

The Origin of Instantaneous Action in Natural Laws

By Milo Wolff – Milo Wolff's Quantum Science Corner

ABSTRACT: In the last millennium we learned that objects obey fixed laws of nature. Until the last decade, these laws have been entirely empirical; that is, the laws were measured properties of nature, no theoretical or physical origin was known. These measurements indicated that the movement of energy and information, which are needed to carry out the laws, travel consistently at the speed of light. This motion satisfied our rule of causality; that is: *Events always occur after their causes.*

However, some events have annoyingly seemed to violate the rule of causality. Certain forces and events seem to be transmitted instantaneously. These events are the transmission of energy and information which are related to the gravitational force, the magnetic force, inertial force, and relatively new phenomena termed "The EPR Effect " (Einstein, Podolsky and Rosen) and the Mossbauer Effect.

It is the purpose of this article to explain the origin and cause of the strange instantaneous events associated with these laws. We will show that causality is not actually being violated. Instead, the strange events are merely appearances, "schaumkamm" in the words of Irwin Schroedinger. They were created by our former incomplete knowledge of the Wave Structure of Matter and of the energy exchange mechanism of quantum wave structures. All communication is actually at velocity c .

In order to understand this it is first necessary to review the origin of the natural laws and the newly developed Wave Structure of Matter, because the cause of these events lies in this wave structure and the medium of the waves. Without this preliminary review, instantaneous action cannot be explained. The Wave Structure of Matter is an exciting frontier of science which reveals the connectedness of all matter in the universe. It provides new understanding of quantum events and unravels many puzzles, including that of instantaneous action.

A. Wave Structure, Instantaneous Action, and the Natural Laws

INTRODUCTION

The origins of the natural laws from the Wave Structure of Matter are new topics in science. To study them you must first reject the ancient Democritus particle made of 'substances' and replace it with the correct quantum wave structure of matter. The rules of quantum waves are simple and easy to visualize. The hard part is getting rid of old thinking

habits, particularly 'matter substance,' and replacing it with 'wave structure.' One major fault of the particle 'matter substance' concept was that it did not provide answers to fundamental questions like: How are the basic units of time, length, and mass formed? What is the mechanism of energy exchange? What is the origin of the natural laws? What is a photon? What is a particle? The review below describes how the Wave Structure of Matter provides these answers.

The key to understanding 'instantaneous action' is recognition of two ways of energy transfer between quantum structures. One way is direct; source and receiver undergo a resonant exchange. In the other way, the quantum wave medium acts as an intermediate 'broker' in the exchange. It is the broker behavior which leads to the appearance of instantaneous energy transfer. These two will be discussed below when explaining 'instantaneous action.'

The extraordinary revelation of the quantum universe is that the laws of physics are properties of the quantum wave medium which itself is formed from waves of all other matter. Thus, all science grows out of the medium's properties. As we learn more about it, prepare yourself for a fascinating adventure.

B. History of the Wave Structure of Matter

The search for the structure of the electron started over a century ago in H.A. Lorentz's book, *Theory of the Electron* (1909) [1]. In 1876, the famous geometer-mathematician Clifford suggested that all physical laws were the result of undulations (waves) in the fabric of space [2].

Ernst Mach convinced Einstein that any theory of the structure of the universe must contain his inertia principle [3], but Einstein could not incorporate it into relativity because relativity has no medium of communication. Einstein knew this was the weakness of relativity and suggested that matter was a communicating wave structure. In 1924, Einstein's friend, Hans Tetrode, was the first to propose that energy transfer required two-way communication between particles [4].

Louis Duc de Broglie proposed a wavelength $\lambda = h/p$ for the quantum waves of an electron containing an oscillator of frequency $f = mc^2/h$ [5]. Nobel laureate Paul Dirac, who developed much of the theory describing the quantum waves of the electron, was never satisfied with the point-particle electron because the Coulomb force 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!" [6]

Weyl, Clifford, Einstein, and Schroedinger agreed that the puzzle of matter will be found in the structure of space, not in point-like bits of matter [7]. They speculated, "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 represented a charged particle by assuming a pair of spherical inward and outward electromagnetic waves [8]. Their use of advanced (inward) waves is an apparent violation of the principle of causality, "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 work pioneered a key concept that every particle sends outward quantum waves and receives a 'Response from the Universe,' as described later.

Phipps hypothesized that the electron-positron is the fundamental particle of the universe [9]. He reasoned that the infinite extent of charge forces were more fundamental than local effects of baryons. Cramer used an analogy of the inward and outward waves of the Wheeler-Feynman electron to interpret the waves of classical quantum theory as real, in contrast to the older unreal "probability wave." [10] He named them an offer-wave (outward) and a response-wave (inward). In 1990-98, Wolff expanded these ideas and showed the origin of the natural laws [11-26]. In 1996, he pointed out that the Wave Structure of Matter may have anti-particles with anti-gravity. This may remove objections to Hannes Alven's book, *Worlds and Anti-Worlds*, and suggests a solution for the redshift and missing matter paradoxes.

C. Questioning the Natural Laws

As recently as ten years ago we did not know where natural laws come from or even that it was possible to find out. Some scientists believed, in a religious fashion, that we were not allowed to know, that we must just accept the empirical laws given to us by nature. Still others believed that the natural laws were already complete and to obtain further understanding all we needed to do was manipulate them mathematically. Now the origin is found in the behavior of the Wave Structure of Matter. Let's review the basic requirements of the laws by asking questions about their behavior [19, 21, 24].

Particles, Laws, and the Universe are Mutually Dependent. What is the connection between particles and the universe? Without particles the physical universe is undefined because our definition of universe is a collection of particles or objects and their distribution.

Similarly, the natural laws are meaningless without particles because laws require particles upon which to operate. The converse is also true: we cannot identify a particle and its properties without the force laws to locate and measure it. Thus the cosmos, particles, and laws form a trilogy, each dependent on the others for its properties. This trilogy of laws, particles and the cosmos can prevail only if there exists a medium of communication linking each particle to all other particles in that universe. The communication link must establish a uniform measure of time and length for all matter.

Mach's Principle. The above concept, that laws and particles were dependent on the universe, had its first birth with Ernst Mach and Bishop Berkeley 100 years ago, who explained Newton's law of inertia, $F = ma$. At that time, the unknown origin of Newton's law of inertia attracted frequent attention. Mach boldly suggested that inertia depends upon the existence of the distant stars [4]. His reason arose from two fundamentally different methods of measuring a body's rotational inertia. First, without looking at the sky, one can measure the centrifugal force on a rotating 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 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: The laws of inertia are established by all the matter of the universe. It is now known that not only was Mach correct, but his concept applies to all the other laws as well.

Scales of Measurement

Consider two particles in space, Figure 1. They obey natural laws interacting with each other. We know that the laws involve scales of time, length, and mass. How are scales established and communicated between two particles? What process measures the distance between them, establishes the force, and guides each particle to the vector of acceleration it must undergo? Consider the length scale used by the particles. Every particle must have access to the same length scale, otherwise interactions would be chaotic, not the orderly laws we observe obeyed by all particles. But we know if no other matter is present, length scales are meaningless since length is a relative measure. Thus the length scale and the laws which use it must depend on the existence of other matter.

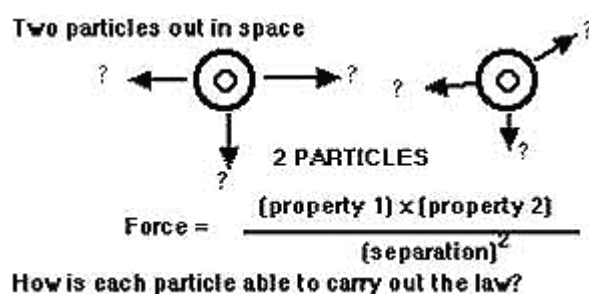


Figure 1. How do Force Laws Operate? Two particles move towards each other obeying a law. How is the direction found? How is the separation measured?

What establishes length scales? Similar questions apply to time. Every particle, everywhere, has to have access to the same clock in order to carry out orderly laws in the cosmos. Where is the universal clock? How is time communicated among all particles? They cannot behave independently so there must exist a common clock related to all the matter of the universe.

The Cosmic Clock

The quantum wave medium pervading all space is common to all particles and establishes the cosmic clock. Such clocks are alike because the homogeneity of the medium of the waves produces a fixed wave frequency. As suggested by de Broglie, the cosmic clock is the well-known frequency of the electron $f = mc^2/h$ [5]. This frequency is a property of the quantum wave medium and, thus, it is the same for all particles. Similarly the uniform quantum wave medium also provides a measure of length - the electron wavelength.

Finding Range and Location

The spherical wave structure of particles provides range and location information for the force laws (see Figure 3). Everyone who has learned nautical navigation knows that the curvature of a wave front is sufficient to determine the range and position of the center of the source of the wave fronts. This is the simple mechanism available to two particles to find their relative range and position.

D. Properties of the Quantum Wave Medium [19,21,24]

Property 1. Dimension scales are a property of the ensemble of matter. The scales of length and mass, for any particle if alone in the universe, would be meaningless because scales of measure can only be defined by comparison with other matter. For example, at least six separated particles are necessary to crudely define length in a 3D space. Thus the scale of length requires the existence of an ensemble of particles. There is no way to choose a special ensemble, thus the required ensemble must include all observable matter. This ensemble creates the quantum wave medium observed in Mach's Principle. The ensemble has to be assigned great importance because time, length and mass are the basic scales used to describe all science and engineering.

Property 2. Interacting particles must communicate with each other. Force laws between two particles cannot operate unless they are aware of each other's location. Continual two-way communication between particles is required to execute the laws of nature. This communication takes place by spherical waves in the space (quantum wave medium) between the particles.

Property 3. The scale of time requires a cosmological clock. Laws cannot operate if particles have no reference to a cosmological clock. Each particle must have a way to relate its own time-related behavior with other particles. Nature's cosmological clock is the frequency of quantum waves in the uniform quantum wave medium common to all particles.

Property 4. Mach's Extended Principle. The only possible reference for changing motion (acceleration or rotation) is the entire ensemble of matter in a universe, as proposed by Ernst Mach in 1883. Not only inertia, but other laws of physics must similarly depend on the matter of the universe mediated by the quantum wave medium.

Property 5. Natural constants. The extension of Mach's Principle shows that the natural constants such as c , h , m , and e also depend on the quantum wave medium. These constants determine measurable properties of solids and electromagnetism: For example, the solid crystal array, shown in Figure 2, is a space matrix of atoms held rigidly in space. How are the atoms suspended in space? We must conclude that the crystal's rigidity derives from fixed standing quantum waves propagating in a rigid quantum wave medium. Calculations for diamonds and nuclear structure, yields an enormous rigidity.

Property 6. Particles are wave structures. The wave structures are found below as solutions of Principle I - the Quantum Wave Equation. As we will show, wave structures, like the electron, are produced by properties of the quantum wave medium. In the laboratory, these wave structures have measured properties identical to what we call 'mass' and 'charge.' Accordingly we realize that mass and charge 'substances,' as such, do not exist.

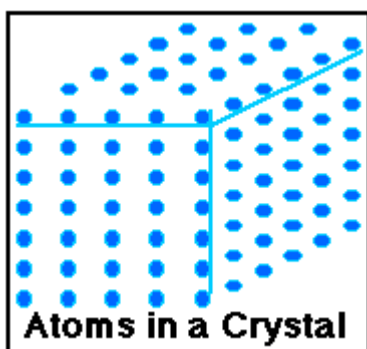


Figure 2. The Presence of the Quantum Wave Medium. The nuclei of the atoms in a solid crystal are suspended in a lattice of the quantum waves of their surrounding electrons. The lattice consists of three sets of standing waves forming the boundary of the crystal. Suspension of the lattice, in apparently empty space, reveals the presence of the quantum wave medium.

Discussion of the Quantum Wave Medium

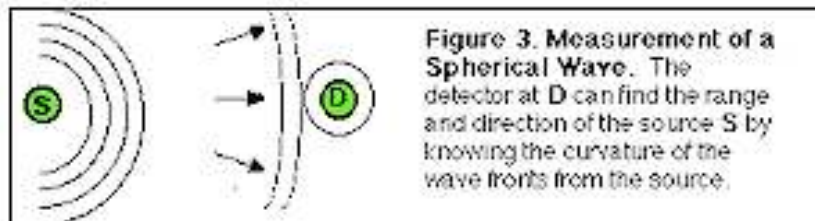
The rule of simplicity of nature is remarkably true for the quantum wave medium. This single entity underlies all the laws of nature. The entire content of physics, the structure of matter, space and time, and the natural laws, arise from only three mathematical principles which govern the behavior of the quantum wave medium.

The Next Scientific Revolution

The quantum wave medium is a new revolution in science! Because the quantum wave medium, or “space” or “vacuum,” is the basis of the structure of matter as well as the natural laws, it is the biggest topic in basic science. The task of studying the quantum wave medium is NOT a minor dissident issue. It is the source of nature’s laws and it is the frontier adventure.

E. Energy Transmission by the Quantum Wave Medium

About 1900, an ether concept arose to explain the transmission of light and other electromagnetic (e-m) waves. Scientists sought to find a propagation medium similar to air, the medium of sound waves. No such ether medium for e-m waves exists. Instead the wave phenomena involved is actually quantum waves and a quantum wave medium supports these quantum waves. What appeared as e-m waves were large numbers of energy exchanges between quantum states and acting in concert. Insensitive apparatus does not see single exchanges. Quantum waves and the quantum wave medium are real physical entities, whereas e-m waves are calculations of our subjective impressions. The failure to recognize that e-m waves are a representation of many quantum exchanges has been the root cause of much confusion.



F. The Three Principles of the Quantum Wave Medium

Only three basic principles are needed to describe the properties of the quantum wave medium and the structure of the electron and other particles. The first principle determines the form of the quantum waves which propagate in the medium. The second principle describes how the medium is formed by all the matter in the universe. The third principle describes how waves combine to minimize amplitudes in space.

Principle I - The Quantum Wave Equation. The following Wave Equation from Wolff [11, 12, 13] determines the form and character of waves propagating in the quantum wave medium:

$$\text{Del}^2(\text{AMP}) - [1/c^2] \text{d}^2(\text{AMP})/\text{dt}^2 = 0 \quad (1)$$

where Del is the differential operator, AMP is a scalar quantum wave amplitude and c is the wave velocity. The solutions of this equation are spherical waves whose centers are the measured location of particles. The waves extend everywhere, but energy exchanges appear as if there was a point of charge.

G. The Wave Structure of the Electron

Structure of the Electron

Most people, even some scientists, prefer to imagine that the electron is a "particle" like a baseball or a bullet. Laboratory evidence does not support this idea. Instead, an electron is a quantum wave structure, shown in Figure 4, whose spherical waves travel with fixed velocity c in the quantum wave medium. Its nominal location is the spherical center. The electron is composed of two solutions of the Medium Wave Equation: an inward and an outward spherical quantum wave traveling at light speed, c.

$$\begin{aligned} \text{AMP}(\text{electron}) &= \text{AMPIN} + \text{AMPOUT} \\ &= (1/r)\text{AMPo} e(i\omega t + ikr) + (1/r)\text{AMPo} e(i\omega t - ikr) \\ &= \text{AMPo} e i\omega t \sin(kr)/r \quad (2) \end{aligned}$$

The exponential factor is an oscillator of frequency ω and wave number k . The sine function modulates the oscillator with a standing wave of wavelength $2\pi/k$, the Compton wavelength of the electron. AMPo contains the numerical constants. The inward wave rotates phase at the center, reverses direction, and becomes the outward wave. The factor $1/r$ causes the wave amplitude to decrease inversely as the radius increases. At $r \rightarrow 0$, the amplitude of the separate waves is infinite. But when the two solutions are combined the opposite signed infinities cancel and a finite standing wave results.

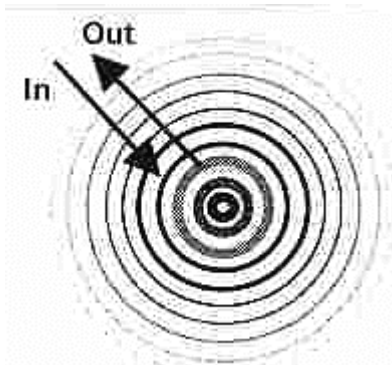


Figure 4. Electron Structure. The IN and OUT waves combine to form a standing wave. The amplitude of the continuous quantum waves is a scalar number, not an electromagnetic vector. At the high density center, the standing wave amplitude is finite, not infinite. At the center, the IN wave rotates 180 degrees converting it to an OUTwave.

This fixed rotation creates the + or - quantum spin. It becomes an electron or positron, depending on the rotation direction.

Formation of the IN Waves. It is mathematically convenient to envision a particle alone, comprised of its IN and OUT waves, separated from other particles in the universe. This simple structure allows us to examine and study the particle, uncluttered by waves of other particles. But this simplest representation does not allow us to understand the origin of the inward waves. We are puzzled because we have ignored other waves from the universe.

Two hundred years ago Christian Huygens, a Dutch mathematician, found that if the spherical wavelets from multiple sources in a flat surface were examined at some distance away, the wavelets combined their separate amplitudes to create another larger wave-front. This plane wave is said to be a 'Huygens combination' of the separate spherical wavelets. Huygens combinations can take many forms; for example, a line of sources will form a cylindrical wave-front.

Apply Huygens discovery to the single electron and consider each particle's waves as composed of the Huygens components of all other waves. The electron's in-wave is a Huygens combination of wavelets, formed from "reflections" of its own out-wave after encountering other particles in the universe. At each encounter, a signature of the initial particle is transferred to the out-waves of the other particles. These outward wave signatures return as a 'response from the universe' [8]. When the response waves arrive at the initial particle center, they form its in-wave. You can envision the entire structure of the electron as an enormous spherical standing wave, obscured in a sea of other waves. The electron waves travel between the particle center and other matter of the universe.

We Are Part of the Universe! A particle cannot exist without all the other particles in the universe. Each particle depends on all other particles to create its in-wave. Thus, in a very real sense, the substance of our bodies is part of the universe and the universe is part of us. We are totally inter-dependent. Take a breath now! The forced conclusion is awesome. We have to think of ourselves, our bodies, our brain and its mind, every atom and molecule within us, as inextricably joined with other matter of the universe. If the rest of the universe did not exist we could not exist.

At this point we have to take a hard look and ask, "Is this crazy? Is this science fantasy? Or is there evidence to prove that the universe really behaves this way?" The answer is: "Yes, it is more real than the old physics." The indisputable proof is that this wave structure correctly predicts the origin (below) of the empirical natural laws which had never been known before.

Spin of the Electron

The nature and cause of spin was unknown before the Wave Structure of Matter. Quantum spin occurs when the returned inward wave rotates at the wave center with a phase shift to become an outward wave. The phase shift requirement is similar to light reflecting at a mirror. Phase shift requires a 180 degree rotation of the wave, either clockwise or counter-clockwise. The two rotation choices produce angular momentum of $+\hbar/2$ or $-\hbar/2$. One choice is an electron with +spin, the other is a positron with -spin. Thus the electron is the mirror-image of the positron.

Rotation of the inward waves involves an astonishing property of 3D space called spherical rotation. This allows the electron to retain spherical symmetry while imparting a quantized "spin" along an arbitrary axis. The rotation property is described by Misner, Thorne & Wheeler [27]. Batty-Pratt & Racey show how this property leads to the famous Dirac Equation [28]. Wolff shows how the spin rotation operators multiply Eqn (2) [23]. Then the electron wave becomes,

$$AMP_{total} = ROT_{in}AMP_{in} - ROT_{out}AMP_{out} \quad (3)$$

Where ROT_{in} and ROT_{out} are the Dirac operators which rotate the waves. Eqn (3) is the link between the Wave Structure of Matter and the Dirac theory.

Principle II - Source of the Quantum Wave Medium. Both logic and observation have told us that the presence of all matter of the universe must determine local natural's laws, such as inertia, according to Mach's Principle. A quantum wave medium has to be created throughout all of space by all the matter of the universe. Wolff [11, 12, 13] expresses this as:

N

$$mc^2 = hf = \hbar k' \sum_{n=1} [AMP_n^2 (1/r_n^2)] \quad (4)$$

That is, the mass and frequency of an electron are proportional to the sum of the intensities of waves from all the particles in the universe, including the waves of the electron itself. The variables m and f are the mass and frequency of that electron, c is the velocity of light and h is Planck's constant.

This basic principle is a prescription for the density of the quantum wave medium. The density is proportional to the sum of wave intensities from all matter, producing Mach's

Principle. The principle yields a density nearly uniform everywhere as required by Property 3 of the quantum wave medium, uniform because there are an enormous number of particles contributing to the density.

Testing Principle II. How do we know that the quantum waves are really dense at the electron center? This is not obvious. We can test by comparing the wave intensity from the universe with the local intensity of the electron's wave. The local intensity at some small radius, say r_0 , must equal the total intensity of the waves from the other N particles in a universe of radius R . This condition results in:

$$r_0^2 = R^2/3N \quad \text{"Equation of the Cosmos"} \quad (5)$$

Is the test correct? We find out by putting in the usual values from cosmology: $R = 10^{26}$ meters and $N = 10^{80}$ particles. Then the radius r_0 equals 6×10^{-15} meter. This radius must be similar to an electron center. It is! It almost matches the classical radius which is 2.8×10^{-15} meters. Since R , N and r_0 are vastly different sized numbers, this match is not a coincidence. It is proof that dense electron centers really exist, confirming Principle II. Eqn (5) is also a relation between the size r_0 of an electron and the size of the universe, R . The size of an electron depends on all the matter contained within the universe! This fulfills Properties 4 and 5 of the quantum wave medium.

Mass and Charge Depend on the Parameters of the Universe. The Equation of the Cosmos also indicates how matter-waves from the universe produce the mass, mc^2 , of each electron: Combine (5) with the Compton wavelength $r_0 = h/mc$, to get:

$$mc^2 = hc \sqrt{3N}/R \quad (6)$$

We see that mc^2 depends on R and N .

Charge is conserved. The electric charge e^2 also depends on the total N particles. Combine the Equation of the Cosmos with the classical electron radius $r_0 = e^2/mc^2$ to get:

$$e^2 = mc^2 R / \sqrt{3N} \quad (7)$$

The appearance of the factor e^2 is noteworthy! Recall that charge e never occurs alone in physical laws, but always occurs as the product e^2 . Thus e^2 is the meaningful constant. We see that charge e^2 is a property of the quantum wave medium (through R and N). This is why there is only one value of charge in nature. Stop and think a moment about Eqns (6 and 7). They state that the basic constants e , m , and h depend only on the matter in the

universe, R and N. Thus the quantum wave medium underlies the natural constants of science as well as the laws!

H. Energy Exchange Mechanism of Particle Wave Structures

Energy transfers between quantum states in atoms and molecules are the fundamental basis of scientific measurement and knowledge. Calculations and thought processes cannot take place without energy transfers. Every measurement and observation is a transfer of energy between a quantum source and receiver. Storage of information, whether on a computer disk or in our brain, always requires an energy transfer.

Mechanism of Energy Transfer

An energy transfer usually occurs between two atomic or molecular quantum states, a source and a receiver. In the source, an energy shift occurs downward. In the receiver, an equal shift occurs upward. This equality is the origin the conservation of energy. But before the shifts occur, the in/out quantum waves of source and receiver must exchange information to determine that the energy exchange is possible. The preliminary information exchange is accomplished by the in/out waves. At the end of the process, the two final shifts can be observed in our lab. No 'photon' travels from source to receiver. The photon concept is very useful for calculation, but is not a reality. Note that an energy shift, dE , is equivalent to a frequency difference, $df = dE/h$. Energy, mass, and frequency are equivalents.

Frequency mixing of the in/out waves and information comparison can occur because wave propagation in the dense centers is non-linear. Mixing is similar to A-C signals flowing through a non-linear element, like a diode in an electronic circuit. That is, if two signals are inputs, the output will contain the two signals plus the sum and difference frequencies of the two signals. If the frequency of one wave matches another, resonance occurs. An example is a tuned radio receiver.

Principle II provides the non-linear element because of the large density 'bump' of the quantum wave medium near the center of charged particles. This bump corresponds to the mechanism we call "charge." The electron wave structure looks like a point particle because energy exchanges take place at the tiny non-linear central bump. No mass or charge substance is needed.

Principle III - The Minimum Amplitude Principle (MAP)

Principles I and II provide particle structure and the energy exchange mechanism. But a third Principle is needed to determine the direction in which energy exchanges proceed. This Principle governs particle energy exchanges similar to the entropy law which always decreases available heat within a thermodynamic system. It makes water remain level in a lake. The Minimum Amplitude Principle is:

The total amplitude of particle waves at each point in space always seeks to minimize itself or,

$$\text{Integral } (AMP_1 + AMP_2 + AMP_3 + \dots + AMP_n)^2 dx dy dz = \text{a minimum} \quad (8)$$

$dx dy dz$ is a small volume of space. How does this principle work? First, note that the principle sums wave amplitudes, not intensities. The MAP minimizes the total wave amplitude by moving the wave centers. For example, consider two identical electrons which have identical wave patterns. The two electrons will move apart (repulsion of like charges) in order to reduce the total wave amplitude. But if one of them is a positron with amplitude opposite to the electron, they move together (attraction). Then their amplitudes partly cancel, satisfying the MAP. If their opposite centers move together and coincide, they annihilate each other and their energy, $2mc^2$ is transferred to other particles.

Another example is the Pauli Exclusion Principle. In this case, MAP prevents two identical electron resonances (fermions) from occupying the same state because their total amplitude would be a maximum rather than a minimum. Also, electrons in atomic "shells" always take the pattern of the lowest level. Again we see the awesome conclusion that quantum waves establish and rule the universe.

I. Explanations of Instantaneous Action

Energy Exchanges to the Medium

Principles I and II are basic to the instantaneous action phenomena. They determine the process of all energy exchanges whose speed of transfer was the heart of the action controversy. Instantaneous action occurs when there is an exchange of energy, weak compared to the much stronger electric force exchange. Energy transfer does not take place directly between two objects; it occurs between one object and the surrounding quantum wave medium. This is possible because of the very high density of the medium. Afterwards, the imbalanced medium will readjust to a MAP-determined equilibrium and transfer energy to the second object. Nothing happens instantaneously.

When an exchange takes place, between for example a moving planet and the quantum wave medium surrounding it, the exchange appears instantaneous to us because we think the exchange occurs immediately to a distance object, the Sun. It only appears so because we had a false notion that particles were 'mass substance' in totally empty space without a quantum wave medium. The legacy of Democritus has haunted us for 3000 years!

In hindsight, the only reason this phenomenon appeared puzzling was because we were unaware of the presence of the quantum wave medium as an intermediate agency. Knowing it is there, everything follows the usual rules of mechanics and nothing travels at velocities other than c . Four cases are discussed below:

1. Instantaneous Inertial Forces. Inertial forces were once regarded as mysterious because the quantum wave medium was unknown. It was thought that an instant reaction occurred between an object and somewhere else. Mach's Principle, that inertia depends on the presence of all the matter in the universe, was compelling, but the implied instant action only deepened the mystery. This was dramatized by words attributed to Mach, "When the subway jerks, it is the universe which throws you down!" Now, after understanding the Wave Structure of Matter, we see that the 'instantaneous' forces are local exchanges to the local quantum wave medium. No mystery.

Let's calculate inertia. The forces of inertia, $F = ma$, are tremendously smaller (10^{-40}) than electric charge forces. Therefore they can be perturbations of the electric forces. Acceleration causes a change of the electrons' wavelengths in the quantum wave medium. This wavelength change disturbs the amplitude balance with local waves of the quantum wave medium. The MAP corrects the imbalance by forces to move the accelerated resonance with respect to the quantum wave medium. Forces are energy exchanges which take place between the accelerated electron and local ether waves of all other matter. The recoil energy exchanges are eventually transmitted to other masses of the universe, seeking a MAP equilibrium.

Compute a perturbation, using a force on the accelerated mass analogous to electric force on an accelerated charge:

$$\text{electric Force} = e' \times E \quad (E = \text{electric field}) \quad (9)$$

In analogy,

$$\text{Mass Force} = m' \times M \quad (M = \text{mass field}) \quad (10)$$

The E field of an accelerated charge e depends on the magnetic vector potential A . That is,

$$E = dA/dt = (e) (\text{acceleration}) / (4\pi \epsilon_0 c^2 r) \quad (11)$$

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

$$\text{mass field} = M = (m)(\text{acceleration}) (G) / (c^2 r) \quad (12)$$

The tiny gravity constant G , has replaced the large electric constant $1/4\pi \epsilon_0$, which determines the perturbation magnitude. To find the force on the masses m' , set m' equal to the mass of the universe

$$m' = (\rho)(\text{volume}) = \rho \frac{4}{3}\pi R^3 \quad (13)$$

where ρ = mass density of the universe. Choose the average distance R of masses m' as half the Hubble radius, $R = c/2H$. The force between the particle m and masses m' becomes

$$\text{Force} = (m')(M) = \rho \frac{4}{3}\pi (c/H)^3 (m a G) / [c^2 r]$$

$$= \left\{ \frac{8\pi G \rho}{3H^2} \right\} m a \quad (14)$$

Choose ρ equal to the density of a flat (critical) universe $\rho_c = 3H^2/8\pi G$. Insert it into Eqn (14). Nearly everything cancels so the factor in braces $\{ \}$ above becomes one and the remainder is Newton's Law of inertia, $F = ma$. This surprising result shows that inertial mass equals gravitational mass as observed, predicts a flat universe, and reaffirms Mach's Principle.

This result may clarify another controversial paradox - the cause of the redshift and the big bang. Note that the Hubble radius, $R = c/2H$ above, is proportional to the presumed age, R - of the object m . If the age of m were younger than matter near us, as suggested by the quasar studies of Halton Arp, then the mass forces would be less [29]. This is exactly the requirement used by Jayant Narlikar and Halton Arp to explain the origin of quasars and the redshift without an expanding universe or the big bang [30].

2. Instantaneous Gravity Forces. Gravity forces were regarded as mysterious because they appear to act instantaneously. Astronomers and spacecraft navigators get the correct answers for the motions of the planets and the spacecraft by assuming gravity acts instantaneously. Why? Using the 'exchange to the medium' mechanism above, we can assume that if energy is exchanged between a particle and the nearby medium, the space of the medium must be moving or changing. The only possible motion we know is the 'redshift' which appears as if space were expanding. We try that below by calculating

gravity force using redshift measurements and the Wave Structure of Matter. It is not necessary to choose a cause of the redshift.

Gravity energy transfer is small (10⁻⁴⁰), so treat it as a perturbation of the electric force. If there is a particle motion relative to the quantum wave medium due to space expanding, the inward waves of the electron are not exactly the same length as outward waves because the IN wave at a point precedes its companion OUT wave at the same point. The space expansion causes an imbalance of the wavelengths which is proportional to the time and the distance from the center. The MAP will correct the imbalance by movement due to gravity force.

Estimate the ratio of the gravity force to the electric force. Define: dF = gravity force, F = electric force, T = time, dT = a time interval, R = radius to a point. The fractional expansion of space equals dL/L, during a time interval dT. Using the Hubble relation, one gets dL = HdT dF/F. The time interval to traverse R is dT = R/c. The measure of distance for a charged-particle wave is its wavelength, so approximate R = h/mc.

Using these relations, Wolff obtains the ratio of the gravity and electric forces between a proton and an electron [13]:

$$\text{electric/gravity force} = F/dF = mc^2/hH = 5.8 \times 10^{-39} \quad (15)$$

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 error. This match is not likely to be a coincidence because these are very large numbers.

This result helps understand the origin of gravity and the origin and growth of matter in the universe. For example, continuous creation of matter may produce the redshift, which in turn creates the gravity forces above. This perturbation is like an induction of a gravity force by the changing space. The cause of the redshift is also the cause of gravity. Such an interpretation is more satisfactory than the Big Bang.

3. Instantaneous Magnetic Forces. Peter Graneau has done experiments to show that energy exchanged by magnetism appears instantaneous, not according to the Poynting vector $E \times H$ [31]. His results are explained as an instantaneous perturbation of the electric force, where the perturbing factor is the relative velocity law and special relativity. Lorrain and Corson rewrite this little-known, 90-year old derivation with the well-known result [32]:

$$\text{Magnetic force on a moving charge} = F = q (v \times B) \quad (16)$$

where q is the charge with relative velocity v , and B is the magnetic field.

Importance of the IN Waves

The inward waves are just as real as their symmetrical partners, the outward waves. Neglect of the IN waves often gives an incorrect result because the inward and outward waves contribute equally when quantum properties are involved. Both the IN and OUT waves together are necessary to communicate between particles. Difficulties are not encountered when using full quantum theory since it implicitly contains both waves. This is one reason why quantum mechanics has stood the test of time.

4. The EPR Paradox. Quantum theory puzzles are often created by incomplete knowledge of the Wave Structure of Matter and the energy exchange mechanism involving the in/out waves. This puzzle arose because of neglect of the role of the in/out waves which transfer information between the source and the receivers. The particles involved must fulfill physical boundary conditions in order for their wave sets to resonate and initiate an energy shift upward in one atomic state and a shift downward in the other. Exchange of information of the boundary conditions must take place, unseen by us, before the final energy shifts which we actually observe. Not knowing the precursor information exchange has taken place, one feels the energy exchange is instantaneous and mysterious.

In 1935, Einstein, Podolsky and Rosen (EPR) proposed a 'gedanken' experiment which they thought could not be accounted for by quantum theory [33]. They trusted the causality idea that "Events cannot occur before their causes" and concluded that quantum theory was not always right. The experiment would prove it. In their experiment, polarized photon pairs are emitted from a central source, pass through the adjustable polarization filters on the left and right, and enter two coincidence detectors on each side. Simultaneous detection (coincidences) are recorded and plotted as a function of the angular difference between the filter settings.

The central source simultaneously emits paired photons which always have parallel polarization. The polarization filters at each of the oppositely-located detectors can be set at any angle with respect to each other. If the filters are at right angles, there will be no coincident photons detected. If filters are set parallel, all the photon pairs will be detected. The plot of coincident detections versus the angular difference of the filter settings was output of the experiment. The shape of this plot became a controversy.

The EPR paper predicted a straight line plot. The prediction was based upon the belief that two independent 'photons' traveled from source to detectors. They reasoned that since 'photons' cannot travel faster than the speed of light, neither photon detector could have

advance knowledge of the polarization of the photon entering the other detector. Therefore the plot would be linear.

Einstein also knew that quantum theory predicted the plot of the experiment to be a somewhat curved line, in violation of the photon concept. No one tried this experiment for 37 years because everyone trusted the EPR argument! Then the experiment was carried out many times and quantum theory was verified. This was a big surprise because the failure of the photon concept, and apparently causality, suggested that communication was taking place at speeds greater than the velocity of light, perhaps instantaneously.

The most recent experiment by Aspect et al used acoustical-optic switches at a 50 MHz rate to shift the polarizer's during the supposed flight of the photons to eliminate effects of one detector on the other [34]. They reported that the EPR assumption was violated by five standard deviations, whereas quantum theory was verified.

Interestingly, a close friend of Einstein, the German philosopher-physicist Hans Tetrode, took another view of causality even more puzzling at the time. In 1922, he made the remarkable proposal that a particle never emits radiation except to another particle [4]. He said "The Sun would not radiate if it were alone in space and no other bodies could absorb its radiation;" and "a star in my telescope, 100 light years away, already knew 100 years ago that I would observe it tonight." It now appears that Tetrode was correct! Tetrode appeared to understand the advance information exchange process but never wrote his ideas in detail.

Explanation of the EPR Paradox

Causality is not violated in the EPR experiments if one understands the process of radiation in terms of the inward and outward waves. The in/out waves contain information which identifies the atoms, their energy and polarization states. Before the actual energy shifts can occur in the detectors, the in/out waves determine if source and detector have matching boundary conditions. If suitable, the final exchange process is a coupling of two resonant oscillators, the source and detector. One increases its frequency by $df = dE/h$, and the other decreases frequency by df . The exchange proceeds in five stages:

- 1) Before changes of state occur, the IN/OUT waves of source and detectors contain information of their own energy state (frequency) and polarization, including the filter settings.
- 2) Before transition, all three devices 'learn' the wave state of the other two, otherwise the exchange could not begin because it must conform to the MAP. This precursor information

exchange is not observable by humans because there are no frequency shifts which we can detect. It travels at velocity c of the waves.

3) In a transition stage, if an exchange is possible, the IN and OUT waves begin a resonant exchange of their wave frequencies and amplitudes to minimize the total amplitudes, following the MAP.

4) In a final stage, the source atom (S), which has the higher energy level, shifts its energy state downward. This event is observed by us and interpreted as a “photon” leaving the S atom. Information of the lowered energy state of S arrives later at the detector atom D. We interpret this as if a “photon” particle had arrived at D with the velocity c of the quantum waves.

5) Atom D changes its energy state upward, thus satisfying MAP. We observe this event and imagine a “photon” had gone from S to D. MAP is satisfied and both atoms remain in their now stable states.

We see that both detectors receive information via the in-out waves concerning the frequency and polarization of the future photon pair before the change of energy state of the detector. This precursor information was conveyed by quantum waves and not moving 'photons'. Communication traveled between the atoms at the speed c of quantum waves. Thus there was no violation of causality even though it was unobservable to us. We can only observe the final energy state changes at the source and detector.

J. Proof of the Wave Structure of Matter

Before the Wave Theory of Matter, all laws of physical phenomena were obtained from empirical observations. They were experimentally observed to be true but were not predicted from any underlying physical cause. Their existence was a matter of faith in nature. Nature became a god. Now, using the quantum wave description of the electron, the natural laws are predicted as observed. They are not god-given but are results of the quantum wave structure of the universe. The prediction of the natural laws is overwhelming evidence that the quantum wave description is correct. It is not possible to review all the laws but several interesting examples are mentioned below. The remainder can be found in the literature.

Conservation of Energy

In an energy exchange, a source shifts frequency downward and a receiver shifts frequency upward. These exchanges must occur between resonant states with identical frequencies, resulting in equal and opposite energy changes. This is the origin of conservation of energy.

Spin of the Electron: Spin is a result of rotation of the inward (advanced) quantumwaves of an electron at the electron center in order to become the outward (retarded) waves. Rotation is required to maintain proper phase relations of the two wave amplitudes, similar to mirror reflection of e-m waves. The spherical rotation, which is a unique property of 3D space can be described using SU (2) group theory algebra. In SU (2), the IN and OUT waves of the charged particle are the elements of a Dirac spinor wave function. Thus all charged particles satisfy the Dirac Equation [see 23, 28].

Origin of Quantum Mechanics and Special Relativity: Quantum mechanics and special relativity have one feature in common: Both laws depend on the relative velocity between two particles. Noticing this, we immediately ask: What happens to the waves of two space resonances (SR) in relative motion with velocity $b = v/c$? One SR is a source and the other SR is an observer (detector). To answer this, write out the Equation (2) of a space resonance modified by the Doppler effect,

$$\begin{aligned} \text{AMP}(\text{received}) &= \text{Doppler shifted}\{\text{AMP}_{\text{IN}} + \text{AMP}_{\text{OUT}}\} \\ &= \text{AMP}_0 \left\{ \frac{2}{r} e^{ikg(ct + br)} \sin[kg(bct + r)] \right\} \end{aligned} \quad (17)$$

where the wave-number $k = 2\pi/\text{wavelength}$, $r = \text{radius}$, $b = v/c$, and $g = [1 - (v/c)^2]^{-1/2}$.

Eqn (17) gives the waves seen by either SR. Both see an exponential oscillator of the quantum wave frequency, modulated by a sinusoid containing the de Broglie wavelength. Each SR receives identical Doppler waves from the other because the two SRs are symmetrical compared to each other. Because of this symmetry, the resulting quantum and relativistic effects do not depend on the direction of relative motion, exactly as observed.

The Doppler effect of relative motion also creates a de Broglie wavelength, h/mv , in the modulation of the electron waves in Eqn (17). Recalling that the de Broglie wavelength is the experimental basis of quantum theory, we understand how quantum theory arises from the space resonance wave structure. Only a wave structure of matter could produce this behavior.

The relativistic mass increase factor in Eqn (17) is $g = [1 - (v/c)^2]^{-1/2}$. This result is remarkable! The Doppler Effect miraculously changes the combined IN and OUT wave frequencies in exactly the right way so that every momentum and mass (frequency) increases by the observed relativistic factor, g . This is the origin of the relativistic mass increase of moving particles - often sought but found only in the Wave Structure of Matter.

K. Conclusions

1. Instantaneous Action is Misunderstood

Causality is not actually being violated in the puzzling events termed 'Instantaneous Action.' Instead, the strange events are merely appearances. They were created by our incomplete knowledge of the Wave Structure of Matter and of the energy exchange mechanism. Actually, all energy and information transfer is at c , the speed of light. The cause of these events lies in the wave structure of the charged particles and the universal quantum wave medium. The Wave Structure of Matter is itself a new exciting forefront of science which displays the inter-dependence of all matter in the universe and restores some of the original adventurous spirit of natural philosophy.

2. An Inter-dependent Universe

The most extraordinary conclusion is that the laws of physics and the structure of matter ultimately depend upon waves established by the matter itself. Every particle communicates its wave state with all other matter so that energy exchange and the laws of physics are properties of the entire ensemble. Mach's Principle is just one of a family of inter-dependent principles.

3. Two Views of our Universe

Depending upon whether we observe with our human senses or with laboratory quantum-logic, we see different worlds. One world that we see with five senses is our familiar 3D environment governed by the natural laws. Electromagnetic energy exchanges stimulate our senses to form mental images of this world. These images create our sense of human reality. This is termed the "Energy World" since energy-exchange allows us to observe it.

"The "Quantum World," composed of unseen quantum waves which form the structure of the fundamental particles (electrons, protons, neutrons), can only be seen with laboratory instruments. We cannot observe these waves directly although they fill the empty space around us. We know of their existence when two particles change their quantized wave states (energy levels), and one of the two particles is in a human sense

organ. Quantum waves and the quantum wave medium are the hidden fountainheads of both worlds.

4. Theories of Everything

There is a story about a Newtonian physicist who challenged the idea that the Earth was supported on Atlas's shoulders. He asked, "What is Atlas standing on?" The reply, "On a turtle." "And what is the turtle standing on?" "On another turtle." It was turtles all the way down. The physicist scoffed and thought he had won the argument.

Have we finally found the theory of everything? In my opinion the search has no end. True, wave-structure has identified length, time, and mass. It explains the origins of the laws, resolves the wave-particle duality and other paradoxes, and provides a new tool for science. This might convince us that we finally understand everything. But do we? Inevitably a new question pops up: "How do the properties and structure of the quantum wave medium arise?" This new question is created by the old question which we thought we had so cleverly explained. Again it is, "Turtles all the way down." The next frontier is to learn and understand the quantum wave medium. Wolff has begun a world-wide-web public forum to investigate the Quantum Wave Structure of Matter [25].

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