Meeting “Beyond Einstein” at Stanford University

Light and the Electron - Einstein’s Last Question

Milo Wolff (milo.wolff@QuantumMatter.com)
M.I.T. (retired)
1124 Third Street. Manhattan Beach, CA 90266
Geoff Haselhurst (Geoff@SpaceAndMotion.com)
West Australia

Abstract: Light is an energy exchange between electrons. However, the exchange mechanism was unknown, as Einstein implied when he said: "I would just like to know what an electron is." Einstein's question is answered and new applications described.

A. Introduction

In his later years, Einstein was asked his thoughts about the huge numbers of short-lived heavy particles, kaons, pions, quarks, mesons, etc. found using high-energy accelerators and enormous amounts of time and money. These physicists thought they were finding important basic matter. They wanted to know what Einstein thought of their work. Einstein was a careful thinker and not given to theatrics so he was very serious when he replied, “I would just like to know what an electron is.”

Why did he say this? His answer implied, contrary to popular thinking, that the pedestrian electron, known since Greek times, was more important to science than the billions of dollars spent on accelerators. Little attention was paid to his remark. This was unfortunate because the Wave Structure of the Electron has suddenly produced many valuable applications.

Einstein saw [2] the electron as the leading player in the universe, as could any careful scientist because most of the activity of the Universe is dominated by energy transfers involving the electron - light and electromagnetic waves. Neither Einstein nor anyone else understood the causes and mechanisms of light energy transfers between molecules and atoms. Although the ‘force’ between ‘electrons’ could be calculated using rules taught in Physics I, the suggested mechanism and rules do not always match the behavior of Nature. The structure of the electron itself was in question. It did not appear to be a discrete material particle. Something was wrong and Einstein knew it.

Answering Einstein’s question. This article will show, just as Einstein speculated, that the electron is indeed the leading player in the universe and is intimately involved with light, matter, the laws of nature, and our lives. The path to the answer, shown below, is simple: Reject the discrete material electron and replace it with a wave-structured electron as proposed by Schroedinger and Clifford - using a scalar-wave equation. The math and the proofs are straight-forward because scalar waves are the only possible choice. You can’t go wrong! Only two principles underlie all results. Despite this simplicity the bountiful harvest of results includes Einstein’s answer plus the origin of the natural laws, new applications in micro-physics and chips, understanding light energy

exchange and lasers, plus the answers to most current paradoxes of physics. It is breath-taking to find so many results together – answering Einstein's question.

Particle or a wave? When J. J. Thompson discovered the electron in 1904 using cathode-ray tubes that enabled him to calculated the charge to mass ratio, everyone was convinced that electrons were discrete material particles. This discrete particle belief began to be questioned about 1930, because the existence of electrons in the 'wave functions' of the Schroedinger Equation need not be assumed unless you choose. The Equation does not demand this. You may assume that discrete material electrons exist, or do not exist. It is up to you. The math of quantum mechanics is neutral and takes no position. The wave functions provide exact values of energy transfers but do not reveal how transfer happens. But knowing how was what Einstein wanted. We will see below that it is not possible to understand energy transfer unless you abandon the notion of a discrete particle and accept the fact: *The electron is a quantum wave structure*. No one had worked on this the last half century, even though Einstein suspected it and Schroedinger proposed it. Few scientists investigated the quantum wave electron since the discrete particle has been accepted for centuries and the wave concept does not advance the popular, richly-funded, high-energy accelerator physics of discrete particles.

"He who pays the piper calls the tune."

B. Historical Proposals for a Wave Structure of Matter (WSM)

William Clifford (1845-1879) a brilliant mathematician whose legacy includes modern Clifford Algebras, lectured before the Cambridge Philosophical Society [3] on *The postulates of the Science of Space*. He discussed our ability to deduce the geometry of space at astronomical distances and in space too small (i.e. particles) to be observed, stating: *I hold*

1) *That small portions of space are in fact analogous to little hills on a surface which is on the average flat, namely that the ordinary laws of geometry are not valid in them.*
2) *That this property of being curved or distorted is continually being passed on from one portion of space to another after the manner of a wave.*
3) *That this variation of the curvature of space is what really happens in that phenomenon which we call the motion of matter, whether ponderable or ethereal.*
4) *That in this physical world nothing else takes place but this variation subject to the law of continuity.*

He was bold enough to conclude that the entire physical world (*motion of all matter)* therefore all of science and the Universe, was a result of this property of space. This implied that all matter and motion was contained in ONE entity – space. In hindsight, this paper shows that his analysis of the geometric properties of space, more than a century ago, before quantum waves were discovered, were correct.

In 1937, Irwin Schroedinger [4] proposed to eliminate point particles by using a quantum wave structure. He wrote: *What we observe as material bodies and forces are nothing but shapes and variations in the structure of space. Particles are just schaumkommen*

(appearances*)*. That is, quantum waves structures are real and discrete material particles are not. Instead all matter is a wave structure in a quantum medium while material bodies are only their appearance to us. As the father of modern quantum theory, he added one element to the work of Clifford – that the structure of the waves of space lead to the appearances we observe of discrete particles and to the rules we measure for their behavior. Again, by including all material bodies and forces, he was concurring with Clifford that one substance (space) is the basis of everything.

A partial wave structure was found by Wheeler and Feynman [5] in a 1945 pioneer attempt to find the energy-transfer mechanism of the electron – typically light. He sought a *response of the universe* to the acceleration of an electron, by calculating waves traveling inward and outward from the location of the electron center. This is reviewed in Section E below. In 1986, John Cramer gave elegant arguments in the Reviews of Modern Physics that quantum waves were a real aspect of the universe and not mere probabilities, as was commonly thought.

These leading scientists had concluded that the logical structure of matter is quantum waves in space. A goal of this paper is to show that their far-sighted conclusions were correct. Recent mathematical proofs by Wolff [6,7], and Mead [8] are reviewed and summarized in section H below.

C. The Problems of the Discrete Electron Seen by Einstein and Others

The structure of the electron has always been a puzzle and in hindsight the reason is the erroneous belief that it is a discrete material particle. Einstein deduced this particle was impossible since Nature's forces and properties do not match the belief. Einstein and other philosophers realized that matter is inseparable from the space it occupies. To find the solution only a simple step was needed: Replace the material point electron with a spherical quantum-wave electron. This fulfills early proposals by William Clifford and Schroedinger, but it is a new electron structure in current main-stream thinking. Surprisingly, all the natural laws are found embedded in the wave structure of the electron – as proposed by them.

'Truth is no match for emotions.'

Eric Storri a science historian at Bradley University has carefully studied [1] the accuracy of the periodic table of the elements, a foundation stone of every chemistry course. He finds the rules of counting electrons in orbits do not always work. He questions the assumption that electrons exist inside the wave functions, writing, *According to quantum mechanics the very notion of individual electrons in stationary states was shown to be invalid.* He concludes, like Einstein, that a full understanding of the Atomic Table requires a better knowledge of the electron.

In 1950, Einstein [2] thought about the mechanism of the transmission of force from one particle to another and concluded that space must possess a property that extends throughout space to connect particles. In this sense, he agreed with Schroedinger and

Clifford. His knowledge of Nature told him that discrete particles cannot exist because their borders would be an abrupt discontinuity. Particles and space must be continuous. Further, assuming the Bohr concept were true, he asserted the notion of a discrete particle being "everywhere at once" is impossible to imagine. He pointed out that these Bohr ideas are never found in Nature. He rejected the point particle and Maxwell's field Equations, writing: *The combination of the idea of a continuous field with that of material points discontinuous in space appears inconsistent. Hence the material particle has no place as a fundamental concept in a field theory. Thus even apart from the fact that gravitation is not included, Maxwell's electrodynamics cannot be considered a complete theory.*

D. Understanding Energy Exchange

We cannot learn anything from Nature without an energy exchange that tells us something has happened. Experience tells us that communication or acquisition of knowledge of any kind occurs only with an *energy transfer* such as light. Storage of information, whether in a computer disk or in our brain, always requires an energy transfer. Energy is required to move a needle, to magnetize a tape, to stimulate a neuron. There are no exceptions. This rule of nature is embedded in biology and our instruments. Thus, finding the energy transfer mechanism between particles is essential to understanding light, the electron and the natural laws. We must probe energy deeply. Thus, we cannot accept any statement about the measurement of a natural event unless we verify the energy exchange that allowed it. Skepticism is good for science.

To understand the mechanism of energy exchange, we first need to understand its subtle basic meaning. Most people assume that they understand energy exchange because they deal with it every day; Like putting gas in your tank, it is simple and no further thought is needed. This is a logical trap because our human scale experiences are not a guide for the real energy exchanges that take place on the quantum micro level of electron and atoms. Use the technique of Einstein and Socrates and first ask, "What is energy exchange?"

The mechanism of energy transfer had been sought using Maxwell's Equations (ME) and electromagnetic fields but there were problems: The electron has spherical symmetry but MEs have no wave solutions in spherical coordinates. Another problem was the infinite fields (singularities) of the point electron at the center. Singularity avoidance was attempted using a "renormalization" process wherein infinity was subtracted from infinity to obtain the desired result. In 1937, Dirac commented [9]: *This is just not sensible mathematics. Sensible mathematics involves neglecting a quantity when it turns out to be small - not neglecting it just because it is infinitely great and you do not want it.*

Feynman commented on the renormalization problem: *But no matter how clever the word, it is what I call a dippy process! Having to resort to such hocus pocus has prevented us from proving that the theory of quantum electrodynamics is mathematically self consistent. I suspect that renormalization is not mathematically legitimate*.

E. Wheeler and Feynman's Calculation to Find Energy Transfer

In 1945 Wheeler and Feynman (W&F) sought [5] the mechanism of energy transfer by calculating electro-magnetic radiation from an accelerated electron. The electron generated outward and inward waves and evoked a *response of the universe* from absorber charges. W&F calculated the electron mainly to find a fundamental understanding of the universe so they looked at many ideas. They discussed this with Einstein who suggested a proposal by Tetrode [10] that light was two-way communication exchange between source and receiver utilizing in- and out-waves. Tetrode wrote, *An atom that emits light from a star one hundred light years away, knew then, one hundred years ago, that it would enter my eye today, before I was even born.* They considered this proposal realizing it was controversial because in-waves appear to violate the causality principle: *Actions should not appear before their causes*. W&F wished to use in-waves but avoid violation. Their mathematical goal was to verify a formula for radiation force found by Dirac using in-out scalar quantum waves.

They assumed the accelerated electron generated both in- and out-waves. The out-waves then stimulated absorber charges in the universe whose waves returned to the initial charge, a *response of the Universe*. Upon arrival, those waves became in-waves of the initial charge. Remarkably, but as intended, causality was not violated because in-waves from the absorbers were cancelled upon arrival at the initial charge by opposite in-waves of the charge. Force on the electron was assumed to be the product of charge times half the difference of total in- and out-wave amplitudes. Dirac's formula was verified, independent of absorber properties provided that absorption was complete.

W&F described the wave behavior: *Absorber charges at a large distance produce spherical waves headed towards the source. At the moment the source is accelerated these waves just touch the source. Thus all the waves from the absorber charge form an array of approximately plane waves marching towards the source. The Huygens envelope of these plane waves is a spherical in-going wave. The sphere collapses on the source, and then pours out again as a divergent outward wave.*

This description above of in-and out-waves is similar to the quantum waves of the electron that can be obtained rigorously using a scalar wave equation in Section G below. You can conclude that the partial success of W&F's method was due to changing the *vector* e-m waves to *scalar* waves, during their calculation so that in effect they were calculating scalar *quantum* waves, even though they assumed the final sum of waves had e-m properties. This suggested that quantum waves are the real structure of the electron.

F. Philosophical Importance

W&F's work goes beyond explaining radiation forces because energy transfer and the motion of matter are fundamental processes of nature. Further their concept, that the absorbers in the whole universe contributes to each electron, implies an inter-connection, i.e., *Every charged particle is part of the universe and the universe is part of each charged particle.* This caused much speculation and others, such as Hoyle & Narlikar [11], used W&F's work to examine the universe. Cramer [12] in the Reviews of Modern

Physics wrote a *Transactional interpretation of QM*. He used W&F's work to argue that quantum waves were indeed real and e-m waves were not.

G. The Answer to Einstein's Question

Einstein wished to resolve the disparity between the experimental properties of the electron and the commonly assumed discrete electron. He also wanted to know why it appears that "God plays dice" according to the uncertainty interpretation of quantum mechanics using assumed discrete electrons, that he did not believe.

Wolff [6,7], Mead [8], and Haselhurst [13] explored the Scalar Wave Equation and found that its solutions form an in-out quantum-wave structure possessing all the electron's experimental properties that eliminates the paradoxes of quantum mechanics and cosmology. This wave structure completely replaces the material particle. This is what Einstein wanted to know. Finding that the material particle electron does not exist, removes the probabilistic interpretation of the wave functions and assures us that God does not play dice. Their mathematical approach below describes the electron, its origin and role in the universe.

H. Solutions of the Scalar Wave Equation

Principle I – The scalar wave equation in Space. Because space of the universe is 3D, the immediate logical path is to seek solutions of the well-known scalar 3D wave equation. It is not necessary to consider the vector wave equation – so familiar in radar wave guides – because it has no solutions in 3-D space. Thus this single choice was easy to make.
There are only two spherical wave solutions:

$$\text{Outward wave} = \mathbf{Ø}\text{out} = (1/r)\ \mathbf{Ø}\text{o}\ \exp(iwt - kr) \qquad (1a)$$
$$\text{Inward wave} = \mathbf{Ø}\text{in} = (1/r)\ \mathbf{Ø}\text{o}\ \exp(iwt + kr) \qquad (1b)$$

Where **Ø** is a scalar wave amplitude, w is frequency = $2\pi mc^2/h$, k= wave number, r = radius from the wave center. The exponential factors produce the familiar sinusoidal wave shape. These two waves can be combined in only two forms that immediately become the structures of the electron-positron. This is the simplest combination of the two continuous spherical waves:

$$\text{electron} = \mathbf{Ø}\text{in} - \mathbf{Ø}\text{out} + \text{CW spin} \qquad (2a)$$
$$\text{positron} = \mathbf{Ø}\text{out} - \mathbf{Ø}\text{in} + \text{CCW spin} \qquad (2b)$$

CW and CCW are rotation (spin) operators of the waves at the center. Each wave pair contains an inward wave that rotates twice [14] at the center converting it to an outward wave as is Figure 1. The rotation fulfills the geometric requirement of continuity and produces the formerly mysterious quantum spin of value $h/4\pi$. Both the amplitude of the waves and the direction of rotation are exactly opposite in the electron and positron. This is the reason that experimentally their superposition produces *annihilation.*

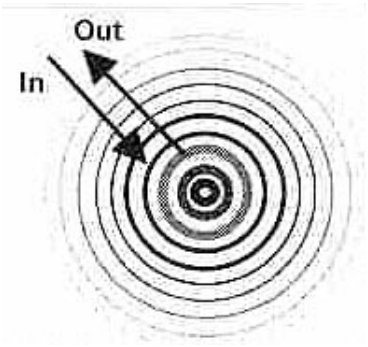

FIG 1. The spherical waves of the electron or positron. Each is a pair of waves, one converging, one diverging, that form a continuous resonant structure in space. The wave amplitudes of the electron are exactly opposite to those of the positron. Rotations of 720^o at the center that transform in-waves to out-waves, are also opposite. The resulting spin = $\pm$ h/4π. Thus, superposition of an electron and a positron causes annihilation since Eqn. 2a = - Eqn. 2b.

W&F in Section E above, described almost perfectly the behavior of the actual waves of the electron or positron even though Eqns. (2a & 2b) were not known at that time. The formation of the in-waves as a Huygens superposition of out-waves from other particles (absorbers) in the universe, shown in Figure 2, accords with other calculations. At the time, W&F were not aware of the 720^o rotation of the in-wave that changes it to an out-wave. This origin of electron spin was not known before the work of Wolff (6).

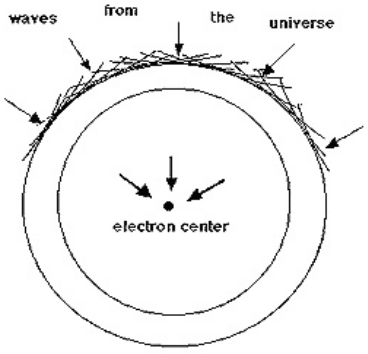

FIG 2. Formation of the in-wave. The spherical out-waves of an initial electron encounter other electron wave-centers. At each encounter, a signature of the initial electron is transferred to the out-waves of the other electrons. The waves generated become a Huygens combination, the in-wave of the initial electron. This intermingled exchange of waves makes each particle like a 3D hologram of all others in the universe, Wolff [16].

The second Principle II is used to calculate the density of the quantum wave medium – which is the apparently empty space all around us. The source and role of the medium was foreseen in 1883 by Ernst Mach [15] who noticed that the inertia of a body depended on the presence of the visible stars. He asserted: *"Every local inertial frame is determined by the composite matter of the fixed stars (the universe)"* and jokingly, *"When the subway jerks, it is the fixed stars that throw you down*." His deduction of the familiar law F=ma, arose from two different methods of measuring rotation. First, without looking at the sky one can measure the centrifugal force on a rotating mass m and use the inertia law F = ma to find circumferential speed and position, as in a gyroscope. The second method is to compare the object's angular position with the fixed (distant) stars. Both methods give exactly the same result! We experience this result in ordinary life too. The laser gyro used in most commercial aircraft is an important example. We conclude from our experience and Mach's principle: That the masses of the universe create the wave medium in all spaces of the universe, including Earth.

How is Principle II obtained from Mach's principle? Wolff [6] extended Mach's principle to calculate the density of the wave medium, as the summation of waves from each particle (10^{80}) in our Hubble universe, each diminished by the inverse square law of

distance. This is Principle II. After you find the density of the medium you can calculate the amplitude of waves and motion of each particle because wave velocity c is determined by the density of the space. The energy transfer carried out by the quantum waves of the electron at speed c is seen by us as light waves.

At first, Mach's Principle was criticized because it appeared to predict instantaneous *action-at-a-distance* across empty space. How can information travel from here to the stars and back again in an instant? It cannot. The answer is that the energy exchange mechanism, formerly unknown, is the interaction of waves from accelerated matter with the universal medium everywhere. Space is not empty because it is a quantum wave medium created by waves from every particle in the universe. Inertia, charge, and other forces are mediated by the pervasive space medium. There is no need to travel across the universe.

It is important to realize that inertia is an interaction between an accelerated object and its surrounding space. You should not try to imagine that the object is interacting with the distant stars. Instead the density the surrounding space is already created by the presence of waves from the distant stars. This agrees with laboratory experience with gyroscopes, accelerometers, and the laser gyros used to navigate aircraft. Before knowledge of the role of the space medium, this was a paradox called *action-at-a-distance*, originally stated by Newton.

If you think this over carefully, you will see a strange feedback loop in Nature, as follows: *The matter of the universe combines to tell the space medium what it is and in turn the medium tells all matter how to behave.* All the waves from all matter combine at each point in space to determine the density of space there. The density of space then determines the wave amplitude and motion of matter (electrons) there which together constitute the universe.

The reader may be inclined to disbelieve this strange result. But there are several confirmations, one of which is Einstein's General Relativity (GTR) which contains the same feedback loop: Reduced to basics, GTR calculates the density of space-time at each point in space using the density of matter and energy everywhere in the universe. A varying density is referred to as *curvature of space*. This space density is then used to determine the paths of moving matter and of light which follows the curvature. In short, *All the matter of the universe combines to tell space how it must behave and in turn all particles tell the matter of the universe what it is.* The feed back loop is the same. This is not surprising because we find that all physical laws are found in the WSM and the space medium. If GTR were <u>not</u> included this would be unexpected indeed. Nevertheless, this feedback in Nature is puzzling and perhaps the reader can assess its further meaning.

Principle II also yields an eye-opening relationship [6] between the effective radius **r** of the electron, the radius **R** of the Hubble universe and the number **N** of particles in the universe, termed the *Equation of the Cosmos*:

$$\mathbf{r^2 = R^2/\sqrt{\ [3N]}}$$

This value of **r** corresponds with the classical electron radius, approximately 10^{-15} m. The waves of an electron have a finite maximum wave density at the center because they are waves - not a discrete particle. This removes the need for the 'normalization' that disturbed Dirac and Feynman.

We don't easily see the space medium because our survival as an animal species depends mostly on our ability to fight with other animals seeking food, and to compete for mates that produce children. Observing the medium would not help our survival. In our self-focused human perspective few of us are even aware of the wave medium in which we exist. For survival, it doesn't matter what space is, or whether we can observe it - it exists nevertheless. As Sir Oliver Lodge quipped:

A fish cannot comprehend the existence of water. He is too deeply immersed in it.

I. Origin of the Natural Laws

The wave structure of the electron Eqns. (2a & 2b) contains the natural laws as experimentally observed. The mathematics are derived by Wolff [6,7] and summarized as follows:

a) The most surprising consequence of the WSM is found from the Doppler effect between two relatively moving wave structures. One is an observer and the other is a source. Using Doppler math, you can derive the relativistic mass increase, the Compton and deBroglie wavelengths, and consequently the Schroedinger Equation. At first it seems astonishing that all these occur together but upon reflection it is logical since each of them depends on relative velocity. They are calculated by writing two waves, like Eqns. 2a or 2b, for the two relatively moving electrons. The Doppler effect is then inserted into both the inward and outward waves. Then you find that each term of the resulting total Doppler shifted wave that contains mass or frequency, has a relativistic mass-increase factor. The Doppler wavelength becomes the deBroglie wavelength, and, the phase velocity contains the Compton wavelength. And of course, there is no dependence on the direction of the relative velocity, as is experimentally observed. There was no theoretical explanation of this before the WSM. Now the reason is immediately clear: Both the in- and the out-waves have symmetrical roles in the Doppler thus there can be no directional dependence.

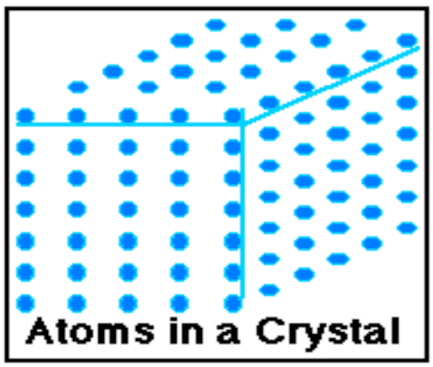

FIG 3. Apparent location of charges.
The wave structures of atoms and the electrons around their centers arrange themselves in a configuration of minimum amplitude or minimum energy. For example, in this crystal, the minimum amplitude arrangement is equal spacing of the wave centers. As a result, most of the wave amplitude of an atom or electron is concentrated around a point. This produces the appearance of a 'particle' that we emotionally expect, as predicted by Schroedinger.

b) Electron and positron waves annihilate when super-imposed. This is immediately obvious because Eqn. 2a = - Eqn.2b.
c) Spin of $h/4\pi$ occurs due to rotation at the center of the in-wave to become an out-wave. This rotation is described by the SU2 group theory of Battey-Pratt [13].
d) The Conservation of Energy is because only identical wave states can resonate with each other, producing equal and opposite frequency (energy) shifts.
e) Electric force interactions appear to occur (as proposed by Schroedinger) at the high-density centers. The wave centers appear to us like point charges, as in Figure 3.
f) Gravity – By definition, the in-wave, on arrival at the center, establishes the position and motion of a particle. Matter nearby modifies the density of the surrounding medium, according to Principle II. The changed medium density changes in-wave motion, moving the particle toward the matter. This is the cause of gravity as well as other forces.
g) The CPT (charge, parity and time) transformation properties of an electron have been known in experimental QM for many years but the reason has not been known. Now you can show with a little algebra that Eqns. 2a or 2b contain this property.
h) Inertia - The acceleration of matter changes its Doppler frequency relative to the wave medium. Restoring frequency equilibrium produces energy exchanges with the medium that appear as local force F=ma. The total energy exchange will follow the relativistic rule from a) above which at small velocity become the familiar, $KE = 1/2mv^2$.

J. New Applications in Electrodynamics

Prof. Carver Mead, an engineer at Cal Tech investigated the e-m consequences of the WSM in his 2002 book "Collective Electrodynamics" [8]. This book is very popular in Silicon Valley because it shows correct ways to solve the electromagnetics of transistor circuits. MIT awarded him two prizes for his book. He recognized that the electron is not a point particle but a wave structure, thus the old point approximations of Maxwell's Equations do not work when dimensions approach the quantum region, especially magnetism. He began with the observed effects of wave structure at low temperatures [17] to derive a vector potential in place of the erroneous magnetic terms of Maxwell Equations, as foreseen by Einstein. Mead has begun a new field of *Natural Electrodynamics* to replace the former work-horse, Maxwell's Equations. Improved rules of optics should also emerge.

K. Conclusions

The proposals of Clifford and Schroedinger were correct that an electron is a continuous wave structure in space, not a material particle, and point particles and electromagnetic waves are merely appearances (s*chaumkommen*). The Schroedinger wave functions must be interpreted as the electron itself, not as probabilities. Many classic paradoxes, including, 'renormalization', wave-particle duality, and Copenhagen uncertainty, no longer occur because they were caused by the notion of a material particle that does not

exist. There is no causality violation because the in-waves are real and do not run backwards in time.

The wave medium - the space around us - is the ONE source of matter and the natural laws. Because the waves of each particle of matter are inter-mingled with the waves of other matter and all contribute to the density of the medium, it follows that every charged particle is part of the universe and the universe is part of each charged particle. Although the dominant portion of each particle wave lies near the center, every wave structure reaches to infinity.

Principle II (extended Mach principle) states that the stars and galaxies of the universe are essential to the laws of Nature and to the existence of the Earth and ourselves. This important fact is not presently familiar to the physics community. For example, the present Physical Society Standard Model of the universe contain no recognition of Mach's Principle, our dependence on the universe, or the interrelationships of matter throughout the universe. But it is unthinkable that the Earth, and us, could exist without the presence of other cosmological matter.

The propagation of light in a fiber is a quantum-wave energy exchange between molecules at the input device and molecules at the receiving device. The fiber serves to guide the exchange of waves between them. This truth of Nature will profitably replace the misleading photon 'bullet' which served only to calculate energy conservation.

There is a dark side to the development of science. It is tempting to imagine scientists as noble pioneers, questing for the greater good of humanity, and transfixed by the wonderful mysteries of the world. However the day to day history of nearly every radical discovery tell an entirely different story portraying a community that usually votes its pocketbook. Scientists are no different than you or I. Recognizing this will help understand why the science community had not avidly sought the Wave Structure of Matter. It takes a long time to dispel treasured scientific illusions even though following the path of the discrete particle led science down a dead end street.

L. The Future

There will be many new valuable applications of the WSM not only in micro-chip design and cosmology but especially in technologies concerned with the behavior of matter at molecular dimensions. The behavior and properties of metals, semiconductors, and ceramics depend on previously unknown interactions between their different composite elements, nearly always mediated by the waves of the electrons. Now it will be possible to create new '*designer alloys'* and also '*designer catalysts'*, instead of finding them by trial and error.

Understanding the quantum world allows us to interpret observations at low temperature where electrons, not disordered by heat motion, move in quantized collective motion, as

found by Meade. The losses of energy known as electrical resistance are due to electron wave interactions in metals of the wires. Thus, understanding the waves should lead to improved power transmission.

Extremely subtle interactions between complex organic molecules are used in the growth and chemistry of living matter. The primary physical tool to understand the role of the interactions has been the conservation of energy. Now, to that can be added the 3D overlap of the waves, as illustrated in Figure 3 because we now understand the *structure* of the wave patterns.

The chips of computer technology are increasingly using chips with smaller and smaller dimensions. Their properties will increasingly depend on the Wave Structure of their matter. Proposals to build molecular computers and electron spin memories will similarly benefit from knowing the wave structure of the molecules and the electron.

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