6) in the limit $t >> t_i$. The time t is since the start of the big-bang (or more correctly, the time since particle production stopped).

While Eqs. (13) and (14) are an apparent derivation of Hubble's law assuming that the galaxies are swept along with the expanding aether, there are several loose ends that need to be tied. First is the issue of where r is measured from. The observations measure the distance to the light sources from earth, while the derivation in assuming that $\vec{v}$ was a function of r only, implicitly took the origin for r to be the position of the big-bang, since it is only in that reference frame that a spherical symmetric universe is a plausible assumption. Second is the fact that the light being observed, and from which the velocity is determined via the redshift of the wavelengths, was emitted at an earlier time. From Eqs. (13) and (14) a higher velocity would have occurred for a given distance at an earlier time. If there is a one to one correspondence between the time the light was emitted and the distance computed to the source, then we would expect Hubble's constant to be smaller for nearby sources since the light was emitted at a later time compared to distant sources. Indeed, there seems to be some controversy about Hubble's constant, with values derived from nearby sources differing by about a factor of two from those from distant sources. [(4)]

Other problems that must be addressed are related to the speed of light being a function of time, and the possibility that other physical constants may also vary with time. This raises the possibility that the redshift is not due to the expansion of space-time (the

aether) but is due to the fact that the emitted photons were already shifted when emitted, since the physical constants at that time were different. Also it is possible that some distant galaxies were formed not in our big-bang, but in another that overlaps ours, and have aether properties different from ours that would produce discontinuities in redshifts from adjacent galaxies. We will return to this point at a later stage.

The above treatment considered the situation after the big-bang had cooled sufficiently so that particles were no longer being created and the aether had a fixed number of particles N_0. The natural question is whether anything can be said about the period prior to t_i. The answer is yes, if we return to the continuity equation and allow a generation term to be present. We now write instead of Eq. (8):

$$\frac{\partial n}{\partial t} = -\nabla \bullet (n\vec{v}) + g(t) \tag{15}$$

where g(t) describes the process through which new particles enter the aether. Later, we will discuss a mechanism, through which the presence of the aether as a negative energy state, provides the energy for additional particle production that results in an increase in the density of the aether. Since the energy available for particle production depends upon the density of the aether, we assume that g is proportional to a power of the density. Thus we write[16]

$$g = \gamma\ n^{\beta} \tag{16}$$

Since the generation process occurs at short times after the initiation of the big-bang when the universe is very small and uniform we will consider what Eqs. (15) and (16) predict when the divergence term is dropped. In particular if we take the case $\beta = 1$, we find[17]

$$n = n_i\ \exp(\gamma t) \tag{17}$$

where n_i is the density at which the generation term g dominates in Eq. (15). From Eq(2) and the assumption that $\dot{R}(t) = \alpha\ v_F = \alpha c$ the exponential growth in n given by Eq. (17) translates into the exponential growth of the radius of the universe (aether) during the time t

$< t_i$ when particle production is occurring. Thus, a period of inflationary growth or "inflation" occurs naturally in the aether model. Other models of cosmology have introduced inflation as an ad hoc assumption,[18] in our picture it can emerge in a natural way.

In summary, in this section we have demonstrated that the aether model can be put into mathematical form and makes reasonable predictions, in agreement with experiment and previous models, in relation to cosmology. It also introduces new concepts and results, such as the time dependence of the speed of light on a cosmological scale.

4. Quantum Mechanics and the Aether Model

The key features of Quantum Mechanics are the Schrodinger Equation[19] and the rules for determining the predicted value for observables. The quantity that the Schrodinger Equation describes is the wavefunction $\Psi(\vec{r},t)$; and the rules tell what information can be determined once Ψ has been found. From the point of view of predicting and accounting for experimental results in atoms, molecules and condensed matter, Quantum Mechanics has been a very successful theory. Where it is flawed is in its foundations, which are heuristic, and in the meaning of Ψ.[20] The usual interpretation of Ψ is that it is a probability amplitude, such that $|\Psi|^2 dV$ is the probability of finding a particle within the volume dV. An alternate approach is the ensemble picture, which states that if one had a large number of identical systems, then $|\Psi|^2 dV$ would represent the fraction of the systems that would be found to have a particle in the volume dV. Quantum Mechanics is excellent in predicting energy levels in "stationary" states such as the energy levels of electrons in atoms or allowed energy bands in solids, and similar problems.

However, for the seemingly trivial case of a free particle it is incapable of providing a reasonable solution.[20] Also there is no "derivation" of the Schrodinger Equation, and the probability amplitude is not a wave in a real medium but rather an abstract concept.

The Schrodinger Equation for a particle of mass m is:

$$-\frac{\hbar^2}{2m}\nabla^2\,\Psi(\vec{r},t)+V(r)\Psi(\vec{r},t)=i\hbar\frac{\partial\Psi}{\partial t}(\vec{r},t)=E\Psi(\vec{r},t) \qquad (18)$$

where ∇^2 is the Laplacian operator V(r) is the potential energy function, $\hbar$ is Planck's constant divided by 2π, and $i=\sqrt{-1}$. For stationary states with constant energy E, such as electrons in atoms, molecules, or condensed systems, the last equality is valid. Hence, given V(r) one can solve for $\Psi(r, t)$, and E, once the boundary conditions have been specified. While there are a very limited number of potentials for which exact solutions can be found for $\Psi(r, t)$, these were the foundation of Quantum Mechanics for several generations. But now one can routinely use computers to obtain solutions for even quite complex potentials and non-stationary states.

For many scientists there is no problem with Quantum Mechanics as it is presently formulated.[21] Others, such as Einstein, deBroglie, Bohm, Dirac, Bell and many many others, find the lack of a convincing derivation for the Schrodinger Equation, the ambiguous interpretation of Ψ, and some of the non-intuitive results predicted by Quantum Mechanics are defects that require a search for a more fundamental theory.[8, 9, 10] To the list of objections to Quantum Mechanics, the fact that there is no way of determining $\hbar$, the key constant in Quantum Mechanics, from any more fundamental considerations should be added. The aether model affords the opportunity to at least address some of these flaws in Quantum Mechanics.

Since the aether is a fluid, one would expect that a particle moving through it would generate waves which could interact with other particles or objects in the aether and act back on the particle. This view is reasonable since this is just what one sees for objects moving through water or air. Hence, one would expect the Schrodinger Equation to be the description of the motion of a particle through the aether. The natural variable to describe a disturbance in a fluid in hydrodynamics or aerodynamics is the fluid density or its pressure. If we use the density n, then the continuity equation (Eq. (8)) is a natural starting point. The key question is how to relate the motion of the particle to the velocity of the fluid. There are analogous problems in other fluids, such as the Brownian motion[22, 23] of small particles in a gas, or the motion of particles through a metal. These are well-known problems in statistical physics but are non-trivial mathematically. One well known result is the diffusion equation which in one dimension is: [22, 23]

$$\frac{\partial n}{\partial t} = D \frac{\partial^2 n}{\partial x^2} \tag{19}$$

where D is the diffusion coefficient determined by the properties of the fluid and n is the density of the particles in the fluid which are diffusing. A very similar equation[22, 23]

$$\frac{\partial z}{\partial t} = D \frac{\partial^2 z}{\partial x^2} \tag{20}$$

represents the probability density z (x, t) of finding a particle at x at time t, and D is again the diffusion coefficient which is related to frictional forces.

These equations are very similar to the Schrodinger Equation (Eq. 18) for a free particle (V = 0), particularly Eq. (20) where the probability density is involved, while the Schrodinger Equation is for the probability amplitude. A further point of interest is that if a long cylinder is placed in a flowing fluid, classical hydrodynamics would predict that there is no force on it.[24] Since this is at variance with observations for macroscopic objects, it is necessary to introduce a boundary layer, which is related to frictional forces at the surface. However, for a microscopic situation with irrotational flow and no friction, D

would need to be related to some other property of the fluid. If we compare Eqs. (19) and (20) with Eq. (18) in one dimension they would be the same differential equation for V = 0 if $D = i\ \hbar/2m.$ [25] Is there any way of showing how this can arise from our aether model? The answer is probably yes, but we have not done it. It is sufficient at this point to note the similarity of the form of the Schrodinger Equation to Brownian motion and diffusion in fluids. The diffusion coefficient for Brownian motion is: [24]

$$D = \frac{kT}{6\pi\eta R} \tag{21}$$

where k is Boltzmann's constant, T the absolute temperature η the viscosity of the fluid and R the particle radius. The temperature enters because kT is the characteristic energy of the particles in the fluid. For the aether, T is zero and some other energy must control the process.

For a picture of what is occurring one can visualize the particle being struck by aether particles from all sides as it moves, with the reflected aether particles changing the distribution in the aether from its equilibrium state. This disturbance is the ψ function of the Schrodinger Equation. For the case of a potential energy term, V(r), it may polarize the aether and hence affect ψ or scatter aether particles and affect ψ. The mass of the particle would enter through its effectiveness in scattering, similar to the radius R in Eq. (21). Thus we approach the Schrodinger equation from a physical point of view that stresses the fluid in which the wave exists, rather than the mathematical approach through heuristic manipulation of classical Hamilton-Jacob theory.[19]

One of the points that we mentioned previously, was that in Quantum Mechanics it is only with great difficulty that a free particle can be represented, and then only by violating conservation of energy. To quote Griffiths[20] after showing that the solutions for $H\psi = E\psi$ (the plane wave solutions) are not normalizable and hence not physically

realizable states; "A free particle cannot exist in a stationary state; or, to put it another way, there is no such thing as a free particle with a definite energy". Since this occurs early in the Quantum Mechanics book, and the course goes on without batting an eye about this, each generation of physicists is simply bulldozed into accepting what should have precluded the validity of Quantum Mechanics in its present interpretation. In the aether model, energy is shared between the particle and the aether, and the above result poses no problem.

5. Electricity and Magnetism and the Aether

5a. General Considerations

Anyone who has considered electric or magnetic fields is confused by what these concepts are. By definition these fields produce forces on electric charges or magnetic poles respectively, but by what means is left unexplained.[26] Here we move the issue one step further in understanding. The electric field exists when an electric polarization of the aether occurs, whereby the minus charges (primarily electrons) in the aether are separated from the plus charges (primarily positrons) in the aether by a distance that differs from the equilibrium separation. This polarization is similar to our view of polarization in dielectric materials, where the separation between the electrons and plus charge in the nuclei in atoms and molecules reduce an applied electric field.[6] An object in the aether would experience a force due to the stress in the aether that constitutes an electric field. This is similar to the view that relativity takes with respect to gravity, namely that it is a bending of space produced by mass.[4] The electric field is thus a disturbance of the aether that results from changing the spacing in the aether between positive and negative charges. The picture of the potential energy surfaces as peaks or valleys about plus and negative charges is reasonable, with other charges tending to slide down these features.

Magnetic fields on the other hand appear to be related not to the polarization of the aether but rather to a flow in the aether. Maxwell's equations that pertain to magnetic fields are: [6]

$$\text{(a)} \qquad \nabla \bullet \vec{B} = 0, \qquad \text{(b)} \qquad \nabla \times \vec{E} = \frac{-\partial \vec{B}}{\partial t}, \tag{22}$$

$$\text{and} \qquad \text{(c)} \qquad \nabla \times \vec{B} = \mu_0 \left(j_{true} + \frac{\partial \vec{P}}{\partial t} + \nabla \times M + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$$

where B is the magnetic induction, E the electric field, P the electric polarization, M the magnetization, μ_0 the permeability, and ε_0 the permittivity of space (aether) and j_{true} the current carried by charges. It is common to write $\vec{B}$ in terms of the vector potential, $\vec{A}$, as:

$$\vec{B} = \nabla \times \vec{A} \tag{23}$$

since then (22a) is automatically satisfied by the vector identity $\nabla \bullet (\nabla \times \vec{u}) = 0$ for any vector $\vec{u}$. It was long thought obvious that $\vec{A}$ could have no physical significance in itself, since it was merely a mathematical artifact, and all physical effects should occur through $\vec{B}$ alone. However, the Aharonov-Bohm Effect[20, 27] showed that $\vec{A}$ can affect the quantum behavior of charged particles in regions of space where $\vec{B}$ and $\vec{E}$ are zero. In addition, prior to Aharonov and Bohm, the London equation[11, 28] indicated that the supercurrent in superconductors was directly proportional to the vector potential $\vec{A}$. Also Dirac had pointed out that in electrodynamics the vector potential is the velocity of something, presumably the aether.[2, 3] Thus, we expect $\vec{A}$ to represent a flow in the aether with the magnetic induction $\vec{B}$ given by Eqs. 23 and 22b).

In regard to 22b it is common to write

$$\vec{E} = -\nabla \varphi - \frac{\partial \vec{A}}{\partial t} \tag{24}$$

where φ is known as the scalar potential, and hence, since $\nabla \times \nabla \varphi = 0$ for any scalar φ, the left-hand side of Eq. 22b) together with the definition Eq. (23) give the right-hand side of Eq. 22b). Thus, for time dependent problems, the vector potential determines both the electric and magnetic fields.

It is common practice to view the electric and magnetic fields as containing an energy U given in free space (aether) as:

$$U = \frac{1}{2}\int\left(\frac{B^2}{\mu_0} + \varepsilon_0 E^2\right)dV \tag{25}$$

Where the integral is over all space. Indeed, it is common to use the Maxwell stress tensor[6] to represent the effects of electric and magnetic fields upon materials in such fields, and also to discuss energy and momentum balance in electromagnetic waves. In particular, the Poynting vector, $\vec{N}$, is given by:

$$\vec{N} = \vec{E} \times \vec{H} = \frac{1}{\mu_0}\vec{E} \times \vec{B} \text{ (in free space)}, \tag{26}$$

and its integral over a surface determines the rate that energy is being carried into or out of a region. The stress tensor $T_{\alpha\beta}$ (α, β are coordinate axes designations i.e., $T_{x\,x}$, $T_{x\,y}$, etc.) can be used to find the volume force through its divergence, and one finds that the divergence reduces to two terms.[6]

$$\frac{\partial T_{\alpha\beta}}{\partial x_\beta} = \left[\vec{F}_{ev} + \frac{\kappa\kappa_m}{c^2}\frac{\partial \vec{N}}{\partial t}\right]_\alpha \tag{27}$$

where $c^2 = (\mu_0\varepsilon_0)^{-1}$ and κ and κ_m are respectively, the relative dielectric constant and permeability of the material in question. $\vec{F}_{ev}$ only exists in the presence of material bodies. However, the second term exists even in free space where $\kappa = \kappa_m = 1$. This caused a problem, since it would fit a theory in which an aether capable of transmitting elastic waves and sustaining a body force exists.[6] To avoid this, while accepting all other conclusions drawn from Maxwell's equation, the second term is subtracted. To quote Panofsky and

Phillips,[6] "in the absence of measurable physical properties for the ether, we are thus forced to modify the law of conservation of momentum....The Poynting vector therefore appears in a dual role, as carrying energy and also as carrying momentum." Furthermore, Panofsky and Phillips note that by defining a momentum density $\vec{g} = \vec{N}/c^2$ which is required to conserve momentum "..., the assumption of conservation of momentum and the absence of an aether can be used to derive the mass-energy equivalence. In this way, the relation $E = mc^2$ can be obtained without introducing the entire relativistic kinematics."

Hence, rather than traditional physics simply saying that an aether isn't necessary and having everything turn out consistently, the absence of an aether causes problems, and ad hoc changes have been introduced to hide the possible existence of an aether.

The question of what form of energy exists in these fields can be addressed in the aether model. In essence the electric fields are a strain energy in the aether, analogous to that in a solid, $\frac{1}{2}kx^2$, with k a spring constant and x the displacement from equilibrium. The magnetic field energy is analogous to kinetic energy, $\frac{1}{2}mv^2$. As in other condensed media, combinations of displacement and motion produce waves. Water and air are two of the fluids with which we are intimately acquainted, and they can sustain a number of different types of waves or excitations. In air there are sound waves, pressure waves (highs and lows of weather fronts), hurricanes, tornadoes, wind patterns (trade winds, jet stream), vortices, and possibly others. For water there are transverse surface waves, longitudinal sound waves, whirlpools, ocean currents (gulf stream) and possibly others. In the electron-ion plasma in condensed matter there are also a variety of excitations including sound, spin waves, charge density waves, helicons, polaritons, plasmons, etc.[11] We would expect the aether to exhibit an equally rich spectrum of excitations.[26]

5b The Photon - Electromagnetic Waves

The most important excitation in the aether is the photon, since we perceive the visual world through optical photons, and receive much of our communications through electromagnetic waves (radio, TV). Consider how an optical photon is generated in the hydrogen atom. Here we picture the Bohr model for the electron orbiting the proton.[29] What do we expect based upon the aether picture? Clearly the electron is moving so one expects it to disturb the aether, and hence a wavefunction is produced. At the same time there exists a strain in the aether due to the fixed electric field of the proton and the rotating electric field of the electron. In addition to this the spins of the proton and electron produce flow patterns in the aether. Hence this "simple" case is in reality quite complex. If the electron is in an excited state there is energy in the system that can be released. First we need to ask what form the energy takes. Above we have mentioned the field energy $\frac{1}{2}\int \varepsilon_0 E^2 dV$. (Eqs. (1) and (25)). However, only differences in this energy are considered in conventional treatments because the total energy diverges unless artificial cutoff radii are introduced for the electron and proton. When considered, the total energy is somehow contained in the "electromagnetic mass" of the charged particles.[6]

Hence, electricity and magnetism also rest on an untenable base, that contains unresolved infinities which the student is to dutifully ignore; the emperor has no clothes, but it isn't polite to mention it. How does the aether model address this same problem? In the model there is a finite density of particles in the aether and hence a natural "pore size" in which there is no aether. Particles thus have no aether around them within a distance equal to this pore size, and hence no electric field in the sense defined above. The field is essentially transmitted by the particle "rattling" around within the pore and transmitting the impulse that polarizes the aether. As we will see later the pore is also the core of a vortex which constitutes the spin of the particle. Hence, by different reasoning we conclude, as do conventional treatments, that there is a field energy U_0 that is carried by the electron and proton, which doesn't diverge when they are isolated.

When the electron orbits the proton, there is a region between them along the line connecting them where the field is enhanced, and hence the energy is higher, and a region beyond them where the fields tend to cancel lowering the energy compared to the isolated electron and proton. In conventional theory, using the potential energy of the electron in the presence of the proton, and its kinetic energy, one shows that the energy of the system is lower than for a free electron or proton. The potential energy approach replaces the field energy calculation, and is simpler, but it masks the true physics of the situation, namely that there is a high energy dipole field region between the electron and proton that is rotating with an angular velocity ω about the electron-proton center of mass.

One can show that the closer the electron is to the proton, the lower the total energy of the system, however the kinetic energy, T, actually increases. By the virial theorem[30] $T = -E$; with E measured relative to the free particles, E is negative. Hence the more tightly bound the system the higher its kinetic energy, and the higher its angular frequency. This follows since $T = \frac{1}{2}mv^2 = \frac{1}{2}mr^2\omega^2$ with $\omega = v/r$. Hence for larger T at smaller r, $\omega = v/r$ increases due to the rise in v and the decrease in r. The reason for the interest in ω and the rotating dipole field in the atom, is that to understand what a photon is we need to visualize how it is generated.

The emission of the photon is mysterious, since in classical theory the radiation is continuous, and in Quantum Mechanics (QM) it is discontinuous, but no details of the process are available even in principle! In QM the quantized energy of the photon is $E = h\nu = \hbar\omega$, and it has an angular momentum $\hbar$, usually referred to as right and left circular polarizations along or opposite to the direction of motion of the photon, where $\hbar$ is Planck's constant divided by 2π. No physical meaning is attempted in explanation of what ω is or what the significance of $\hbar$ as a multiplier for ω is, or what the photon is physically. QM gives results ex-cathedra, and one is not encouraged to ask questions. In the aether model, the photon can be visualized as a rotating polarized region of the aether that has

broken loose from the rotating dipole region in the atom that was described above. It is emitted perpendicular to the plane of the orbit of the electron, when the electron is pulled in closer to the proton. As it moves through the aether with the speed of light c, the rotating polarized region completes a cycle in a time $2\pi/\omega = 1/\nu$ during which the disturbance has traveled a distance $\lambda = c/\nu$. The angular momentum of the aether region is along the direction of or opposite to the direction of propagation, since one has clockwise or counter clockwise motion for the rotating polarized region in the atom. A natural question is how does this picture agree numerically with experiment?

One can show a mathematical relation between the frequency of the emitted photon and the angular velocities in the initial and final orbits of the electron namely from the Bohr model: [29]

$$\omega_{if} = \frac{1}{2}\left(n_f\omega_f - n_i\omega_i\right) \tag{28}$$

where the n's are the principal quantum numbers of the orbits and ω_ns the angular velocities. The value of the ω_n's go as n^{-3} and hence ω_f is greater than ω_i. For $n_i = 2$ and $n_f = 1$, $\omega_{21} = 3\omega_i = 3\omega_f/8$. For the special case $n_i = \infty$ and $n_f = 2$, $\omega_{\infty 2} = \omega_2$, while for $n_i = \infty$ and $n_f > 2$, $\omega_{\infty f} > \omega_f$. The states of the H atom are quantized according to the rule:

$$|E_n| = \frac{1}{2}n\hbar\omega_n \tag{29}$$

From these results it is clear that the angular velocities of the electron in Bohr orbits are similar in magnitude to the angular frequency of the emitted photon and support the picture presented above. What is lacking in the standard picture of QM is how the angular momentum is carried. We have mentioned, that because the aether was dismissed as a real entity,[6] the Poynting vector $\vec{N} = \vec{E} \times \vec{H}$ must be given the task of carrying not only the energy of a wave but also the momentum density per unit volume $\vec{g} = \vec{N}/c^2$, where c is the speed of light. The cross product of $\vec{r}$, the position vector, and $\vec{g}$ integrated over all space gives the angular momentum of the electromagnetic field. Yet despite the importance of

photons, to our knowledge no treatment of the region over which the E and H (or B) fields exist in the photon (i.e., the length and transverse extent) nor the magnitudes of the fields, appear in texts on light or QM. Since the aether is not supposed to exist, no account of how it carries momentum or angular momentum is expected to exist. However, there is a clue from the volume force on the vacuum that comes out of the Maxwell stress tensor, namely:[6]

$$\frac{\kappa\kappa_m}{c^2}\frac{\partial(E\times H)}{\partial t} \tag{30}$$

as well as other terms which previously have been ascribed to media only i.e.[6]

$$-\frac{\varepsilon_0}{2}E^2\nabla\kappa-\frac{\mu_0}{2}H^2\nabla\kappa_m \tag{31}$$

where κ and κ_m are the relative dielectric and magnetic permeabilities of a material. These terms, depend on the density of a medium, which is modified by the passage of particles and waves. Hence, since we consider the aether to be a fluid with a density of electric and magnetic dipoles that determine κ and κ_m, we expect forces from the terms in Eq(31) when a particle moves through the aether. We thus, have a plausible mechanism for the interaction between particles and waves and the aether. In particular, we have pointed out that there are "pores" in the aether due to the finite density of the electrons and positrons, in which particles are trapped within vortices. Clearly there will be gradients in κ and κ_m near such "pores" and the forces will tend to keep any trapped particles in the pores.

To return to the nature of the photon, the electron in orbit in an atom with its rotating polarization field is pulled in from an outer orbit to an inner orbit shrinking the rotating polarized region while simultaneously increasing its angular velocity. At some point in this process a rotating polarized region of aether breaks away, carrying with it energy $\hbar\omega$ and angular momentum $\hbar$. The rotating polarized region constitutes the photon. Based upon this picture we expect the lateral extent of the photon to be on the order of the size of the initial atomic orbit or less. Yet interference experiments done with

light from distant stars with lenses or mirrors spaced meters apart and an average of one photon at a time coming in, suggest an entity of much larger in extent[26] (meters, compared to the 10^{-10} meters size of the atom). How can we reconcile these seemingly contradictory results? The entity, which we identified as the photon as it travels through the aether creates an additional disturbance in the aether as it travels, just as an electron or other particle does. While the rotating aether region that constitutes the photon remains localized as it moves, the aether disturbance can spread out creating a pattern which can steer the photon when these waves encounter lenses or diffraction gratings, etc. his is basically what Huygen's principle states. That the photon is small and localized is attested to by the photoelectric effect,[31] where a single photon ejects an electron locally from a material, and also by photographic plates where the photon deposits its energy locally to produce a chemical change. We can thus account for the non-intuitive behavior of photons consistently with the aether picture.

A further question about the disturbance in the aether caused by either photons or particles, is whether these disturbances carry energy and momentum, distinct from the particle or photon. It would be logical to assume that they do, and that under proper conditions this might be demonstrated. The situation is analogous to that in radiation theory when scattering occurs. There it is known, that other non-radiating fields exist, these "near-fields" (or induction or quasi-stationary fields) die out quickly and hence don't carry energy in the conventional sense.[6] However, their presence can be demonstrated and measured. In the case of photons from distant sources,[26] we have mentioned the very large transverse width over which coherence has been demonstrated, and attributed this to the disturbance in the aether generated by the photon. Since this disturbance has energy, it must have drawn this energy from the photon, and hence lowered the photon's energy, giving a redshift to the light.[32] This redshift explanation differs from other approaches, such as of the expansion of the universe,[4] or the Doppler shift due to relativity,[4] and to the different physical constants in distant regions, which we will treat subsequently.

6. Spin and Statistics

One of the earliest indications of the non-classical properties of particles is the spin quantum number in Quantum Mechanics.[33] The three coordinates (x, y, z, or r, θ, φ) that classically describe a particle's position, in Quantum Mechanics become three quantum numbers per electron in the atom, n, l, and m_l. These, respectively, determine the orbit an electron is in, its orbital angular momentum magnitude, and the orientation of that angular momentum with respect to a coordinate axis, usually the z-axis. In addition, the electron was found to have an internal coordinate.[33] This internal coordinate could have two values, and also had a magnetic moment associated with it, and by inference an angular momentum. In analogy with the planets which not only revolve about the sun, but also spin about their axes, the electron was postulated to have an intrinsic spin with an angular momentum of $\hbar/2$, and a magnetic moment. In a magnetic field the electron's magnetic moment could align primarily with the field or against the field, giving two possible states. This picture gives excellent agreement with a host of properties in atoms and solids. There is just one flaw in the picture; there is no way of having the intrinsic angular momentum of $\frac{1}{2}\hbar$ and a mass m and an acceptable radius without violating the limit on the speed of light, i.e. for a spinning sphere.[20]

For $I\omega = \frac{1}{2}\hbar = \frac{2}{5}mvr$ one finds on setting $v \leq c$,

$$r \geq \frac{5\hbar}{4mc} = 1.25\,\lambda_c = 4.8\times10^{-11}\,\text{cm} \qquad (32)$$

where λ_c is the Compton wavelength. This value of r is larger than r_0 (2.82×10^{-13} cm) the so-called classical radius of the electron and much larger than the radius deduced by scattering which is less than 10^{-16} cm.[20]

The proton, neutron, neutrino, muon, and many other particles also have spin $\frac{1}{2}$ (in units of $\hbar$) and are called Fermions. The reason spin $\frac{1}{2}$ particles are called Fermions is because the statistics they obey is Fermi Dirac statistics[20] which stem from the Pauli exclusion principle.[20] This principle states that no two interacting spin $\frac{1}{2}$ particles can have the same set of quantum numbers (n, l, m_l, s), and hence in an atom at most two electrons can have the same n, l, m_l values since the spin quantum number is either + 1/2 or - 1/2. This principle explains the Periodic Table of Elements and in its more mathematical form explains many of the properties of metals and other condensed matter.[11] The only flaw in this picture is there is no physical reason given why identical Fermions with the same spin should repel one another.

In Section 5, in our discussion of the photon we noted that it carried an angular momentum of $\hbar$ oriented along or opposite to its direction of motion (right and left circularly polarized). The photon is an example of a class of particles, bosons, which have integer values of angular momentum (in units of $\hbar$) and obey Bose-Einstein statistics.[20] There is no prohibition against having an arbitrary number of bosons in the same quantum state. No explanation of why particles with spin 1 should behave so differently from those with spin 1/2 is provided in present theories. Since Fermions are embedded in vortices which ineract, while bosons have no vortices, a difference in behavior is expected from the aether model.

A reasonable question to ask is what constitutes the angular momentum of a particle. For the photon, which has no rest mass, conventional theory assigns the momentum to the Poynting vector $\vec{N}$, through the relation $\int \vec{r} x \vec{N}/c^2 \, dv$, while excluding the term in Eq (27) or Eq (30) due to disbelief in the aether. Our aether picture viewed the

fields as polarizations and flows in the aether, with the photon being a region of polarized aether rotating about the direction of propagation. The angular momentum is clearly carried by the aether. For the electron with mass m_0, one could assert that it could have a mechanical angular momentum, although we saw above accounting for it reasonably was not acceptable.[20] However, for the neutrino which has no rest mass[34] (although theories giving it mass arise from time to time) conventional theory can only be silent as to where the angular momentum resides. In our aether model we propose that the spin of the Fermions is a manifestation of the presence of a vortex in the aether with angular momentum $\hbar/2$. Thus, the electron is a charged particle that is trapped in the core of a vortex, and the neutrino is a vortex with angular momentum $\hbar/2$ with no particle within its core.

There are immediate predictions from such a picture, namely that aligned vortices or spins will stay away from each other due to the repulsion of the flow patterns of the vortices. Such a repulsion is seen between the current distribution of vortices in type II superconductors in a magnetic field, or trapped vortices with no applied magnetic field.[35] This interaction between the aether flows of the vortices can be used to account for the Pauli exclusion principle for spin 1/2 particles, since the flow pattern is expected to persist over fairly long distances.

The magnetic moment $\vec{M}$ of a spinning charge is related to its angular momentum $\vec{L}$ classically by the relation:[36]

$$\vec{M} = \frac{q}{2m}\vec{L} \tag{33}$$

where q is the charge and m the mass of the object. Experimentally for the electron the factor relating M and the spin angular momentum is q/m, or twice the classical value. In standard physics the factor of 2 is explained in terms of relativistic electrodynamics,[36] but

since one can't think of the spin as arising from a spinning charge in the standard theory, it is hard to know what the factor should be. For the aether model we picture the bare electron as not spinning but moving around within the core radius of the vortex. In steady state we would expect the electron to be correlated with the velocity of the aether at the core radius r_c. To account for the factor of 2 between the observed intrinsic angular momentum of $\hbar/2$ and the observed magnetic moment $M = \frac{q}{2m}\hbar$ we consider that the electron is "orbiting" within the core radius r_c with angular momentum $mvr_c = \hbar$ and that the vortex has an angular momentum in the opposite direction of $\hbar/2$. Thus, the total intrinsic angular momentum would be $\hbar/2$. For the total magnetic moment we use Eq. (33) for the electron part and assume the vortex to carry no magnetic moment. The result is that the total intrinsic angular momentum is $\hbar/2$ and the magnetic moment is $e\hbar/2m$ in agreement with observation. (e is the charge on the electron)

One could raise the question of why the vortex angular momentum should be opposite to that of the electron in the core and whether our assumption of zero magnetic moment for the vortex is justified. Since we are claiming that a neutrino is the vortex without a particle, what are its properties and are they consistent with our assumptions? First is the fact that despite extensive searches for it the neutrino has no magnetic moment.[34] Second is a strange property of the neutrino namely that it always has its spin aligned opposite to its direction of motion.[37] This is contrary to the situation for the photon where right and left circular polarizations occur. The assumptions that the electron and its vortex have oppositely oriented magnetic moments is to be expected from energy considerations, since generally the lower the total angular momentum, the lower the energy.

It is known that for the electron the factor in the magnetic moment to angular momentum ratio is not exactly 2. This correction is referred to as the anomalous magnetic moment of the election.[36] The factor of 2 was simply accepted as one of the quirks of nature, but that it differed from exactly 2 was taken to be of great significance. The difference from 2 is 2.319 ... x 10^{-3}, and is known to seven significant figures. The magnitude and cause of this correction can be obtained in the above picture. Since the electron has a charge, its electric field polarizes the aether, and since the aether in the vortex is moving, the magnetization is caused by the rotating polarized aether. A correction of the same magnitude as that observed experimentally is obtained based on a rough calculation. Since the calculation of the exact values of this correction is viewed "... as one of the greatest achievements of theoretical physics,"[36] a rigorous calculation using the aether model might prove interesting.

Another interesting point is that if the particle in the core had its angular momentum and that of the vortex in the same direction, one would have a particle with spin 3/2. Particles with spin 3/2 do exist, namely, the omega particles.[34] However, its spin of 3/2 is explained in terms of its composition being 3 spin 1/2 strange quarks.

Let us now turn to the question of the vortex core radius r_c and why it exists. In a vortex the velocity varies with radius as r^{-1} and hence would diverge as r goes to zero unless something changes as r gets smaller.[38] In any real fluid there are material properties and forces that come into play. Thus, if we consider the force needed to keep a particle in circular motion, the so-called centripetal force, it is mv^2/r, and in a fluid this force would be supplied by pressure gradients and produce density variations or vice versa (density variations that produce pressure gradients). For $v \sim r^{-1}$, the force needed as r becomes small becomes too great, and when the pressure and density drop near the center to nearly zero there is no longer a velocity. Hence, we expect a low pressure region at the

center of a vortex. Indeed, a tornado acts like a giant vacuum cleaner, the lower the center's pressure the stronger the storm is, since it can sustain higher velocity winds.[38]

If one assumes a continuous medium, then one finds for a vortex in a Fermion fluid a cutoff radius that occurs when the velocity of the fluid reaches the highest velocity of the particle in the fluid v_F, which for the aether is c the speed of light, and at that radius the density has dropped to zero. The expression for the particle density can be found to be:

$$n(r) = n_0\left[1-\left(\frac{r_c}{r}\right)^2\right]^{3/2} ; r > r_c \tag{34}$$

where n_0 is the density of Eq. (2) that holds far from the vortex. If we knew the length of the vortex and its behavior at long distances, we could calculate the angular momentum in the vortex directly and calculate r_c. The only condition we can obtain is that:[24]

$$r_c = \frac{K}{2\pi c} \tag{35}$$

where K is the circulation of the vortex and c the speed of light.

In the aether model, the fluid is made up primarily of electrons and positrons and hence is not continuous at small distances on the order of $n_0^{-1/3}$. There are thus, natural "pores" in the aether that make it multiply connected, and able to support irrotational flow while at the same time contain vortices centered on the pores. We thus propose that the radius of the vortex core, r_c, and the radius of the pores due to the finite density of the aether coincide.

In contrast to the situation in crystalline solids, where for a given crystal structure and atom size, one can determine the placement and size of interstices, for a fluid one can only get an estimate based upon the average spacing of the particles. From Eq. (2) with v_F

= c one can write $\frac{4\pi r_1^3}{3} = n_0^{-1}$ and find $r_1 = 1.92\,\lambda_c = 1.92\,\hbar/mc$, where r_1 is the radius of a sphere that would on average contain one electron-positron pair. Hence for distances smaller than r_1 one expects to find regions with no electron or positron. If we compare this value to the r in Eq. (32) we see that r_1 is greater than the r given there. However, in discussing Eq. (32) we were thinking of a spinning spherical electron. Here we are looking at a particle contained within a vortex core with an angular momentum $mvr = \hbar$. If we set v = c, then $r = \hbar/mc = \lambda_c = 0.52\,r_1$. If we set $r = r_1$, then $v = \frac{\hbar}{mr_1} = \frac{c}{1.92} = 0.52c$. Either limit gives a reasonable picture.

From Eq. (35) if we set $r_c = \hbar/mc = \lambda_c$ corresponding to the velocity of the electron within the core equal to c, we find $K = 2\pi c\,\lambda_c = h/m$. The choice may seem arbitrary, and the whole picture of the electron running around within a vortex core of radius λ_c highly suspect. However, if we go to the standard model of relativistic quantum mechanics using the Dirac equation, there is a curious result in solving for the position of a free particle as a function of time. There are three terms.[39] "The first two terms on the right-hand side describe simply the uniform motion of a free particle. The last term is a feature of relativistic quantum mechanics and connotes a high-frequency vibration ("Zitterbewegung") of the particle with frequency $\cong \mu c^2/\hbar$ and amplitude $\hbar/\mu c$, the Compton wavelength of the particle." In this quote μ is the mass of the particle and the frequency given is its angular frequency. If we take the core radius as λ_c corresponding to v = c, the angular frequency $\omega = v/r = c/\lambda_c = \mu c^2/\hbar$ is exactly what relativistic quantum mechanics finds, with the amplitude the radius of the core λ_c. We thus have a physical picture for the Zitterbewegung. In the standard theory the frequency is viewed as somehow a transition frequency between positive and negative energy states, but the amplitude is completely

unexplained. Schrödinger interpreted this as showing that the particle moved in a tight spiral, but when he found its angular momentum to be $\hbar$ instead of $\hbar/2$ he abandoned the picture.[19]

Let us review what this picture seems to accomplish. By taking the neutrino which has no mass or charge, but has an angular momentum of $\frac{1}{2}\hbar$, to be a vortex in the aether, we have a physical picture for the origin of the spin of the Fermions, and from the interaction between vortices an explanation for the Pauli Exclusion Principle, and hence Fermi-Dirac statistics. For the electron we picture the charged particle as trapped in the core of the vortex and moving with it. However, the electron has a magnetic moment that can't be explained in conventional theory, if one attributes it only to a spinning charge with angular momentum $\hbar/2$. Its magnetic moment would have the right value if it corresponded to a charge with angular momentum $\hbar$. To account for this we assumed that the electron circulates in the vortex with velocity c in a direction counter to the spin on the vortex so that the total angular momentum of the vortex and electron in the core is $\hbar/2$, while the magnetic moment has the correct value, since the magnetic moment of the vortex as illustrated by the neutrino has no magnetic moment (at least in a field free region). The core radius we demonstrated should have a value of $\lambda_c = \hbar/mc$ and the electron an angular frequency of $mc^2/\hbar$. These last two results "accidentally" coincide with a prediction of the relativistic Dirac equation, giving a physical interpretation for the predicted "Zitterbewegung" of particles.

Thus, we have plausibly explained spin, the Pauli Exclusion Principle, the magnetic moment of the electron, and Zitterbewegung by simply pursuing where the aether picture leads.

So far we have concentrated solely on the electron-positron component of the aether. Yet we expect that protons and antiprotons and perhaps other particle-antiparticle

pairs may exist, if they are stable. For the sake of argument we will assume that a proton-antiproton $p-\bar{p}$ component exists in the aether. The questions that arise are what fraction of the aether is composed of $p-\bar{p}$, and how is it distributed? In view of the mass difference between electron and proton, if the $p-\bar{p}$ component were uniformly distributed and also had a Fermi velocity equal to the speed of light, Eq. (2) would indicate a density on the order of 10^{10} that of the electron-positron aether. This is contrary to our assumption based upon the energy to create the particle in a hot big bang,[4] that electrons and positrons dominate the aether. An acceptable alternative is that the $p-\bar{p}$ component occurs as condensed separate regions within the electron-positron aether, similar to an emulsion, mimicking the known situation in matter where the nuclear particles are separated from the electrons. The question then remains what are the size and distribution of such regions, and what role do they play in the properties of the aether and other phenomena? The answers to these questions are not obvious, but we can make some suggestions.

First, we would like to keep the number of arbitrary assumptions to a minimum. Since the assumption that spin 1/2 particles were contained within a vortex with angular momentum $\hbar/2$ worked so well for the electron we would like to retain it. But now we can ask what happens if instead of a particle being trapped in the core of the vortex we have a region of $p-\bar{p}$ aether. Since a vortex by itself was a neutrino, which is an excitation of the aether with no mass or charge, this new entity is also a neutrino but of a different type. In the standard model there are thought to be three types of neutrinos,[34] one related to the electron, one related to the muon, and one related to the tau meson. The purpose of the muon which is 208 times the mass of the electron and the tau which is about 17 times heavier than the muon or about 3500 times heavier than the electron remains unexplained in the standard model of fundamental particles. The added feature of the inclusion of regions of $p-\bar{p}$ aether within the core radius of the spin vortex is that these regions by interacting with the electron, could conceivably create the muon and tau meson, but such a pattern is

not obvious at this time. If one takes the neutrino as a vortex in the electron-positron aether, the μ-neutrino as a vortex with mixed electron-positron and $p-\bar{p}$ components, and the τ neutrino as purely a vortex in the $p-\bar{p}$ component of the aether, with the electron within the core giving the particles themselves, one can account for the known situation.

For the proton we propose that the spin vortex is within the $p-\bar{p}$ component of the aether, with the bare proton moving around to give angular momentum $\hbar$ in opposition to the vortex angular momentum. Here, however, since the $p-\bar{p}$ aether is embedded within the electron-positron aether the magnetic moment is not as simple as for the electron case. If we assume that the $p-\bar{p}$ aether has a relatively large dielectric constant compared to that of the electron-positron aether which has a dielectric constant of unity, then the correction term due to the rotating aether is no longer small, and one can account for the proton g-factor. In the standard model the proton g-factor comes from a similar source, only there it is said to be due to "vacuum fluctuations of the pion field and other fields of strongly interacting particles."(41)

It is apparent that given the complexity of the field of elementary particles, with 3 leptons (electron, muon, and tau) with mass, and their 3 massless neutrinos, plus 3 sets of quarks, and their antiparticles, and all the particles that can be constructed from the quarks, that one person working with a new theory is not instantaneously going to account for all the known phenomena. However, the aether model provides a possible means of doing so that avoids multi-dimensional spaces that can't be visualized.(42)

7. Relativity and the Aether

Relativity is one of the areas of physics which was instrumental in the demise of the traditional aether, and is also one which could benefit most from a plausible aether. Among the questions that an aether can hope to answer for Relativity are: why is the speed of light

the same in all frames of reference? what determines the speed of light? what causes the apparent increase in mass as an object approaches the speed of light? what causes the time dilation and space contraction in moving systems? and how can Relativity and Quantum Mechanics be reconciled? The last question has remained as the outstanding problem in theoretical physics for the past seven decades.

In our opinion Relativity and Quantum Mechanics, despite their apparent attention to measurements and definitions of measurements, are both ill-defined fields. Their common failing is the lack of a medium in which the particles they hope to describe move. Thus Quantum Mechanics has a wavefunction that is a probability amplitude in an abstract Hilbert space, and Relativity has an abstract curved space-time. Neither of these spaces is based upon a "real" world. We have already discussed how we believe Quantum Mechanics should be modified, namely that the wavefunction should be viewed as a disturbance in the aether caused by the motion or presence of particles or objects. For relativity the procedure will be similar. Observers and objects move through the aether which is a real medium. In some experiments the aether is pulled along and in other cases it is not. Hence, in contrast to the predictions of Relativity, it should be possible to detect the aether, by using the proposed Laser Interference Gravitational Observatory (LIGO), and perhaps other tests as well.

In many of the elementary discussions of Relativity[6] and in deriving the space and time relations, light beams are designated which give misleading results. In one of the classic derivations, a moving train has a light beam, which to an observer on the train travels vertically to a mirror which reflects it back to the source. To a "stationary" observer on the ground, the light beam is seen as traveling at an angle striking the mirror and being reflected at an angle back to the source which has now moved with the train a distance $d = vt$, in the time it took the light to make the round trip. The fallacy in this

experiment is in the nature of the light beam which is assumed to spread in all directions. If one were to do the experiment with a well collimated vertical beam with a small mirror, then if the light doesn't have a component of velocity in the direction of the train's motion it will miss the mirror and not be reflected. If the train is in fact stationary then the beam is indeed vertical. However, an observer moving relative to the train in either case will see the beam make an angle to the vertical. Contrary to relativity, we claim that these situations are quite different, and a careful analysis will either show that relativity is wrong or deduce a physical condition that the aether must satisfy.

Consider a stationary train and a moving observer, whether there is a light source or simply a rod with a light at its tip that moves vertically upward and then stops and moves down, the moving observer will "see" the lighted tip moving at an angle to the vertical. Clearly in the case of the rod, only vertical motion occurs and the horizontal component of its velocity is an "illusion" caused by the motion of the observer. For a moving train and a stationary observer things are a little more complex. The example of a light source and the rising vertical rod with a light at its end are now not necessarily equivalent. For the rod, since its carried along with the train, the tip has both a vertical and a horizontal component which the stationary observer will correctly "see", while the observer on the train will only "see" the vertically moving rod just as when the train was stationary. For an actual light beam or a single photon, two situations, at least, can occur. The first is that by virtue of the train's motion, as it is emitted the photon has a component of velocity in the direction of the train that is independent of its vertical component, so that it can travel vertically with velocity c and simultaneously with any velocity v in the horizontal direction. This would mean that its actual velocity exceeded c. This case would correspond to the tip of the rod case discussed above. A second possibility is that the photon emitted is limited to velocity c, and hence, when the observer on the train orients the beam to appear vertical, it actually has a horizontal component as well, and thus a velocity less than c in the vertical direction.

These are the only possibilities in the absence of an aether and neither one corresponds to Einstein's assertion that both observers should be able to measure the velocity of the light beam to be c, since in the first case the observer on the train would measure c, and the stationary observer would measure a velocity greater than c, and in the second case the observer on the train would find a smaller velocity than c. This analysis assumes "time" is the same for both observers and so is distance. In Relativity these assumptions are discarded.

When an aether is present and the train is moving, additional possibilities arise. If c is the velocity of light relative to its local aether, then for the moving train one can ask whether the train is "open" or "closed" with respect to the aether, in analogy with an open or closed train in air, i.e. does the train carry the aether with it, or does the aether flow through it, the way air would for an open train. If the train is "closed" and carries the aether with it, then a photon traveling vertically will also have the local aether velocity imposed upon it similar to the first case mentioned above or the tip of the vertically moving rod. For the stationary observer a velocity greater than c should be measured. For the "open" train the aether is stationary for both observers, the photon doesn't acquire the train's velocity from the aether and we appear to have case two again. However, there is another possibility that since the atom emitting the photon is moving with respect to the aether the emitted photon will have this added velocity in addition to its propagation velocity c. This would take us back to the first case again. The stationary train and moving observer with an aether, raises the issues of the state of the aether for the observer, and how the moving observer "sees" what is happening on the train. As the vertical rod's illuminated tip illustrated, the moving observer is mistaken in attributing a lateral motion to the photon.

If one analyzes the length measurement which purportedly "derives" the Lorentz contraction[6] similar fallacious arguments are found. They are most readily seen when the bar is stationary and the observer is moving, i.e., the moving observer perceives that the light has traveled a greater distance, when in fact the observer has moved an additional distance, while the light was in flight.

If the standard derivations are in fact faulty for relativity, what is its content and why has it apparently been successful in predicting experimentally verified results? In terms of the aether model we have no general picture such as for Quantum Mechanics, that allows us to take the whole theory as correct subject to a reinterpretation of some concept in the theory. Hence, we must consider separately the various mathematical and conceptual aspects of relativity and see how and if they can fit into the aether model.

Conceptionally the expanding aether can replace an expanding space-time, so that warping of space-time to visualize the effects of gravity or other forces can be transferred to the aether model. The increase of inertial mass as a particle's speed increases can likewise be visualized in the aether model as due to the inability of the aether particles to move fast enough to get out of the way of a speeding particle. (Deriving the standard form found from relativity is not easily accomplished). The concepts of the dilation of time and the Lorentz contraction of space in a moving reference frame do not seem to emerge as a natural consequence, so far, from the aether picture. The constancy of the speed of light in all reference frames would follow only if one assumes that the aether is not dragged along by any object. If one assumes that only an extremely small displacement of the aether is produced by an object, i.e., primarily the nuclear particles which comprise roughly 10^{-12} of the volume of the atom, then no aether drag would occur for most objects. However, massive bodies would have a region of aether moving with them, the thickness of which depends upon the precise displacement factor. For the earth, if the displacement factor is

indeed only 10^{-12}, then a "skin" of aether on the order of a few microns would move with the earth. However, if the polarized aether region between the positively charged nucleus of atoms and their electrons is dragged along, and/or the vortices in the aether, which comprise the spin of the particles, are dragged along, then the displacement factor can become on the order of unity, and a region of thickness on the order of the radius of the earth could be dragged along.(6)

Hence, depending upon whether the aether is dragged along with the earth or not, the Michelson-Morely experimental results agree or disagree with the aether model respectively.(6)

Yet there are supposedly experiments that show the time dilation. In particular, the decay time of unstable particles in their "rest frame" is much shorter than that observed in the laboratory frame of reference. Since the "cause" of the decay of particles may indeed be affected by the impact of aether particles as the particle moves through the aether, a change in lifetime may be a real phenomenon. However, for two observers to note the "same" event and one to say my clock says it took x seconds, and the other to say it took x multiplied by some factor seconds, has no physical content, unless one proposes a mechanism for how the aether affects the aging process or clock mechanisms. What is missing from Relativity is any rationale for why nature should behave the way it does. What is missing as yet from our aether model is the derivation of the equations of Relativity from the basic properties of the aether. Despite this failing of the aether picture, it at least allows one to pursue a deeper level of nature, rather than to simply state that that's the way nature behaves and don't ask "meaningless" questions.

One can view Relativity as in some sense similar to thermodynamics before the advent of the kinetic theory and statistical mechanics. Globally true statements can be

deduced, but detailed mechanisms are lacking. The equivalence of mass and energy arises in Relativity from several points of view. In our aether model the energy levels discussed in Eq. (3) explicitly used this and we will return to it in section 8a.

We have stated that it should be possible to test whether the aether is present. If one considers a long evacuated tube such as those proposed for the LIGO (Laser Interference Gravitational Observatory) experiments, where several 4 km tubes are under construction, and if sections of their walls were moveable, then the following experiment could be carried out: With two laser beams being bounced back and forth within the evacuated tube and interfering to show optical path differences, "compress" the aether in one of those paths by suddenly moving the walls in. With a higher aether density the speed of light increases, and hence an imbalance in the two paths should be recorded. The sensitivity of the method is such that even with a 10^{-12} displacement factor the effect should be easily observed. In addition the LIGO apparatus can easily measure the speed of light to very high accuracy. Since our model predicts that c is changing with time according to Eqn (4), we can see that its present rate of change is: $\dot{c} = -c_0/2t_0$, where c_0 is the present speed of light and t_0 the time since the big bang. ($t_0 \sim 10^{10}$ years). Hence c is changing by about 1 part in 10^{10} per year, and depending upon the accuracy of the LIGO (or any other) determination of c, the accumulated change in c should be seen after an appropriate time.

8. Miscellaneous Effects - Speculations

a) Energy and particle production in the early universe and inflation

We have shown in section 3 that at present the expanding aether has a fixed number of particles N_0, but that a period of particle production preceded this and caused the universe to expand exponentially, a process that is referred

to in the standard theories as inflation.[4] We have also pointed out that in the aether the particles and anti-particles due to mutual interactions or "correlation energy" are in an energy state lower than the null state or true vacuum. Here we will expand upon these points, and speculate on some of the consequences that are implied.

If we maintain that the aether has a total energy below that of the true vacuum, where has the energy released in forming the aether gone? One place that it has gone, is into the cosmic background radiation[4, 43] (CBR) which has a mean temperature of about 2.7°K. However, we propose that in addition to CBR the aether's total negative energy equals the positive energy of the universe. We can envision the process by noting that photons require the aether to propagate. Hence, when particles and antiparticles were created in the big-bang, if they recombined to give γ-rays, the γ-rays would not have been able to propagate away, and one would expect the energy released could help create additional particles and anti-particles. Since the big-bang itself is unknowable at present, we will shift to a time shortly after t = 0, and assume that an aether has formed but the initial spark that initiated the process has disappeared leaving a hot region that continues to generate particles and anti-particles. If the mean free path for recombination (annihilation) is less than the radius of the aether, the particles will generate γ-rays and other decay products. But since the γ-rays are reflected at the boundary of the expanding aether they return to the central region. With the aether at a lower energy than the null state, the energy content of the γ-rays emitted exceeds the energy needed to generate the particles that gave rise to the γ-rays. This is an exothermic reaction which releases energy, which then generates more reactants. This "chain

reaction" can proceed until the expansion of the aether lowers the temperature of the production region below that needed to generate electron-positron pairs. The time during which particle production dominates we called "inflation" and Eqs. (15-17) controlled the evolution of the aether. Given that the density of the aether prior to time t_i and radius R_i, was much greater than the present value, the negative energy per aether particle pair was much greater, as was the speed of light. Hence the "energy gain" per cycle could have been very high with a rapid build-up of positive energy in particles and radiation, as the energy of the aether became more negative.

After particle production ceased the aether continued to expand, since its particles have intrinsic velocities due to Fermi-Dirac statistics. As the aether expands its density decreases, which lowers the kinetic energy, but an increase in the drift velocity occurs (Hubble's law), and simultaneously a smaller negative correlation energy in the aether as the density decreases. What is unknown in our picture is the "true" annihilation energy of particles. Our energy diagram discussed in section 2, would determine an absolute zero of energy corresponding to the null state or true vacuum. The energy mc^2 in our aether picture simply corresponds to the condensation energy into the present aether, but as we have demonstrated c depends upon the density of the aether, and m may also. From Eq. (2) the density of the aether is proportional to $(mc/\hbar)^3$ and changes with time. Hence the ratio $mc/\hbar$ changes with time. Since at this juncture we have no clear origin for mass nor for $\hbar$, their dependence on aether density remains unsettled. One can obtain a reasonably consistent picture as we have done so far by treating m and $\hbar$ as true constants. This is supported somewhat by noting that, if angular momentum is conserved as the aether expands, then with the

angular momentum of an electron in the core of a vortex given by $mcr_c = \hbar$, $\hbar$ is a constant. We expect r_c to vary with r_1 $\left(n = 3/(4\pi r_1^3) \right)$ so that mcr_1 is also a constant from Eq.(2). This still allows m to vary as well but we have no explicit indication of this. The issue of variation of the fine structure constant over time based on the occurrence of a natural fission reaction is treated in reference 14, where a limit for a change of less than one part in 10^7 in 2×10^9 years is obtained.

To return to the importance of the null energy level, we note that the net energy of the universe in our model is essentially zero relative to this null energy. The particle's rest mass energy, the CBR and anything else with positive energy is pictured as a result of the inflationary period that created the negative energy aether. The negative energy of the aether stems from its density dependent correlation energy and coulomb energy. Hence as the aether expands the magnitude of its negative energy decreases, and so does the positive energy of particles, since mc^2 decreases as c decreases. This leads to the possibility that at some future time the universe will simply fade away as $c \rightarrow 0$, as the density of the aether goes to zero. A more catastrophic end might occur at a density of the aether at which it is no longer at a negative energy relative to the null state, and the aether disappears. The critical density at which this occurs is important because it defines not only when the aether ceases to exist, but also when the aether comes into existence during the start of the universe. While theories of dense Fermi fluids exist, the correlation energy is not one of the properties that is easily obtained. Hence, even an estimate of such a critical density, n_c

is not possible. However, it is certainly greater than the value of $10^{23}/cm^3$ seen in metals. Since the critical time, t_c, is related to the present density n_o and age of the universe, t_o, by $t_c = t_o \left(n_0 / n_c \right)^{1/3}$, unless we are very close to n_c, this is not an imminent worry. Hence, if n_c were a factor of 10 lower than n_o, the universe would last to at least twice its present age.

If we accept as plausible the scenario that the net energy of the universe is essentially zero, then the barrier to creating the universe is low. We may then contemplate that there have been and continue to be mini big-bangs (MBB) outside of our expanding universe. The reason for stipulating that they occur outside our universe is that the inflationary period requires that the γ-rays be trapped and recycled. If a "spark" occurred in a region with an aether present already the "photon recycling" mechanism would not be operative, since the γ-rays would escape through the existing aether. Without the exothermic process, the "spark" is quickly extinguished with no trace. Is there any evidence for such mini big-bangs? Yes. We will discuss several phenomena which may be evidence for MBBs, γ-ray bursters, blackholes, and anomalous redshifts.

b) Gamma-ray bursters

At a rate of one or two events per day, sources of high energy γ-rays are detected by satellite instruments.[44] The γ-rays last for time periods ranging from seconds to hours, appear to come from sources in random directions, and recent data seems to confirm that the sources are at distances near the edge of our universe.[45, 46] The intensity of these γ-rays is such

that if theenergy detected had been radiated in all directions, the integrated energy would be comparable to the total energy of the big-bang.[47]

Given the picture we have presented of the early universe with γ-rays trapped by the limited extent of the aether, consider what would have happened had our universe expanded and contacted a pre-existing region of aether. The γ-rays would be transmitted into the region of aether emptying the universe of radiation in a time on the order of R(t)/c(t), where R(t) is the radius of the universe at a time t after the big-gang, and c(t) the speed of light at that time. Since it is unlikely that the densities of the aethers would be identical at the time of intersection, one would expect a reflection coefficient at the interface which would send the γ-rays on additional trips around the universe extending the duration of the γ-ray burst. If the universe had been in the inflationary stage, any further development would have ceased once the recycling of the γ-rays was no longer possible. Depending upon the stage of the universe's development other radiation (x-rays, optical, microwave) would have been present and also would have been vented at contact.

What the recent well-documented γ-burst has shown is that the initial burst of γ-rays decayed within hours, followed by longer wavelength radiation that continued for days.[45,46] The slow arrival of the longer radiation is what one would expect due to the dispersion in the index of refraction of the interstellar medium. Since the speed of light in a medium depends upon its index of refraction, and the longer the wavelength the slower the speed, a few days delay in a trip that took on the order of 10^9 years amounts to a one

part in 10^{12} difference in index of refraction between γ-rays and optical radiation. This is consistent with what one would expect in the very tenuous interstellar medium. The explanations offered so far by conventional theories is that a neutron star or other explosion occurred giving the γ-rays, followed later by a fireball, that generated the optical radiation.[44] The conventional explanation doesn't account for the initial γ-rays in any detail, i.e., the time scale, and has a separate explanation for the longer wavelength radiation, while our explanation is detailed and self contained.

Based upon the picture above we propose that the γ-burster's are evidence that MBBs exist and are constantly being incorporated into our universe. Does this picture imply any other observable consequences? Yes, the existence of blackholes.

c) Blackholes, mini big-bangs, and galaxy formation

One of the tenets of modern cosmology is, that at the center of the big-bang there must be a singularity.[48] By a singularity is meant a point or region where conventional physical laws are no longer valid, and what occurs is unknown. Another entity that is believed to have a singularity at its center is a blackhole.[49, 50] Blackholes are thought to be objects with sufficient mass packed into such a small region that their gravitational attraction prevents even light from escaping. While the big-bang and blackholes have postulated singularities, we should remember that electrons and protons have singularities also, if something doesn't give them a finite radius. Given our picture of MBBs being incorporated into our universe, one can ask what happened to the singularities associated with them? A simple

answer is that they are still present and constitute the singularities in blackholes.

One of the speculations in present cosmological theories is that there is a blackhole present at the center of each galaxy.[51] No specific reason for this is given. A problem in cosmology is that there is no simple model that gives the distribution of galaxies in the universe. The reasoning is that there must have been some precursor inhomogeneties that gave rise to the galaxies. Hence in the studies of the CBR, variations were sought that would trace the structure back to the time before matter and radiation decoupled.[43] Such inhomgeneities are not needed if blackholes act as nuclei for the galaxies attracting stars around them, and have been incorporated into our universe at random times and places since the "beginning." The quotation marks on the word are to indicate that we have no criteria for determining the age of the universe.

d) The age of the universe and a possible steady state cosmology.

In cosmology the theories have alternated between the big-bang picture and possible steady state models. Einstein had originally thought that only a static universe was possible and even added an ad hoc constant to his relativistic field equations, the so called cosmological constant, so that this could be true.[4] When Hubble's law was discovered, and time dependent solutions to Einstein's equations were found, the world view shifted toward the big-bang model. The counter movement toward a steady-state universe around 1950 gained support for a while, but current evidence and theories have placed the big-bang model in the ascendancy again.[4]

We have, so far, explicitly embraced the big-bang picture of cosmology. In our local part of the universe which includes as far as our instruments can see, there seems to be an expansion of our big-bang. However, if we take the MBB picture seriously then we are constantly incorporating new supplies of aether and matter into our universe. If our big-bang is not unique then neither is the origin of time. Eventually as our universe expands it should encounter a larger "older" big-bang with galaxies older than the time since our local big-bang. This may already have happened. Repeatedly in the history of cosmology there have been inconsistencies where the then accepted time since our big-bang, appeared to be less than the age of some feature dated by accepted techniques. In each case the age of the universe has been increased and the discrepancy removed. At present the accepted age of the universe (the time since our big-bang) is 10-15 billion years, and there are structures which are believed to be at least that age. Hence the conventional picture continues to teeter on the edge of believability.

We thus propose that the universe is essentially in steady-state, but big-bangs occur which initiate the growth of an aether and matter which expand and link with other big-bangs and incorporate mini-big bangs. Eventually these regions expand to the point that the aether fades away or its density reaches a critical value and that part of the universe reverts to a true vacuum. Since the big-bang can only grow in the presence of the true vacuum, that part of the universe can restart the process. The singularities that start the big-bangs or MBBs are unknown at present. The process resembles the regrowth of areas after a major forest fire, where long dormant seeds suddenly sprout. It may be that the singularities are "immortal," and survive the destruction of the aether to restart the process. Obviously in

such a picture of the universe there is no big crunch and no missing dark matter.

e) Redshifts and Anomalous Redshifts

Earlier we had expressed misgivings about the accepted explanation of the cosmological redshifts and blueshifts seen in light from distant sources. The accepted explanation for the blue shift, which is rarely seen, is that it is the Doppler shift due to the relative velocity of an approaching source. In sound an approaching sound source has a higher frequency and a receding one a lower frequency. For light the issue is more complex, since the frequency of a photon is directly related to its energy through $E = h\nu$. Hence, if a photon leaves a source with energy E_s, and travels through a vacuum with no interactions, how does its energy increase or decrease based upon the motion of the receiver? For the redshift, the expansion of the universe is the supposed cause, but the explanations are postulatedrather than proved, since the Doppler effect and Relativity are invokedwithout critical evaluation of whether they are in fact applicable. Since others have also found the standard explanation of the redshift unconvincing, suggestions that the mass of the electron, in distant galaxies might be different have been made.[52] Our aether model lends itself to an alternate picture of the origin of the redshift. Indeed there are several possible causes for the redshift that emerge from our model.

i) We have indicated that the speed of light changes with time due to the expansion of the aether, with the subsequent decrease in its density and consequently a decrease in its Fermi velocity (Eq. (2)) which we have assumed is the value of c(t). Light which is reaching earth now was emitted

at earlier times when c(t) and perhaps other physical constants m and e had different values. The more distant the light source, the earlier in time its light was emitted, and the greater the difference in physical constants from our values it would be expected to have. Since in the hydrogen atom the emitted photon's energy depend upon the constants as:

$$E = \frac{me^4}{8 \in_0^2 h^2} \tag{36}$$

where $\in_0^{-1} = \mu_0 c^2$, the emitted photons would have longer wavelengths from distant sources as long as the combination of constants was smaller in the past. Since, Hubble's law as derived from the aether model shows more distant sources moving with higher velocity (assuming the galaxies are carried along with the expanding aether), one would have the ingredients for a consistent explanation for the observed redshifts, although not a numerical agreement, since the time dependences of m and e, if any, are not yet known[14].

ii) The mini-big-bang picture raises the possibility that there are and were regions that have an aether that is not yet in equilibrium with the aether that originated in our big-bang. These regions would have physical constants differing from those expected at a given distance, since the origin in time and space of a MBB is different than for our big-bang. Hence, the redshift from such a region would differ from its neighbors at equal distances from the earth. Anomalous redshifts of this nature have been reported.[52] Indeed discrete or quantum differences in the redshifts from neighboring galaxies have been found.[52,53] The aether model with the redshift due to the physical constants being different rather than velocity or the expansion

controlling the wavelength, can account for such phenomena more readily than the standard picture of cosmology.

iii) The third explanation for the redshift that the aether model allows, is as mentioned earlier, that as the photons travel through the aether they lose energy to the disturbance that they create as they move. This allows the "particle" part of the photon to remain localized on the scale of the atom, while the accompanying wave disturbance can extend over a region meters in diameter. Thus, light from distant stars can show interference effects with lenses or mirrors meters apart,[26] and still produce a photoelectric effect or a chemical reaction in a photographic material at the atomic scale.

f) The arrow of time -

In the area of irreversible statistical mechanics, a question remains as to the reason for the apparent irreversibility of physical and chemical phenomena, since both the classical and quantum laws of physics seem to be symmetric in time.[54] The problem is often associated with the statistical observation that entropy increases in all natural processes.[54] The aether model gives a natural direction to time through the fact that as the aether expands, the speed of light and perhaps other constants are changed monotonically. Hence, at a later time the universe has changed, and in reversing a process one has a different set of physical constants to deal with, as well as propagating disturbances in the aether, which means that reversing a process to restore the identical conditions which prevailed previously, is literally impossible.

g) Planck's Constant -

One of our hopes in developing the aether model was to obtain a relationships among the physical constants. In particular, Planck's constant which is the fundamental constant in Quantum Mechanics is key. It appears in a number of interrelated ways:

i) In the deBroglie relation $\lambda p = h$

ii) In Schrodinger's Equation (Eq(18))

iii) The Heisenberg uncertainty relations $\left(\Delta x \, \Delta p_x \geq \hbar/2\right)$

iv) Spin angular momentum $\left(\hbar/2\right)$

v) Orbital angular momentum $\left(\text{units of } \hbar\right)$ and photon angular momentum

vi) In quantum statistical mechanics as the smallest volume in phase space (h^3)

vii) Quantized energies ($E = h\nu$)

In our expression for the speed of light Eq. (2), we have used the quantum theory and hence h appears immediately without any prior definition. The intrinsic spin angular momentum of $\hbar/2$ has been identified with a vortex in the aether. Hence, if we could calculate simply the angular momentum of a vortex perhaps the relation between $\hbar$ and the aether density could be established. Likewise we have identified the photon to be a rotating polarized region of aether with angular momentum $\hbar$ and energy $\hbar\omega$. The common thread in all of these appearances of h is the variation scale of the aether. Thus, in the Schrodinger Equation $\hbar$ multiplies the gradient of the wavefunction to give a momentum. An alternate view is to say the

momentum of a particle generates a disturbance in the aether, with a spatial variation such that $\hbar \nabla \psi \approx p$. This is basically the content of the deBroglie relation which identifies the gradient of ψ with the wavelength of the disturbance i.e. $\nabla \psi \approx k = 2\pi/\lambda$.

Thus, the momentum of a particle creates a disturbance on the scale of h/p in the aether. As we have seen there are "pores" in the aether with a size on the order of $r_c = \lambda_c = \hbar/mc$ and spacing on the order of $r_1 = 1.92\ r_c = 1.92\ \lambda_c$. This would give a "natural" gradient in the particle density on the order of λ_c^{-1} and a "natural" momentum on the scale of mc. Indeed, the momentum of the particles in the aether that can move at the Fermi surface, is mc. The variation in ψ due to a particle of momentum p can be viewed as if the particle were stationary and the aether streaming by with velocity v. There exists a vortex around the particle with a coherent velocity that extends many times r_c (3.84×10^{-11} cm). It is interesting to note that the ratio of r_c to a_b the Bohr radius is exactly the fine structure constant $\alpha = e^2/4\pi \in_0 \hbar c = 1/137.036$.

It is likely that the vortex patterns that extend out from the electron and the proton together determine the appearance of h or $\hbar$ in all the situations indicted above.

Thus, the use of $h/m = K$ the circulation of spin $1/2$ vortices, is the ultimate source of the appearance of Planck's constant in physics. This in turn came from the pore size or core size of the vortex in the aether, which is tied to

the density of the aether, which changes with time as the aether expands. We had earlier speculated that if angular momentum were conserved as the aether expands then $\hbar$ could remain constant with time (Section 8a). This would mean that $\hbar$ is set by factors not contained within the aether model. This is also the situation for the particle masses, although we will discuss mass below.

The uncertainty principle can be viewed for Fermions at least, in terms of the spin vortex around the center or "position" of the particle, the closer one comes to the center the higher the aether velocity, and the stronger the interaction with any probe that is present there, and the larger the change in momentum the particle will sustain. The faster a top spins the greater its rebound in touching a wall or other obstacle. The fact that $\Delta x \, \Delta p \geq \hbar/2$ and the spin angular momentum is $\hbar/2$, may not be a coincidence.

The orbital angular momentum of electrons in atoms is given by n $\hbar$ in the Bohr model for stationary states. If we note that the moving electron and its aether vortex will cause a disturbance in the aether along the path of the electron, that for steady state should smoothly mesh with the spin vortex, we have a criterion for why only certain stationary orbits are permitted.

h) Mass and Charge

These concepts are at the heart of all substance and yet remain unexplained in all theories. The fact that there are three charged leptons with different masses, the electron, the muon, and the tau meson, and that these also have different neutrinos associated with them still lie outside of the standard model of particle physics. From the point of view of our aether model

where the neutrino is a vortex in the aether, there may be a way to account for three different neutrinos, and perhaps the three different masses for the charged leptons.

We have maintained that the aether is primarily composed of electrons and positrons in a bound Fermion fluid, but that embedded within the electron-positron aether are inclusions of a proton-antiproton fluid or other baryons. The three types of neutrinos can be visualized as follows: the electron neutrino is a vortex in the electron-positron component of the aether; the muon neutrino is a vortex with a region of proton and anti-proton aether in its core, and the tau meson neutrino is a vortex entirely within a region of proton and anti-proton aether.

Having proposed this for the associated neutrinos, what constitutes the "particles". In solids, electrons have different effective masses based upon the band structure of the material and the chemical constituents. An electron in an ionic material polarizes a region around it, thus distorting the lattice. Hence, when it moves it has a high inertial mass[13], because the polarization must move with it. This polaron idea can be carried over into the masses of the elementary particles. Thus, for the electron we can picture a "bare" electron within a vortex core of the electron-positron aether giving us m_e the observed electron mass, while the same bare electron within a vortex consisting of both electron and positron and proton and anti-proton aether gives the mass of the muon. When the bare electron is within the vortex of protons and anti-protons, it gives the tau meson mass.

While this picture would give some systematics to the lepton masses, if we could calculate the masses m_e, m_μ, m_τ, from some simple equation, it would still not tell us what the bare mass is numerically or what mass is conceptually. In addition, all the particles that have mass also have charge or like the neutron can be considered to be composed of charged particles. Hence, we also need to consider the nature of charge and why there is a single unit of charge observed (the quarks have charges of $\frac{2}{3}$ and $-\frac{1}{3}$ of the electronic charge, but are not directly observable.) The existence of charge is known through the fact that a charge has an electric field, around it, a moving charge creates a magnetic field as well, and an accelerating charge emits electro-magnetic radiation. The effects produced by these fields or radiation are readily detected with appropriate instruments.

The fact that charge and mass seem to be closely connected, and that Eq. (1) is often used to define a cutoff radius to the charge distribution by equating the field energy associated with the charge to the rest mass energy of the particle, shows the close relationship envisioned in standard physics. Since most of the field energy occurs at very small distances, even the neutron with no long range field could also be treated this way. However, mass and charge are generally believed to be separate concepts and have different origins, i.e., while the electron and proton have equal and opposite charges, or positron and proton have identical charge, their masses differ by a factor of nearly 2,000. If we followed the logic of Eq(1) a cutoff radius 2,000 times smaller would be required for the proton (and neutron). Indeed we have asserted that the vortex core radius for the proton is smaller i.e. the Compton wavelength of the proton $\lambda_p = \hbar / M_p C$. However, this cutoff

doesn't coincide with the "classical" radius needed when field energy is set equal to rest mass. Hence, if the concept of the field energy equaling the rest mass energy were true, we would be forced to introduce artificially the "classical" radius.

While charge and mass are undoubtedly closely linked, even if we subscribed to the rest mass being equal to the field energy concept, the unique value of the electronic charge (1.6×10^{-19} Coulomb) still remains to be accounted for, and also the difference in rest mass for electron (positron) and proton. Our two component aether model (electron-positron, with proton-antiproton inclusions) also envisions that at least two distinct entities exist. Hence at this stage in the evolution of the aether model the charge and mass of the electron and proton must be considered to arise from an even more basic model, which has yet to be devised. Of course this same issue is also unresolved in the standard model of particle physics.

i) The collapse of the wavefunction[20]

In Quantum Mechanics a long standing problem has been that in systems in superposition states, where the expectation value of some measurable quantity is a weighted average of eigenstate values, when the measurement is made, one of the eigenvalues occurs. The question is what determines which eigenvalue will occur? This question is often referred to as the collapse of the wavefunction. The question is in what state was the system prior to the measurement? Can the aether model resolve this issue? It can at least provide some insight.

In the aether model a particle has a definite position and produces a disturbance pattern in the aether. The particle and its disturbance (or wave function) are an entity which in Quantum Mechanics replaces the particle concept. In the process of making a measurement the particle and its wavefunction must interact with the measuring apparatus in some way. One could view the wavefunction as the particle's "feelers", similar to antennae on insects or whiskers on animals, that interacts with the surroundings and acts back on the particle to direct its motion or other properties. The "measurement" forces the particle to choose a definite position or state, in the same way a roulette wheel in stopping forces the ball to pick a definite number. Prior to coming to rest the ball was not in a particular slot, it was traveling around passing all the possible numbers until it used up its kinetic energy by bouncing in and out of the slots before coming to rest in one of them. The wavefunction as modified by the interaction with the measuring apparatus, and acting back on the particle (or quantum system) determines the final measured state of the particle.

9. Summary and Conclusions

In this work we have replaced the abstract aether of the nineteenth century with a specific fluid composed primarily of electrons and positrons in a negative energy state relative to the null state. We have thus replied to the Einstein and Infeld[1] objection to a mechanical view of the universe. This model of the aether allows insights into many phenomena in physics and cosmology for which conventional theory provides no answers or unsatisfactory answers. Among the most interesting results are:

i) wave-particle duality (the particle creates a disturbance in the aether which travels with the particle while interacting with the environment and back upon the particle);

ii) spin (a vortex in the aether);

iii) electric field (polarization of the aether);

iv) Zitterbewegung (bare particle orbits within the core of the spin vortex);

v) Hubble's law (solution of the continuity equation for the expanding aether, yields an outflow velocity proportional to distance);

vi) Inflation (solution of the continuity equation for the aether during the period of particle production, yields an exponential growth to the radius of the aether);

vii) the arrow of time (due to the expansion of the aether the speed of light changes with time and perhaps also some of the other fundamental constants, changing the universe monatonically with time, and removing the seeming reversibility in time of Newton's, Maxwell's, and Schrodinger's equations);

viii) Pauli exclusion principle (repulsive interaction between parallel spin vortices keeps Fermions apart);

ix) Photon (a region of rotating polarized aether propagating through the aether with a screw-like motion, with lateral extent on the order of atomic dimensions, and accompanied by an additional disturbance in the aether analogous to the wavefunction associated with particles);

x) redshift (the shift to longer wavelengths in the light from distant sources is attributed to three non-standard causes: different physical constants at the time the light was emitted due to the earlier stage of the universe, or due to the aether in that region of the universe originating in a different big-bang

than ours; and loss of energy of the photon to its expanding aether disturbance mentioned in ix above.)

Other important results include the mechanism by which the aether is formed, which can explain the source of energy and matter in our universe, and the likelihood that other mini-big-bangs (MBBs) have occurred and continue to occur outside our expanding universe. We have also speculated that evidence for such MBBs is in the γ bursters that are observed to occur at the rate of about one per day, and that the remnants of these MBBS that have been incorporated into our universe are the singularities associated with black holes, which have then attracted galaxies around them. Mass, charge, Planck's constant, relativity, the three types of neutrinos, the magnetic moments of electrons and protons, possible models for muon and τ meson masses, and the collapse of the wavefunctions in Quantum Mechanics were also discussed.

While our treatment of the various topics is quite uneven, with quantitative results in some and qualitative results and speculation for others, the aether model proposed enables one to pose questions and answer them in ways that are unaccessible in the presently accepted picture of the universe.

It is unlikely that all the features of the model and all our speculations will turn out to be correct on closer examination. However, the approach reopens a mode of thinking that has been largely prohibited for the past century. From our results it appears to be a fruitful approach.

References and Endnotes

1. A Einstein and L. Infeld, "*The Evolution of Physics*" (Simon and Schuster, N.Y. 1951) P126.
2. P.A.M. Dirac, Nature 168, 906 (1951).
3. P.A.M. Dirac, Proc. Roy Soc. A209, 291 (1951)
4. P.J.E. Peebles "*Principles of Physical Cosmology*" (Princeton University Press, Princieton, N.J. 1993.)
5. C.D. Jefferies and L.V. Keldysh, "*Electron-Hole Droplets in Semiconductors*", (North Holland-Amsterdam 1983.)
6. W.K.H. Panofsky and M. Phillips, "*Classical Electricity and Magnetism*", (Addison-Wesley Pub. Co. Inc. Reading, MA 1955;) P 164, 271, 315, 300.
7. I. Ciufolini and J. A. Wheeler, "*Gravitation and Inertia*", (Princeton University Press, Princeton, N.J. 1995,) P218.
8. D. Z. Albert, "Bohm's alternative to Quantum Mechanics", Scientific American, May 1994, P58. S. Goldstein, "Quantum Theory without observers" Physics Today Vol. 51, No. 3, 42; No. 4, 38 (1998).
9. J.S. Bell, "*Speakable and Unspeakable in Quantum Mechanics*" (Cambridge University Press 1987.)
10. D. Bohm, Phys. Rev. 85, 166 (1952); 85, 180 (1952); 89, 1458 (1953).
11. C. Kittel, "*Introduction to Solid State Physics*" 5th ed. (John Wiley & Sons, Inc., New York 1976.)
12. K.P. Sinha, E.C.G. Suarshan, and J.P. Vigier, Phys. Lett. 114A, 298 (1986): F. M. Meno Physics Essays 4, 94 (1991); 7, 450 (1994). 8, 245(1995); 10, 304 (1997); and http://www.neuronet.pitt.edu/~meno/ Aether Theories A collection of Scientific Theories of the aether http://magna.com.au/~prfbrown/aether.html.
13. C. Kittel, "*Quantum Theory of Solids*", (John Wiley & Sons, Inc. 1963,) P144.

14. P.A.M. Dirac, Nature, 139, 323 (1937). Proc. Roy Soc. A165, 199 (1938). Recently Dyson has summarized the evidence on whether the fundamental constants have varied with time in the paper T. Damour and F. Dyson, Nuclear Physics B480, 37 (1996).

15. P. Coles and F. Lucchin, "*Cosmology*" (Wiley & Sons 1995,) P53, 35.

16. In condensed matter physics processes with $\beta = 1$, 2 and 3 occur.

17. The choice of $\beta = 1$ is to keep the calculations simple, $\beta = 2$ or 3 are more likely at the densities involved.

18. A. Guth and P. Steinhardt, "*The Inflationary Universe*" (Scientific American, Jan 1990,) P 116.

19. W. Moore, "*Schrodinger life and thought*", (Cambridge University Press, Cambridge,) 1989, P 256.

20. D. J. Griffiths, "*Introduction to Quantum Mechanics*" (Prentice Hall, Englewood Cliffs, N.J. 1995,) P1, 45, 155.

21. Phillip R. Wallace, "*Paradox Lost-Images of the Quantum*", (Springer 1996.)

22. A. Einstein, Ann d. Physik 17, 549 (1905)

23. G. E. Uhlenbeck and L. S. Ornstein, Phys. Rev. 36, 823 (1930).

24. See for instance G. Joos "*Theoretical Physics*", (G. E. Stechert & Co. N. Y., 1934,) P 189, P 566.

25. G. Baym, "*Lectures on Quantum Mechanics*", (The Benjamin/Cummings Pub. Co. Inc., Reading, MA 1969,) P 50.

26. E. Whittaker, "*A History of the Theories of Aether and Electricity*" Vol I, (Thomas Nelson and Sons. Ltd. London, 1951,) Vol II (Philosophical Library, New York 1954.) These volumes cover aether theories and the development of physics up to 1926. K.E. Schaffner, "Nineteenth Century Aether Theories," (Pergomon, 1972).

27. Y. Aharonov and D. Bohm, Phys Rev. 115, 485 (1959).

28. F. London and H. London, Proc. Roy, Soc. (London) A 149, 72 (1935).

29 . Bohr's model for the atom is treated in most elementary physics texts, and is discussed in a historical context in ref. 19, P 135.

30. For Central forces with potential energy $V = a\, r^{n+1}$ the average kinetic energy $\overline{T}$ is related to the average potential energy $\overline{V}$ by $\overline{T} = \frac{n+1}{2}\overline{V}$. Hence for an inverse square law n = -2, $\overline{T} = -\overline{V}/2$ and $E = \overline{T} + \overline{V} = \overline{T} - 2\overline{T} = -\overline{T}$. See H. Goldstein "*Classical Mechanics*", 2nd ed., (Addison Wesley Pub. Co. Inc. 1980,) P 82.

31. A. Einstein, Ann Phys. 17, 132 (1905) (See English translation in D. Ter Haar, "*The Old Quantum Theory*", (Pergamon, Oxford 1967).

32. Any mechanism by which a photon loses energy will shift the light to longer wavelengths since $E = h\nu = h\, c/\lambda$.

33. See any text on quantum mechanics, such as ref 20.

34. See any text on elementary particles; also Handbook of Chemistry and Physics (CRC Press Inc.,) any recent edition for tables of particle properties.

35. P. G. deGennes, "*Superconductivity of Metals and Alloys*", (W. A. Benjamin Inc., New York 1966;) P 66.

36. See ref 20, P 240-41.

37. See for instance S. Flugge, "*Practical Quantum Mechanics*", (Springer-Verlag, New York 1974,) Problem 200.

38. See texts on fluid dynamics, also "*Fluid Vortices*" G. J. Green (Ed.) (Kliwer Academic Pub. Dorchecht, The Netherlands 1995.) Different types of vortices exist.

39. E. Merzbacher, "*Quantum Mechanics*", 2nd ed. (John Wiley & Sons, New York 1961) P 597-98.

40. See ref 19 P 256-58.

41. See ref 25 P 546.

42. See for instance the discussion of twenty-six dimensional string theory in "*The End of Physics*", David Lindley (Basic Books, Harper Collins Pub. Inc. 1993;) P 224-25.

43. G. Smoot and K. Davidson, "*Wrinkles in Time*", (William Morrow and Co. Inc., New York 1993.)

44. See July 1997 Physics Today (Vol 50, no. 7, P 17) for a brief description of the history and recent results on the gamma burst of May 8, 1997.

45. M. Metzger, S. G. Djorgovski, S. R. Kulkarni, C. C. Steidel, K. L. Adelberge, D. A. Frail, E. Costa, and F. Frontera, Nature 387, 878 (1997).

46. S. G. Djorgovski, M. R. Metzger, S. R. Kulkarni, S. C. Odewahn, R. R. Gal, M. A. Pahre, D. A. Frail, M. Feroci, E. Costa, and E. Palazzi; Nature 387, 876 (1997).

47. J. P. Norris, R. J. Nemiroff, J. T. Bonnell, J. D. Scargle, C. Kouveliotou, W. S. Paciesas, C. A. Meegan, and G. J. Fishman; The Astro-Physical Jour. 459, 393 (1996).

48. S. W. Hawking and G. F. R. Ellis, "*The Large Scale Structure of Space-Time*", (Cambridge University Pres 1973.)

49. R. Penrose, Phys. Rev. Lett. 14, 57 (1965).

50. S. W. Hawking and Penrose, Proc. Royal Soc. Lond., A314, 529 (1970).

51. K. S. Thorne, "*Black Holes & Time Warps*", (W. W. Norton & Co., N. Y. 1994,) P 354.

52. See papers in "*New Ideas in Astronomy*" editors F. Bertola, J. W. Sulentic, and B. F. Madre, (Cambridge University Press, Cambridge 1988,) G. Burbridge P 223, mentions suggestion by Hoyle and Narlikar that mass of electron was different in distant galaxies and would give an intrinsic redshift.

53. See also in “New Ideas in Astronomy”, paper by W. Tifft P. 173.

54. I. Prigogine, “*The End of Certainty*”, (The Free Press, N. Y. 1996.)