

**Beyond the Point Particle -
A Wave Structure for the Electron**

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Abstract. The dual particle/wave nature of the electron has long been a paradox in physics. It is now seen that the electron consists entirely of a structure of spherical waves whose behavior creates their particle-like appearance. The correctness of this structure is supported by the physical laws which originate from this wave structure, including quantum theory, special relativity, electric force, gravity, and magnetism. This type of structure is termed a Space Resonance.

Key words: Electron, Physical Laws, Cosmology, Particles, Space, Quantum Mechanics

Reprinted from:

***Galilean Electrodynamics* 6**

No. 5, October 1995, pages 83-91
(updated 15 May 1998)

**Technotran Press, 1124 Third Street
Manhattan Beach, CA 90266.**

INTRODUCTION

The apparent inconsistencies between the point particle theory and the observed wave behavior of the electron are reconciled by an electron structure, the Space Resonance. Electrons or positrons can be described as a pair of spherical scalar waves diverging and converging at their

particle structure is then found to be the origin of the basic laws of physics, including quantum theory, relativistic mass increase, inertia, charge and electromagnetism.

The Space Resonance structure is obtained from three assumptions or principles: (1) a wave equation describing spherical scalar waves, (2) the *Space Density Assumption*, which leads to an energy exchange mechanism, and (3) the *Minimum Amplitude Principle*, which regulates particle interactions.

Origins of Natural Laws.

The business of physics is the abstract quantification of facts observed in nature. The rules we form for reconstruction and expression of the observed facts are the *laws of nature* and *Principles of nature*. The distinction between them is tied to their generality. Principles are considered to be more general and by implication more basic. For example, the Principle of Least Action is inferred from several of the force laws and the principle of Conservation of Energy expresses all the various heat and energy flow laws.

Since laws are obtained by measurement of nature rather than derived from other knowledge, they are by definition empirical and "of unknown origin". Therefore if we seek to find the origins of laws we cannot use the existing laws themselves but must use other observed facts together with logical deduction and established mathematics. Rarely a law is found contained within another law. For example the gas law $PV=nRT$ half a century ago was seen to be a result of Newton's laws and QM applied to molecules in a closed container. Such serendipity is the exception; today, the search for origins must probe deeper into nature than heretofore and we must be prepared to find unprecedented perspectives of nature. Growing evidence cited by Galeczki [1] is compelling that the basic laws are intimately involved with cosmology and are dependent on relationships between individual particles and the remaining matter of the universe. Accordingly in the search for the the origins of natural laws, observations of unexplained puzzles of quantum particles and cosmology are attractive sources of input data.

When seeking origins, it is important not to inadvertently use existing laws to deduce themselves. Although the quantum laws of quantum particles can be extrapolated to large macro-objects, the inverse is not possible. Such circular reasoning can occur if, for example, an e-m field or mechanical model from macro-physics is assumed to be the structure of a quantum particle. Logically, finding the origins of existing laws requires forming new concepts that nevertheless satisfy observed data. It is a major result of this article to further deduce that most of the natural laws originate from the properties of the quantum waves of the charged particles (electron, proton, etc.), and the properties of the space (ether, vacuum, etc.) which is formed from the totality of all those particle quantum waves. One such effect is already known as Mach's Principle which asserts that inertia is a result of an inertial reference frame established by all matter in the universe.

The discovery of these origins from the work of this article creates a radical new picture of the physical world: quantum mechanics and relativity are in a sense united, origins of forces are understood, puzzles and paradoxes are explained and, most important, relationships between microphysics (electrons and particles) and the universe (cosmology) are seen to be a result of an all-pervading "space" (the vacuum or ether) filled with oscillating quantum (particle) waves.

The reader should be aware that he is evaluating a new basic proposal that all natural science results from just three assumptions about the properties of space.

SECTION I - HISTORY

The search for the structure of the electron started over a century ago, in H.A. Lorentz's book [2]

Einstein was asked if he could explain the confusion of hadron particles which were being found in ever increasing numbers. He replied, "I would be happy just to know what an electron is!"

Many have suggested that a wave-structured electron plays a fundamental role in nature. The famous geometer-mathematician Clifford [3] suggested in 1876 that all physical laws were the result of undulations (waves) in the fabric of space. Nobel laureate Paul Dirac, who developed much of the theory describing the quantum waves of the electron, was never satisfied with its point-particle character because the Coulomb electron required a mathematical correction termed "renormalization". In 1937, he wrote, "*This is just not sensible mathematics. Sensible mathematics involves neglecting a quantity when it turns out to be small — not neglecting it because it is infinitely large and you do not want it!*"

Weyl, Clifford, Einstein, and Schroedinger [4] agreed that the puzzle of matter will be found in the structure of space, not in point-like bits of matter. They speculated that the physical world is based upon a geometry of space. What we observe as material bodies and forces are nothing but shapes and variations in the structure of space. The complexity of physics and cosmology is just a special geometry. This idea had an enduring appeal because of its economy of concepts and simplicity of design.

In 1945, Wheeler and Feynman [5] represented charge by assuming a pair of spherical inward and outward *electromagnetic* waves. Their use of advanced (inward) waves is an apparent violation of the principle of causality which states, "Events cannot occur before their causes." Wheeler and Feynman showed that the puzzling inward waves do not violate causality because they are not directly observable. Their results hold for scalar waves which are exact solutions of a wave equation in spherical coordinates.

Phipps [6] put forth a *beta-structure hypothesis*, in which he suggested that the electron-positron is the fundamental particle of the universe. He reasoned that the infinite extent of charge forces were more fundamental than local effects of baryons. Wolff [7, 8, 9] formulated the results described here.

This paper shows that these scientists' visions have come true. Dirac was correct. The electron is a wave structure without particle substances. The medium of the waves is space, still unexplored but related to "vacuum" and "ether"; terms increasingly used as the wave nature of matter becomes unmistakable.

SECTION II - PUZZLES OF ELECTRON STRUCTURE

A. Is the Electron a Wave or a Particle?

The electron exhibits properties of both particles and waves. However, many experiments have been done to search for a core of the electron without results. What we do observe is that energy exchanges take place at "point-like" locations in the metallic lattice of detectors. On the other hand, wave properties of an electron are obvious from the success of Quantum Mechanics. This theory describes a mechanism where waves interact at point locations and thereby produce the results that we observe as particle-like.

B. What is the Mechanism of Energy Exchange?

Exchanges between charged particles is the dominant way in which energy is transferred in our solar system. An exchange is always required to darken a film, move a needle, record a bit, or fire a neuron. These exchanges dominate our technology, daily lives, and Nature. They are the means of our human senses, laboratory experiments, and the production of knowledge, but the mechanism is unknown.

special relativity, the DeBroglie wavelength, and Conservation of Energy. For example, the force laws describe force as the change in energy over distance, $F = dE/dr$. Therefore, whatever motivates the change in energy generates what we observe as force. The coulomb and gravity force laws do not describe what creates these forces because they are only formulas to calculate force. That is, they do not imply any particular energy exchange mechanism. This mechanism for the electron, described below, depends on the existence of other matter in the universe.

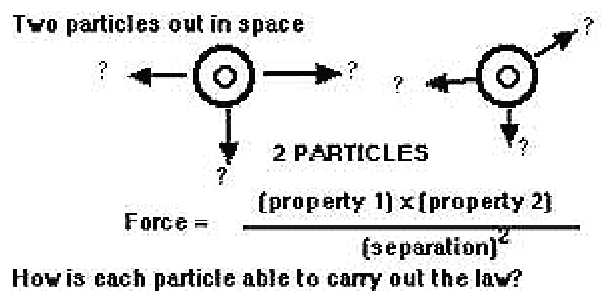
C. How does Matter depend on other Matter in the Universe?

The mere existence of a particle imposes requirements upon its properties. Without particles to populate a universe, the universe could not exist because our concept of "universe" is simply a collection of particles and their distribution. Thus our understanding of our universe depends on our understanding of the particles in it. Further, the natural laws of the universe could not exist without particles ; Laws demand the presence of particles, upon which the laws can operate. Laws without particles are meaningless because particles are the objects of the laws. Especially we need to understand the relationship of the laws to the electron and proton, the two charged particles whose infinite fields dominate the universe

And the opposite is true. We cannot identify a particle without the force laws to locate and measure it. Thus our perception of particles depends on the form of the natural laws. These three, particles, laws, and the universe are an interdependent *trilogy*. Each requires the existence of the others. Therefore, we cannot expect to understand cosmology, the structure of the universe, unless we also understand the relationships within the trilogy. The nature of the relationships between separated particles of matter, more basic than forces between them, are brought out by the following arguments.

Measurement is a Property of an Ensemble of Matter. A particle entirely alone in the universe cannot have dimensions of time, length, or mass. These measures are undefined without the existence of other matter because dimensions can only be defined in comparison with other matter. For example, at least five separated particles are necessary to crudely define length in a 3D space: four to establish coordinates and one being measured. Thus the measurement concept requires the existence of an ensemble of particles. In our universe the required ensemble must include all observable matter, for there is no way to choose a special ensemble. The importance of this fact becomes clear when we recall that time, length and mass are the basic unit set used to describe all scientific measurements.

Particle Properties require Perception-communication Between Particles. If there were no means for each particle to sense the presence of other matter in its universe, the required dimensional relationships above could not be established. How can a particle possess a property which is dependent on other particles, if there is no way for the particles to impart their presence to each other? Without communication, each particle would be alone in its own separate universe. Therefore continual *two-way* perceptive communication between each particle and other matter in its universe is needed to establish the laws of nature. The laws are then established in terms of the dimensions (units) established by the ensemble of matter.



We deduce that the waves of an electron structure are the means of the communication between particles of matter. Below in Section III we shall see that the mathematical solutions of the wave equation indeed allow for two-way continuous communication by means of waves

which form the the electron structure. This reasoning underlying measurement yields boundary criteria on the structure of the electron summarized in the two corollaries below :

Corollary I. There exists a means of continual communication between particles which takes place in the space (ether, vacuum) of the universe of the particles.

Corollary II. A "universe" is defined for each particle as the space and other particles within the space which are able to communicate with the particle.

The Measurement of Time requires a cosmological clock. Using reasoning similar to the above but for the dimension of time, we can conclude that time measurement requires the existence of *cyclic events* among the particles of the universe; a kind of clock. Those properties of particles which involve the measurement of time, notably mass and frequency, cannot have a meaning if particles have no scale of time. That is, the particles themselves, must have a way to compare their own cyclic events with other particles. Therefore, there must exist a standard cosmological clock. One straight-forward proposal is a cosmic clock contained in every identical particle structure as an oscillator which communicates with other particles. Because of the uniformity of space (the oscillator medium) the clocks would be alike.

The role of Space. Since all the laws of nature are written in terms of the dimensions [time, length, mass] defined by ensembles of matter communicating in the space of a universe, we infer that the behavior of matter is at least partly determined by the geometric properties of the space (aether) within the universe.

It may be noted that Einstein's general theory of relativity (GTR) is also derived from properties of space that determine the large scale motion of matter and light beams. Similarly, measurements in GTR space depend upon the distribution of matter in the universe. However, unlike the viewpoint employed here, the GTR theory is descriptive rather than investigative. And the large-scale GTR does not involve quantum-level properties nor is it concerned with communication between particles. Nevertheless the properties of space viewed from this quantum perspective, particles dependent upon particles, should, when expanded to the limit of large scale matter, be the same as the GTR.

D. Mach's Principle.

The unknown origin of Newton's law of inertia, $F=dp/dt$, has attracted frequent attention. Ernst Mach [10] in 1883 boldly suggested that inertia depends upon the existence of the distant stars. His concept arises from two fundamentally different methods of measuring the speed of rotation. First, without looking at the sky, one can measure the centrifugal force on a mass m and use Newton's Law in the form, $F=mv^2/r$, to find circumferential speed v . The second method compares the object's angular positions with the fixed (distant) stars. Mysteriously, both methods give exactly the same result. Mach reasoned that there must be a causal connection between the distant matter in the universe and inertia. He asserted: *Every local inertial frame is determined by the composite matter of the universe.* (This wave structure of the electron now proves that Mach was right.)

Mach's Principle of Inertia is the clearest evidence that very distant bodies can affect us instantaneously. Phipps [6] quotes Mach, "When the subway jerks, it is the fixed stars that throw you down." Mach's Principle is criticized because it appears to violate causality: "Events cannot occur before the causes which produce them." but this does not actually occur as will be seen below where Mach's Principle is used to find the energy exchange mechanism of the electron.

SECTION III - THEORY OF THE NEW ELECTRON

Three assumptions about the properties of space determine the space resonances. In return for this investment, the theory obtains a physical and mathematical origin for natural laws plus relationships between particles and cosmology.

A. Assumption I - The Wave Equation.

Because it must be compatible with quantum theory, a scalar wave equation is needed to describe the structure of natural electrons. Spherically symmetric solutions are required because charged particles have spherical symmetry. Quantum theory requires the frequency of the waves to be proportional to the mass according to the formula $f = mc^2/h$. Two solutions of the wave equation shown in Figure 1 describe the physical structure of the electron.

Equation (2) below shows that an electron is comprised of two spherical scalar waves traveling in space with velocity c ; one inward to a center and the other outward. The two superimposed waves form a standing wave, termed a space resonance (SR). The center of the wave structure is the nominal location of the electron. These space resonances are perpetual spherical oscillators. Each resonance extends throughout space and interacts with other resonances so that the natural laws result from the properties of the waves and the medium they travel in, 'space' or the *ether*.

The Wave-equation for the electron, in spherical coordinates, is:

$$d^2(\text{AMP})/dr^2 + 2/r\{d(\text{AMP})/dr\} - 1/c^2 \times d^2(\text{AMP})/dt^2 = 0 \quad (1)$$

where **AMP** is a continuous scalar amplitude with values everywhere in space and **c** is the propagation speed. This equation has two spherical wave solutions for the amplitude **AMP**: One of them is a converging IN wave and the other is a diverging OUT wave, shown in Figure 1,

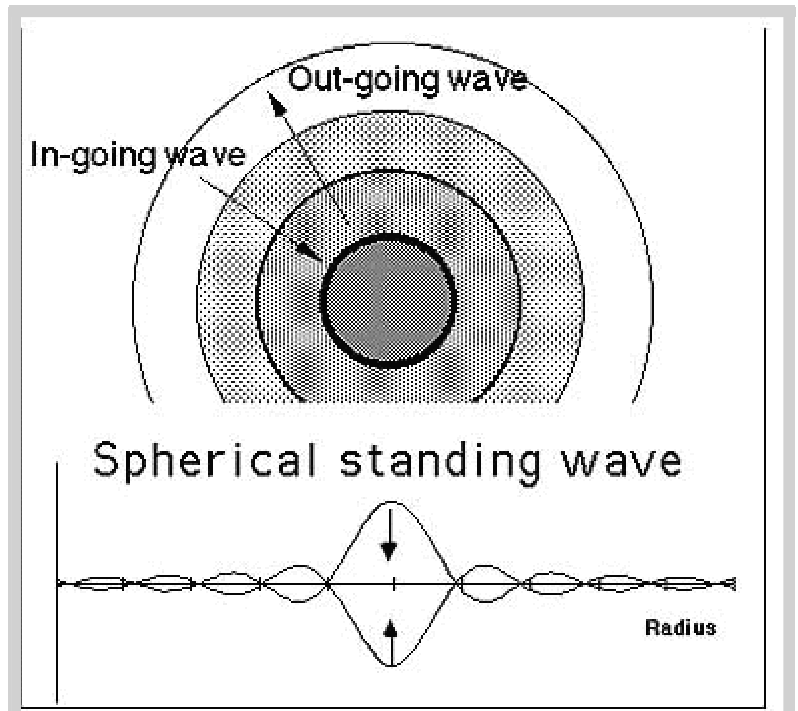


Figure 1. The Dynamic Waves of a Space Resonance. The resonance is composed of a spherical IN wave which converges to the center and an OUT wave which diverges from the center. Their separate amplitudes are infinite at the centers. When combined, the two waves form a *standing wave* which has a finite amplitude at the center. The standing wave is the structure of the electron. The inward and outward waves provide communication with other matter of the universe. Spin of the electron is a result of the reversal of the IN wave at the center to become the OUT wave.

$$\text{AMP}^{\text{IN}} = (1/r) \text{Ao} e^{(i\omega t + ikr)} \quad [1]$$

$$\text{AMP}^{\text{OUT}} = (1/r) \text{Ao} e^{(i\omega t - ikr)}$$

The IN and OUT waves combine to form a standing wave. ω is the frequency characteristic of an electron proposed by deBroglie and Schroedinger. k the wave constant. The amplitude of the continuous waves is a scalar number, not an electromagnetic vector. At the center the standing wave amplitude is finite not infinite, in agreement with the observed electron.

A standing wave results by combining them with their amplitudes opposing at $r = 0$, to get

$$\mathbf{AMP}^{\text{STANDING}} = \mathbf{AMP}^{\text{IN}} - \mathbf{AMP}^{\text{OUT}} = (1/r) \mathbf{A}_0 e^{i(\omega t + ikr)} - (1/r) \mathbf{A}_0 e^{i(\omega t - ikr)} \quad [2]$$

The equation, $\text{Energy} = mc^2 = h\omega$, converts units of energy into units of frequency. Thus mass is proportional to frequency of the electron's space resonance oscillator: $\omega = 2\pi mc^2 / h$. All the waves of all the charged particles in the universe have this same frequency because the frequency is a property of the wave medium - space itself, the *ether*. This frequency is the universal cosmic clock which regulates the laws of nature and our sense of time. The velocity c is also a universal property of the ether which we observe as the speed of energy exchange (light).

This equation becomes clearer when changed to a simpler exponential function,

$$\mathbf{AMP}^{\text{STANDING}} = \mathbf{A}_0 e^{i\omega t} \sin(kr)/r$$

The exponential factor is an oscillator. The sine function modulates the rapid oscillator waves with a standing wave of wavelength $1/k$ which surprisingly is the Compton wavelength of the electron. The intensity is the envelope of $\mathbf{AMP}^* \mathbf{AMP}$, which decreases as $1/r^2$ away from its centers This equation is simulated in the [animation of the electron](#) on this web-site.

The amplitude, $\mathbf{AMP}^{\text{STANDING}}$ corresponds to the electric potential of the electron. The amplitude at the center is obtained by taking the limit as $r \rightarrow 0$ in $\sin(kr)/r$ in the equation above and is equal to \mathbf{A}_0 . This finite amplitude explains why 'renormalization' in QED theory works. Renormalization boils down to an arbitrary cut-off of the Coulomb electric potential to avoid an unwanted infinity at the center when $r \rightarrow 0$. Avoiding the infinity because it is was annoying was Dirac's complaint. Although the reason was contrived, the cut-off worked. Now, since experiments show extremely accurate verification of the cut-off, one can regard the cut-off as an observed correction to the electron potential, which elsewhere is the well-known $1/r^2$. The space resonance structure correctly shows the origin of the correction, the finite center amplitude.

Predicted Properties from the Wave Equation.

From only the first of three assumptions, several properties of the electron are already observable:

1. There are two kinds of SR electrons as a result of two ways to superimpose the IN and OUT waves. One combination has a negative IN-wave amplitude at the center and corresponds to the electron. The other has a negative OUT-wave at the center forming an anti-resonance which is the positron. If the anti- resonance is superimposed upon the resonance, they annihilate like electron and positron. This is seen from the equations.

2. They obey Feynman's Rule: A positron is an electron going backward in time. To see this, replace the variable t with a $-t$ in the function for an electron resonance, Equation (2). Replacing the time exchanges the IN and OUT waves and you obtain the equation for a positron as Feynman said.

3. The Origin of Conservation of Energy. Energy is exchanged in nature by two resonances (oscillators) interacting with each other. For all oscillator pairs known in nature, significant coupling occurs only if both have the same resonant frequency. If one oscillator changes

changes of interacting space resonances are equal and opposite. This is exactly the content of the Conservation of Energy law.

B. Assumption II - Establishing the Density of Space

The wave equation provided a structure which possesses some of the electron's characteristics but a means for the SRs to interact and exchange energy is also needed. Unfortunately, since waves in a homogeneous medium pass through each other, the medium has no means for interaction. To find the means of interaction, we recognize that space is not homogeneous everywhere. For example, it has been observed that a star will bend the path of light which goes near it. A similar behavior occurs at the center of a charged particle.

To examine this requirement we first make a quantitative assumption, similar to Mach's Principle, which establishes the density of space (ether or vacuum). Then we will examine the density formula seeking a means of interaction. **The Space Density assumption is:**

Assume that the mass (wave frequency) and propagation speed of an SR wave in space depends on the sum of all SR wave intensities in that space; a superposition of the intensities of waves from all particles inside the Hubble (H) Sphere of radius $R = c/H$, including the intensity of a particle's own waves.

$$mc^2 = h\omega = k' \text{ SUM OF: } \{(\text{AMP}_n)^2 \times (1/r_n^2)\} \quad (4)$$

In other words, the frequency ω or mass m of a particle depends on the sum of amplitudes squared of all waves **AMP_n**, from the N particles in the universe, whose intensities decrease inversely with range squared. That is, waves from all particles in the universe combine their intensities to form the total density of 'space'. This density determines the electron's wave frequency. This space corresponds to Einstein's "aether" or quantum theory's "vacuum."

Now examine the homogeneity of the space. The universe contains so many particles that the density of space is nearly constant everywhere. But close to the center of an electron, the amplitude of an electron's own waves following the $1/r^2$ rule, is larger, producing a "lump" in space density. This lump at the center of the electron causes wave interactions. It is the way energy is transferred and what we call "charge". Its correctness is tested below.

Energy Transfer Mechanism of the Space Resonance.

How does the charge mechanism operate? It is well-known that a-c signals flowing through a non-linear element in a circuit will mix. That is, if there is a two-signal input:

$$\text{INPUT} = A\cos(\omega_1 t) + B\cos(\omega_2 t)$$

then the output will be:

$$\text{OUTPUT} = AB[\cos(\omega_1 t + \omega_2 t) + \cos(\omega_1 t - \omega_2 t)] / 2 + \text{other components}$$

The non-linear element produces sum and difference frequencies of the original ω_1 and ω_2 .

Similarly in space, different waves passing through the dense, non-linear region at the particle center will mix. If an input frequency and a particle frequency are similar, resonance can occur. An example of this is a tuned radio receiver. An energy (frequency) exchange between resonances behaves like two coupled oscillators in a circuit, or like two pendulums joined with a spring.

A Test of Assumption II . If an electron's own waves can create a denser region near its center,

intensity of waves from all other N particles in the Universe. This requirement is written: Intensity

$$I = \text{AMP}_o^2/r_o^2 = \text{SUM} \{ \text{AMP}_n^2/r_n^2 \}$$

$$= N/V \times \text{INTEGRAL OF:} \{ \text{AMP}_o/r_o \}^2 4 \pi r^2 dr$$

where V is the volume inside the Hubble Sphere and R its radius. The integral, from $r = 0$ to $R = cT = c/H$, extends over a sphere whose expanding radius R depends on the age T of the particle. Thus T is the maximum range of the particle's spherical waves. This reduces to $r_o^2 = R^2/3N$
(5)

Inserting values from astronomy measures, $R = 10^{26}$ meters and $N = 10^{80}$ particles, the critical radius r_o equals 6×10^{-15} meter. If the assumption is right, this should approximate the classical radius $r_c = e^2 / mc^2$ of an electron, which is 2.8×10^{-15} meters. The two values almost match, so the prediction is verified. Apparently dense centers do exist, and

$$e^2 / mc^2 = R / \text{SQUARE ROOT OF: } \{3N\} \quad (6)$$

Equation (5) is a relation between the size r_o of an electron and the size R of the Hubble Universe. It is termed the **Equation of the Cosmos**.

Observations on the non-linearity Properties of Space Density

The large density of an electron's own waves at the center are the causes of 'charge' effects, wave-coupling, and energy exchange between particles.

1. Charge and mass interactions occur at the center (lump). The electron resonance extends throughout space but energy exchanges take place in the non-linear bump at the center. Thus the SR "looks" like a point particle but no mass or charge substance is required to produce this experimental appearance. It is all waves.

2. Modulation of the waves behaves like a photon. When two resonances exchange energy (shift frequency - Section H below), the IN/OUT waves traveling between them are modulated with the frequency-shift information. This modulation travels at velocity c, like a photon. But the only events we observe are two energy shifts, one at the source and one at the absorber. This corresponds exactly with experimental observation of the photon.

C. Assumption III - The Minimum Amplitude Principle.

Assumptions I and II describe the electron's structure, its energy exchange mechanism, conservation and electric force. But there has to be a law to determine whether two particles should move together or apart, or whether their frequencies will change up or down. One more assumption is needed that governs the behavior of energy exchanges within a group of particles. A Minimum Amplitude Principle (MAP) is found, described by $\text{INTEGRAL OF: } \{ \text{AMP}_1 + \text{AMP}_2 + \text{AMP}_3 + \dots + \text{AMP}_n \}^2 dx dy dz = \text{a minimum}$ (7)

or, *The total amplitude of particle waves in space always seeks a minimum.*

In other words, all the waves of the total number n of particles inside the Hubble Sphere adjust themselves at each point to make total amplitude a minimum. To accomplish this, energy (frequency) exchanges take place, or wave-centers move in order to minimize the total amplitude. This principle is very powerful and predicts many observations. For example, waves of two electrons close together will have a higher intensity than electrons farther apart. Therefore two electrons must repel in order to satisfy the MAP. A positron and an electron will attract. It also creates the Pauli Exclusion Principle, forces between atomic nuclei, and gravitation.

Observations on the Minimum Amplitude Principle.

1. The Pauli Exclusion Principle is one result. This is because MAP prevents two identical resonances (fermions) from occupying the same state since their total amplitude would be a maximum rather

2. The electric charge force between two resonances is $F = k/r^2$, where $k = e^2/4 \pi \epsilon_0$. It is the same as Coulomb force everywhere except at the center. This force arises as a result of the Minimum Amplitude Principle which attempts to minimize wave amplitudes near the resonances. The $1/r^2$ factor is the result of the 3D geometry of ordinary space. The electric constant k is a measured parameter which can be approximated from Equation (6) which shows it to be a property of space. Thus only one value of charge occurs in nature. The complex amplitude AMP can be regarded as the electric potential of the electron.

SECTION IV - APPLICATIONS OF THE SPACE RESONANCE ELECTRON

The structure of the SR leads to new applications that solve puzzles of physics and cosmology. The examples below are important applications.

A. Properties of a Moving Space Resonance.

Quantum mechanics and special relativity seem unrelated, but they have one feature in common: Both laws depend on the relative velocity between two particles. Therefore, we should investigate the interaction of two space resonances in relative motion. One SR may be thought of as a source interacting with the other SR, as an absorber or observer.

Consider two SRs moving with relative velocity $b = v/c$. Each receives the same Doppler shifted waves from the other. They are symmetrical. Their IN waves are red-shifted and their OUT waves are blue-shifted according to the usual Doppler factors, $g(1+b)$ and $g(1-b)$ which shift frequency and wavelength.

The received amplitude of each SR is the sum of Doppler-shifted IN and OUT waves which reduces to, $AMP = \text{shifted } \{AMP^{IN} + AMP^{OUT}\} = (2/r) e^{ikg(ct + br)} \sin[kg(bct + r)]$ (8)

Equation (8) is composed of an exponential carrier wave modulated by a sine function. The relativistic term, $g = [1 - (v/c)^2]^{-1/2}$, occurs properly to match experimental observation. It is a result of the Doppler effect on the combined IN and OUT waves. These matching results are:

The parameters of the exponential oscillator are:

wavelength = h/gmv = deBroglie wavelength, L .
 frequency = $kgc/(2 \pi) = gmc^2/h$ = mass-energy frequency.
 velocity = c/b = phase velocity.

The parameters of the sine function are:

wavelength = h/gmc = Compton wavelength.
 frequency = $gmc^2 b/h = b \times (\text{mass frequency})$ = "momentum frequency".
 velocity = $bc = v$ = relative velocity of the two resonances.

The above matching results are remarkable! They clearly show the origin of mass increase and quantum mechanics in the wave structure of matter. It is instructive to compare Equation (8) for moving electrons with Equation (2) for a stationary electron. They are of the same form but (8) contains the velocity $b = v/c$ and the related quantum and relativistic properties for moving particles.

Origin of Quantum Mechanics and Special Relativity. Both moving resonances see the other with its momentum and mass (rest frequency) increased by the factor $g = [1 - (v/c)^2]^{-1/2}$. This predicts the observed relativistic mass increase of particles moving relative to a lab. Each electron also receives a QM deBroglie wavelength $L=h/p$ from the other. This is the original experimental basis of quantum theory. We conclude that quantum theory and the mass increase

dependent on both the IN and OUT waves.

B. A Single Value of Charge.

Combine the Equation of the Cosmos (5) with the classical electron radius $r_0 = e^2/mc^2$. Eliminate r_0 and obtain $e^2 = mc^2 R/\sqrt{3N}$. This shows that the charge e^2 is dependent on the total of all N particles. We also recall that charge always occurs in natural laws as e^2 , never as e alone. Thus, charge is a property of space and total matter, not of particles, and there is only one value of charge in nature e^2 . Conservation of charge follows from the anti-symmetrical structures of the SR and anti-SR described in Section III above.

C. Forces depend on the Structure of Space.

Understanding energy exchanges enables us to understand the origin of forces. In general, force = dE/dr where dE is the energy exchanged between resonances. For an electron, the potential is proportional to AMP. The energy changes depend on the variation of force along the distance dr between them. For example, the dominant force in the universe is the electric force between charges which varies as $1/r^2$, the geometric property of distance in 3D space.

Inertia. Below in section IVD, it is shown that a tiny inhomogeneity of space perturbs the enormous charge force and thereby produces the inertial force law, which is $=10^{40}$ times smaller than charge force. Space becomes inhomogeneous where a particle is accelerated ($F=ma$). In this situation the Minimum Amplitude Principle (MAP) compensates the inhomogeneity with amplitude-minimizing energy exchanges that cause forces and movement. These compensations first occur in the local space, with an immediate local energy exchange to the space waves. The energy exchanged and force appear like action at a distance, unlike the charge (photon) exchanges which propagate at velocity c . Thus Newton's original statement of inertia and gravity force is upheld.

Other types of space inhomogeneities also appear as force laws including Mach's Principle, gravity, and magnetism, which are discussed in III E and III F. Rotation, angular momentum, [spin](#) and the [Dirac Equation](#) are discussed in References [8, 9, 11].

D. The Origin of Inertial Forces.

The force of inertia on an accelerated electron is a perturbation of the electric force produced by changes of wavelength caused by the acceleration. The energy exchange takes place directly between the accelerated resonance and other waves in space. Recoil force is eventually transmitted to other masses of the universe via their space waves.

To analyze this, examine the IN/OUT wavelength change from acceleration and calculate the forces caused by acceleration relative to the masses of the universe. This change disturbs the local balance with waves from other matter in the universe. The MAP corrects the imbalance by readjusting frequencies of the accelerated resonance:

To calculate this perturbation, use a force on the accelerated mass analogous to force on an accelerated charge (radiation damping):

$$\begin{aligned} \text{electric Force} &= e' \times \mathbf{E} && (\mathbf{E} = \text{electric field}) \\ \text{In analogy, mass Force} &= m' \times \mathbf{M} && (\mathbf{M} = \text{mass field}) \end{aligned} \quad (9)$$

The \mathbf{E} field of an accelerated charge e is computed from the magnetic vector potential \mathbf{A} . That is,

$$\text{electric field} = \mathbf{E} = d\mathbf{A}/dt = (e) (\text{acceleration}) / (4\pi e_0 c^2 r) \quad (10)$$

For the analogous particle m , assume an analogous mass field derived from an analogous vector potential,

$$\text{mass field} = \mathbf{M} = (m)(\mathbf{acceleration}) (G) / (c^2 r) \quad (11)$$

Following the analogy, the gravity constant G has replaced the electric constant $1/4\pi\epsilon_0$. To find the force on the masses m' , set m' equal to the mass of the universe (This produces Mach's Principle):

$$m' = (d_u)(\text{volume}) = d_u (4/3) \pi R^3 \quad (12)$$

where d_u = mass density of the universe. Choose the average distance R of m' as half the Hubble Sphere radius, $R = c/2H$. The force between the particle m and masses m' becomes **Force**
 $= (m')(\mathbf{Mass\ field})$
 $= d_u (4/3) \pi (c/H)^3 (m \mathbf{a} G) / [c^2 r]$

$$= \{(8\pi G d_u) / 3H^2\} m \mathbf{a} \quad (13)$$

Now if we choose d_u equal to the critical density of the universe, a flat universe in general relativity, then $d_u = d_c = 3H^2 / 8\pi G$. We can insert it into Eqn (13). Then the factor in braces { } becomes one and the remainder is Newton's Law of inertia: $\mathbf{F} = m \mathbf{a}$. This result confirms that inertial force is a perturbation of electric force, that inertial mass is equivalent to gravitational mass as experimentally observed and predicts a flat universe.

E. The origin of Gravity Forces.

The force of gravity can also be found as a perturbation of charge force. MAP seeks an energy exchange (\rightarrow force) between a given mass and the waves of other nearby masses that will balance the observed perturbed (changing) properties of space described by the Hubble constant. Wolff [8] obtains the ratio of the electric to gravity force:

$$\text{electric/gravity force} = F_e/F_g = mc^2/hH = 5.8 \times 10^{39} \quad (14)$$

Compare this with the measured ratio $= e^2/(4\pi\epsilon_0 G m_e m_p) = 2.3 \times 10^{39}$. They agree within Hubble constant error.

One can regard this perturbation as an induction of a gravity force by the changing space property. It is analogous to the induction of an electric field by a changing current. Like Lenz's law, the force opposes the change.

F. The Origin of Magnetic Forces.

Magnetic forces can be regarded as a perturbation of electric charge forces where the perturbing element is the relative velocity $(v/c)^2$ between two charges. This little known result was found about the year 1910. Lorrain and Corson [12] use it to derive the magnetic force equation beginning with Coulomb's law and special relativity, with the result:

$$\mathbf{F} = q (\mathbf{v} \times \mathbf{B})$$

where special relativity creates the cross product, q is the current producing charge with relative velocity \mathbf{v} , and \mathbf{B} is the magnetic field.

G. Parameters of the Electron Depend on the Parameters of the Universe.

Equation (5), the Equation of the Cosmos, provides an important numerical relation between the

the small. Remarkably, it describes how all the mass of the universe acts together to create the "charge" and mass of each electron as a property of space.

To see how the electron mass depends on other matter, combine Equation (5) with the Compton wavelength $r_o = r_c = h/mc$. Eliminate r_o to obtain:

$$mc^2 = hc / \text{SQRT}\{N/R\} \quad (15)$$

Again, confirming our logical deduction, we see that the electron mass like the charge is a property of the universe, that is the total particles N and its size R.

H. The Puzzle of the EPR Effect.

The well-known but mysterious EPR effect [13, 14] is an fascinating example of particle-to-particle communication. Section II (C) above pointed out that two-way communication between particles was a fundamental requirement for the existence of natural laws and we have seen how the IN and OUT waves provide the means for this two-way communication. This is what happens in EPR:

Ordinarily we observe communication as two energy-exchange events: an energy shift at a source particle and later an absorption event at a receiver particle. We calculate the message velocity (c) using the time between the events. We used to think of this as a moving photon but this leads to confusion. The correct picture uses the IN-OUT waves traveling at space-wave velocity c .

Before two potential partners can undergo those energy shifts, the IN/OUT waves must exchange information (boundary conditions) of their respective particle energy states so that energy exchanges can take place in a way that minimizes wave amplitudes in accordance with the MAP (Assumption III). If minimization is not possible no exchange can take place. In this respect, the Minimum Amplitude Principle is similar to other physics principles such as the Principle of Least Action, and "Energy flows down-hill". It underlies them.

These prior information exchanges do not produce energy changes visible to us. The mysterious EPR experiments use two separated photo-detectors which appear to have instantaneous knowledge of each other's state of polarization. We are not aware of the prior information exchanges because they are hidden from our laboratory instruments since they are not energy shifts but are carried by the IN-OUT quantum waves. After we understand the role of the quantum waves we recognize that Nature is a puppet-master who allows us to see the puppets but not the quantum wave ensemble behind the curtain.

Several variations of the EPR effect have been found and Greenberger et al [15] describe a general method of calculation.

SECTION V - CONCLUSIONS

Space underlies physical laws. The most extraordinary conclusion of the space resonance electron structure is that the laws of physics and the structure of matter ultimately depend upon the properties of space determined by the matter itself. Matter in the universe is inter-dependent. Every particle communicates its quantum-wave state with other matter so that energy exchange and the laws of physics are properties of the entire ensemble of matter. Mach's Principle is a law conspicuously displaying this particle inter-dependence.

Two Worlds within our Universe. The work of this paper shows that there are two real and parallel 'worlds' partaking in the physical behavior of matter. One world is our familiar 3D

extensions as laboratory instruments. Its attributes are familiar material objects, events, and forces between objects, plus the related energy exchanges which enable us to observe the objects and form mental images of them. This world can be termed the World of Energy-exchange since energy-exchange is the unique attribute which allows us to observe this world.

A second World of Scalar Waves forms the structure of the basic particles, electron, protons, and neutrons which compose the material objects and the space(ether) of our world of energy-exchange. These waves in space are unseen by us. We only know of their existence when an energy (frequency) exchange occurs to stimulate our senses. Nevertheless this unseen scalar wave world is basic and determines the real action in both worlds. The waves obey the rules of superposition and interference and are governed by Assumptions I, II, and III.

The behavior of the particles (space resonances) in their interactions is largely due to their oscillating scalar waves which reveal their behavior to us via the rules of quantum mechanics and relativity. These waves (inward and outward) fulfill the requirements of matter inter-dependence discussed in Sections III and IV above.

One role of the scalar waves is inter-particle information exchange of their quantum states. This is usually unseen in our world but it is conspicuous in the mysterious EPR effect (Einstein et al, 1935). Information must be exchanged because partners of a future energy exchange cannot act until they have "knowledge" of each other's state. This is necessary so that the MAP (Assumption III) can determine whether an exchange will minimize net wave amplitudes. These information exchanges are usually hidden from our laboratory instruments because they are not energy shifts. Nature is a puppetmaster who allows us to see the puppets but not the orchestration behind the curtain.

Another role of the waves is as a universal cosmic clock which Galezki [1] has pointed out is a requirement behind Newton's laws. The clock is the fixed frequency of the IN and OUT waves pervading the universe.

Relation to Special Relativity. The relativistic law obtained from analyzing the movement of two SRs in Section IVA is the well-confirmed mass increase of moving matter. But the controversial time-space contractions are not predicted. An explanation outside the scope of this article predicts that the speed of an energy transition is equal to the speed of the IN wave to the receiver. This wave always moves in the frame of the receiver at a constant velocity c . This is observed but does not imply contraction of space or time..

Some Other Predictions already verified:

1. The space resonance theory predicts and shows the origin of the natural laws: QM and relativistic mass-increase, the conservation of energy, charge, and momentum; and the forces of charge, inertia and magnetism.
2. The lifetimes of atomic and nuclear decays are not constants as once thought but depend on their quantum-wave states and the distance between partners of the energy exchange. Such variable lifetime atomic decays have been investigated by Walther et al [16] and Greenberger et al [15].
3. Inertial and gravity forces are predicted to be of the action-at-a-distance type as originally stated by Newton. This agrees with action-at-a-distance gravity as recognized by astronomers to account for planetary motions. Lorrain & Corson [12] and Graneau [17, 18] verify action-at-a-distance for magnetism confirming the SR electron but not conventional older physics.

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