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A paradigm shift in mathematical physics, Part 1:

The Theory of Elementary Waves (TEW)

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ABSTRACT

Why is quantum mathematics (QM) the only science based on probability amplitudes rather than probabilities? A paradigm shift called the Theory of Elementary Waves (TEW) posits zero energy waves traveling in the opposite direction as particles, which a particle follows backwards: like a probabilistic guidance system emanating from detectors. Probability amplitudes are the mathematical analog of these elementary rays. Although this proposal might sound like gibberish, that is the hallmark of a paradigm shift. Thomas Kuhn warns that previous paradigm shifts were rejected because they sounded like gibberish. TEW is internally coherent, explains a mountain of empirical data, and resolves insoluble problems of QM. For example, it dispenses with the need for wavefunction collapse because probability decisions are made at the particle source, not the detector. It is the only local realistic theory consistent with the Bell test experiments. That which QM calls "nonlocality," TEW calls "elementary rays." One term is vague, the other involves elegant mathematics. This article introduces that mathematical notation, explains complementarity in double slit experiments, and reinterprets Feynman diagrams. QM and TEW are partners that need each other. One is a science of observables; the other a science of how nature works independent of the observer.

Indexing terms/Keywords

Theory of Elementary Waves, TEW, Lewis E Little, Feynman diagrams, local realism, nonlocality, Bell test experiments, complementarity, wavefunction collapse, Dirac notation

Academic Discipline And Sub-Disciplines

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TYPE (METHOD/APPROACH)

Most mathematicians never heard of the Theory of Elementary Waves (TEW). This article describes TEW as a paradigm shift. In a previous article, we showed that TEW is a local realistic theory that can explain many of the Bell test experiments. TEW takes an approach never previously considered: waves and particles travel in opposite directions. QM and TEW are symmetrical: one being the science of observables, the other the science of physical nature independent of the observer. The central focus of this article is to introduce new mathematical notation and demonstrate how equations work in TEW and also in QM.

1. INTRODUCTION

James J. Binney, who teaches Quantum Mechanics at Oxford University, says, "Quantum mechanics is the piece of physics that is least understood. Relativity and so on is relatively clear and tied up. But here we have a piece of physics, which it is universally agreed, is not properly understood. It is still fundamentally mysterious."[1]

Our goal in this article is to outline the mathematics of a new picture of physical nature independent of the observer, one that clears up the mystery described by Binney. The math we will construct describes the world of everyday experience in a way that is symmetrical with quantum math. We define quantum math as the science of observables. What we propose to build is a new science, which is the corresponding depiction of physical reality that explains how those observables got there. We will use quantum math as a roadmap of physical nature, not just in terms of "observables," but also in terms of how the guts of quantum equations corresponds to the guts of physical nature. Amazingly, we will do so in a way that preserves local cause and effect, and that explains the Bell test experiments with a kind of local realism that never crossed Einstein's mind. This article develops a new mathematical notation to build an artificial world that is completely symmetrical to QM, yet completely different than QM. The new science is called the Theory of Elementary Waves (TEW).[2–8]

When you learned quantum math you entered a world of abstractions that have no apparent connection to the physical world around you, except that as you turn the gears "observables" drop out of the machinery, and those "observables" can be taken to the laboratory and verified. This machinery works magnificently for its goal, which is to predict how experiments and technology will perform in the future. But there is persistent awkwardness, because of the nagging suspicion that this abstract machinery must have some parallelism with physical nature, otherwise the observables wouldn't always be so accurate. For a century some of the greatest geniuses of all time have tried to crack the code of how quantum machinery and physical reality relate, and have failed.

TEW has the arrogance to say, "We have done it!" We have the hubris to claim that, by making radically different assumptions about how the physical world works, we can describe the physical counterparts of quantum machinery. In other words, by jumping down the rabbit hole into an ingenious way of thinking, we will use quantum math to envision a physical universe symmetrical to QM. The rules of the game are different down the rabbit hole, and hard to understand. It would be easier to eat mushrooms than to learn the new math contained in this essay.

The symmetry is so startling (see Figure 1 and Equations 1 and 2 below) that TEW and QM predict exactly the same outcome to almost all experiments. There are a few specially designed experiments in which they predict different outcomes. On the two occasions when such experiments have been conducted the outcome data are more consistent with TEW than with QM. When we have finished building the artificial world of TEW, we will leave it to the reader to decide whether that artificial world is one he or she would want to live in and adopt as a new home. This is an ambitious project, a tall order.

2. Overview

TEW was discovered by Lewis E. Little: a dissident working alone, outside the world of academic physics. He was a maverick with a PhD in physics who felt that QM didn't make sense of the physical world, although he accepted quantum math. He spent decades alone, seeking a way to explain quantum experiments without use of the hypothesis of nonlocality. Eventually he came up with TEW, only to find that the scholarly world was not receptive to a paradigm shift of that magnitude. Thus TEW is a dissenting minority viewpoint.

TEW is usually dismissed as gibberish. Before it is listened to and understood, it is rejected. Thomas Kuhn says the great paradigm shifts of the past were dismissed as gibberish in their day.[9] Consider plate tectonics. Alfred Wegener proposed in 1912 that all continents used to be part of a supercontinent for which he coined the name Pan-Geo or Pangaea, meaning "All Continents." After Pangaea broke up, the continents drifted apart. He had no idea why or how. His theory was dismissed as nonsense and absurd. Science was sure that there was no mechanism or force strong enough to move massive continents across the face of the earth. Arthur Holmes proposed a mechanism for continental drift in 1929: there were convection currents in the earth's mantle, similar to water in a boiling pot. His ideas were ignored: not even worth considering. By the 1960's knowledge of the sea floor and the mid-oceanic ridges accumulated, at which point Wegener and Holmes stopped being ridiculed. An obscure crackpot idea became the dominant paradigm, taken for granted by everyone.

TEW has two levels: Introductory and Advanced. Introductory TEW starts with the premise that particles follow zero energy waves backwards. Particles carry all the momentum and energy. A wave by itself is invisible: it lacks the energy and momentum to make a detector "click." Only a wave–particle can make a detector "click." These wave–particles are not those of QM: the wave and the particle are traveling in opposite directions. We infer the existence of waves from the behavior of particles. There are waves without particles but never particles without a wave.

Mathematicians consider it obvious that all waves convey energy. In TEW we have a theory based on waves of zero energy! It is wise to remember that the idea that waves always convey energy is not based on rigorous proofs. Nor are there any experiments in which zero energy waves are coupled with particles that can and do carry all the energy.

Advanced TEW makes another radical assumption. A pair of entangled photons in a Bell test experiment are each following the same bi-ray, which consists of two elementary rays traveling coaxially at the speed of light in opposite directions. "Hidden variables" are not concealed inside particles, but are properties of the bi-ray, which can be hundreds of kilometers long and therefore violate John Bell's definition of how a local theory is supposed to behave. Yet TEW is local and realistic. A train of identical ocean waves can travel hundreds of kilometers, but when you stand in the surf you experience local and realistic effects.

What will emerge from this article is that TEW and QM are natural partners. TEW is a theory of physical reality independent of the observer. It is not a theory of laboratory predictions or meter readings. QM is a theory of observables. QM gets into trouble when it tries to masquerade as a theory of physical reality independent of the observer. They are symmetrical. Each one needs the other.

3. Our notation and Dirac's

We need to translate TEW into quantum math and back: to learn how the bones and arteries of one relate to the bones and arteries of the other. The thorny problem immediately facing us is to explain what the symbols ψ and $|\psi\rangle$ mean in a TEW environment. In QM ψ is the wavefunction. In a system limited to one particle, ψ refers to that particle, which includes the concept of wave particle duality. The Dirac ket $|\psi\rangle$ can defined as a complete set of amplitudes (for those observables such as angular momentum or energy that have discrete values). An amplitude is the basic building block of all quantum math; it can be described as the square root of a probability. $|\psi\rangle$ is described as "the dynamical state of our system," or "quantum state," or "state vector." Before we can translate these ideas into TEW, we need to develop new notation.

In this author's version of TEW the symbol $Æ$ will be the symbol meaning an elementary ray. $Æ$ is the first letter of the term Ælementary Ray. It is from Old English and Old Norse, pronounced "ash." The corresponding Anglo-Saxon rune, carved into ancient stones unearthed by archaeologists, was meant to resemble an ash tree:

"$Æ$ "is found in musical scores today and in the International Phonetic Alphabet. The great advantage of using $Æ$ is that we emphasize that ælementary rays stand outside QM. Greek letters are used in QM. No one would accuse $Æ$ of being a Greek letter.

To reiterate: we define $Æ \equiv$ elementary ray.

Such an elementary ray may or may not have a particle attached to it. We should use the symbol $Æ_R \rightleftarrows Æ_L$ to refer to bi–rays in Advanced TEW instead of $\psi_R \rightleftarrows \psi_L$ that we used in previous publications. We will use the symbol ψ to refer to a wave–particle combination. Thus $\psi \equiv Æ + \text{particle}$.

We adopt Π as the symbol for this particle. TEW particles differ from QM particles because we split off the concept of a wave from a particle. In a system restricted to one particle, we say $\psi \equiv Æ + \Pi$, whereas QM would merge the wave and particle in a duality. We reject wave particle duality. A wave and particle cannot be identical if they travel in opposite directions.

Another problem with wave particle duality is that it claims to be a picture of physical reality independent of meter readings, and that is an arena in which QM is outside its area of expertise. What should be learned from Schrödinger's cat is that QM may be unsurpassed as a theory of observables, but it becomes grotesque when it tries to speculate about physical reality independent of the observer. Wave particle duality crosses that boundary line, into physical reality independent of the observer. Because of wave particle duality QM robbed itself of its ability to be a local realistic theory.

There are two varieties of ælementary rays: those to which a particle is, versus those to which no particle is attached. Franco Selleri called the latter "empty rays," meaning a ray with no singularity or particle attached. In any volume of space there are an infinite number of empty rays, but a finite number of wave-particles, limited by the number of particles. No one has ever seen an empty ray $Æ$. Einstein said that zero energy waves would be invisible and leave no trace in any experiment, because they have no energy, no momentum, and no way make a detector "click." Therefore Einstein called them "ghost fields" (German: *Gespensterfelderi*).[10]

We know of them only by inference. For example, in the double slit experiment discussed below, if an electron is triggered by a ray $Æ_x$ originating at point "X" on the target screen, the electron was not triggered by all the competing empty rays impinging on the electron gun from all other points on the target screen. The experiment only makes sense if we posit that elementary rays were coming from everywhere on the target screen.

The only elementary rays that we study are those attached to a particle, and even there it is the particle and not the ray that is visible to our detectors. Only the particle has energy, momentum, angular momentum, spin, charge, etc. What the particle and ray have in common is frequency and inverse directions.

No one has ever seen an unattached Π either, just like no one has ever seen an empty $Æ$. The only particles that appear in our experiments are $Æ + \Pi$ = wave particles. There is no such thing as a particle with no wave.

TEW defines the term ψ the same way as QM defines it: for a simple system it is a wave–particle. TEW differs from the QM in terms of the direction of the wave. In Bell test experiments we define:

$$\psi_{\text{ENTANGLED}} \equiv \Pi + (Æ \rightleftarrows Æ) + \Pi.$$

Like Paul Dirac we define $|\psi\rangle$ to be a complete set of amplitudes (for observables that have discrete values), and we call $|\psi\rangle$ "the dynamical state of our system," or "quantum state," or "state vector."

Comparing the behavior of a wave–particle in TEW versus QM, with one exception the wave particle moves and acts the same in either system. It moves in the direction of the particle and is detected only when and where the particle is detected. The rest of the wave is much longer, but is invisible and undetectable.

The difference between ψ in TEW versus QM is that a TEW wave–particle responds to information from the detector ahead, since the detector is the origin of the ray $Æ$ embedded inside the identity of the wave particle. In QM there is no a-priori reason to expect that the wave particle would interact with the detector before getting near the detector. That which Einstein called "spooky action at a distance," we call Æ, thereby bringing it into the scientific enterprise so it can be studied, classified and quantified. Æ is a specific real thing that replaces the vague QM term "nonlocality." The Æ can be modeled mathematically, whereas "nonlocality" is too vague and fluffy to calibrate, define, or use as a variable in future experiments.

Aristotle described four kinds of causality, the fourth of which was the final cause: the end, destiny or goal. This teleological perspective is absent from science today. With the TEW concept of a wave–particle, for a one particle system, $\psi \equiv Æ + \Pi,$ the detector toward which the particle travels is part of the cause of what happens to the particle, in the sense that the elementary ray $Æ$ emanates from the detector. In this limited way, Aristotle's fourth cause is part of TEW. The particle's future destiny, its teleology or goal, is one of the determinants of its current behavior.

These definitions mean that the Schrödinger equation is unchanged.

$$i\hbar \frac{\partial|\psi\rangle}{\partial t} = H\,|\psi\rangle$$

where H is the Hamiltonian operator. Other wave equations of QM can also be imported into TEW, because wave equations are the same if the direction of the waves is reversed.

Even processes that are irreversible because of entropy can be imported into TEW, because energy is carried by particles rather than waves, and the particles in TEW travel in the same direction as particles in QM. For these reasons the math of TEW is, with one exception, identical to the math of QM. The exception is that TEW seeks to read equations as road maps of the geography and function of the physical world in the context of ælementary rays. QM makes no effort to connect math to physical reality independent of the observer, other than the golden eggs called "observables" laid by the golden goose of a QM equation.

4. Symmetry of double slit experiments

Now let's see how this approach to quantum math applies to a double slit experiment. Richard Feynman says there is no possible logical explanation of why "the electrons in a double slit experiment act different if we are looking at them." TEW provides a simple and logical explanation. But first we must explain the double slit experiments, before discussing Feynman's enigma.

4.1 Symmetry of TEW and QM pictures of a double slit experiment

Figure 1 compares the QM and TEW viewpoints on a double slit experiment. The two sides of Figure 1 are skew–symmetrical. The differences between the left and right of Figure 1 is where the interference is located and the direction of the red arrows. This diagram corresponds to Equations 1 and 2, which are identical: one being the quantum math and the other being the TEW math describing the interference fringe pattern on the target screen.

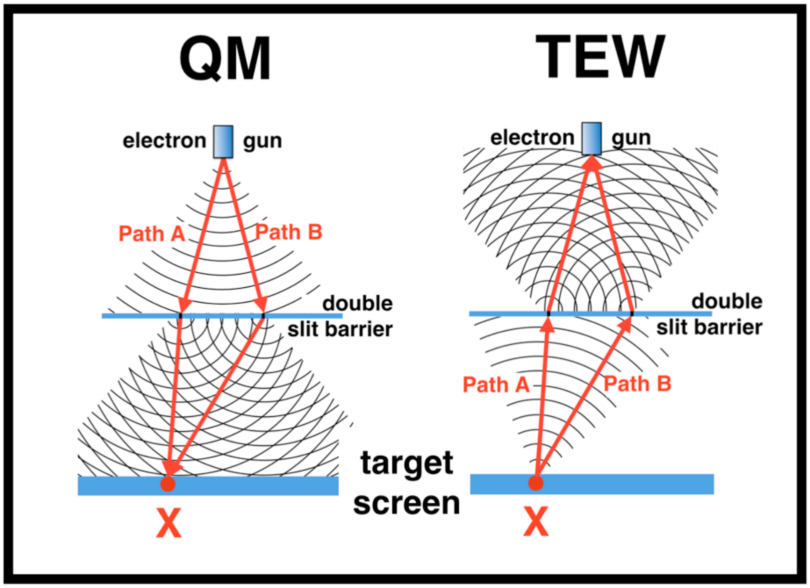

Fig 1: Comparing a QM picture to a TEW picture of a double slit experiment.

In TEW every point "X" on the target screen sends out elementary waves, and some penetrate through the two slits. The two diagrams are symmetrical and generate the same math.

On the left of Figure 1, let $A = |A|e^{i\theta}$ be the probability amplitude that an electron impinging on "X" at the target screen comes through slit A, and $B = |B|e^{i\varphi}$ the amplitude that it comes through slit B. Then the combined amplitude is $A+B$. The square of that is proportional to the probability of a dot appearing at "X" on the screen:

$$\begin{aligned}
P(x) &= |A+B|^2 \\
&= |A|^2 + |B|^2 + \mathrm{Re}(AB^* + A^* B) \\
&= |A|^2 + |B|^2 + |A||B|\,\mathrm{Re}(e^{i(\varphi-\theta)} + e^{i(\theta-\varphi)}) \\
&= |A|^2 + |B|^2 + 2|A||B|\cos(\varphi-\theta)
\end{aligned} \quad \textbf{(1)}$$

The phase difference $(\varphi-\theta)$ is determined by the distance from slit A to "X" versus slit B to "X", measured in wavelengths. One wavelength equals 2 π rotations of phase. For example, if we move "X" laterally so that there is ¼ wavelength more between slit B and X, than between slit A and X, then the phase difference $(\varphi-\theta)$ will be changed by $\pi/2$.

TEW proposes the symmetrical picture shown in Figure 1-right. Every point "X" on the target screen emanates empty zero energy waves of all frequencies, all the time. We limit our attention to waves of a frequency corresponding to the electron's energy. The interference is located in proximity to the electron gun, and precedes emission of an electron (Figure 1-right).

On the right side of Figure 1, let $A = |A|e^{i\theta}$ be the amplitude that an elementary ray emanating from point "X" comes through slit A to reach the electron gun. Let $B = |B|e^{i\varphi}$ the amplitude that it comes through slit B. Then the overall amplitude at the electron gun is $A+B$. The square of that is proportional to the probability of an electron being triggered in response to that elementary ray. If an electron is triggered then a dot will appear on the target screen at point "X." Once triggered an electron follows its ray with a probability of one. No further interference has any impact. It doesn't matter which slit the electron uses. So the probability of a dot appearing at "X" is:

$$
\begin{aligned}
P(x) &= |A+B|^2 \\
&= |A|^2 + |B|^2 + \mathrm{Re}(AB^* + A^*B) \\
&= |A|^2 + |B|^2 + |A||B|\,\mathrm{Re}(e^{i(\varphi-\theta)} + e^{i(\theta-\varphi)}) \\
&= |A|^2 + |B|^2 + 2|A||B|\cos(\varphi-\theta)
\end{aligned} \qquad \textbf{(2)}
$$

The phase difference $(\varphi-\theta)$ is determined by the distance from "X" to slit A versus "X" to slit B, measured in wavelengths. One wavelength equals 2 π rotations of phase. For example, if we move "X" laterally so that there is ¼ wavelength more between X and slit B, than between X and slit A, then the phase difference $(\varphi-\theta)$ will be changed by $\pi/2$.

That last sentence suggests a helical structure of Æ. We propose that $Æ_A$ is a cylindrical helix traveling at the speed of light from "X" to slit A and then bending so it travels towards the electron gun. $Æ_A$ has amplitude ***A*** which is a complex number. The amplitude is defined as the square root of the probability of an electron following that ray backwards. The radius of $Æ_A$ is $r \equiv |A|$, and θ is the angle of rotation at any location and time (Figure 2).

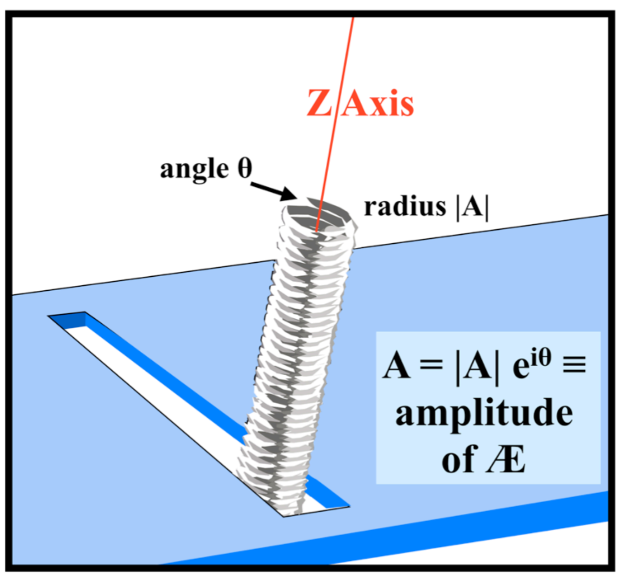

Fig 2: Sketch of an elementary ray Æ of amplitude A as it penetrates slit A

Let the Z axis be the almost vertical red line stretching from slit A to the electron gun (Figure 2), with the origin at that gun. We will define an imaginary plane (x, iy) at the origin, orthogonal to Z, with X being the real and Y the imaginary component. We define θ as the angle of rotation of the corkscrew at the (x, y) plane. θ is a function of time: it spins at incredible speeds. Æ can be described as follows: The energy of Æ is zero: $E(Æ)=0.$

$$
\begin{aligned}
x &= |A|\cos(\theta) \\
y &= |A|\,i\sin(\theta) \\
z &= c\beta t
\end{aligned}
\tag{3}
$$

where c is the speed of light along axis Z. β is a constant of our choice, although “constant” is a misnomer since its value will vary depending on the frequency of the wave. ω is the angular frequency and ν is the frequency, so: $\theta = \omega t = 2\pi\nu t$ and $\nu = \frac{\theta}{2\pi t} = \frac{\omega}{2\pi}$. The wavelength is $\lambda = \frac{c}{\nu}$ and the wave number is $k = \frac{2\pi}{\lambda}$. Although this helical object travels at the speed of light up the Z axis, we are primarily interested in a cross section at the electron gun. In that plane $A = |A|e^{i\theta}$.

Amplitudes from two different elementary rays can be added, as we saw in Figure 1–right when $Æ_A$ overlapped with $Æ_B$ at the electron gun. The combined amplitude is $A + B$. Amplitudes can be multiplied by a scalar. Thus elementary ray amplitudes form a vector space V. An adjoint of A is defined $A^* \equiv |A|e^{-i\theta}$. Elementary rays Æ with a right handed helix have adjoints Æ* with a left handed helix. The adjoint form an vector space V^*. We define an inner product: $\langle A|B\rangle = \sum_n (A_n{}^*)B_n$. The vector space V is complete, and is a Hilbert space.

4.2 Adding helices of different wavelength

Rays Æ of multiple frequencies fit the description of having an amplitude of $A = |A|e^{i\theta}$ at the electron gun. The only ones that are relevant have a frequency of $\nu_e = \frac{E_e}{h}$, where E_e is the energy of the electron about to be emitted and h is Planck’s constant. The wavelength of the elementary ray we seek is $\lambda = \frac{c}{\nu_e} = \frac{ch}{E_e}$. The frequency of an elementary ray must match its particle. In the energy representation, if $|\psi\rangle$ is defined as a complete set of amplitudes for different levels of energy, $\{E_1,\ E_2,\ E_3,\ \text{etc}\}$, this corresponds to a set of amplitudes for a family of elementary rays with different frequencies $\{\nu_n = \frac{E_n}{h}\}$. Every member of this family would have the same radius $r \equiv |A|$. Different members of this family would be able to connect with an electron with a different energy level E_n.

There are two equivalent ways to think about this. On the one hand we could say that different frequencies define a set of elementary rays of the same radius. Alternatively we could say that there is only one elementary ray, which can carry a multitude of different frequencies simultaneously. A violin string, for example, can vibrate at many frequencies simultaneously, which is what makes the music deep and rich, with complex overtones. When a violin string vibrates, it can be in a circular or eliptical motion. The state of the entire elementary ray (violin string) adds together all the component frequencies. Thus the Hilbert space we defined three paragraphs above is n dimensional.

In any specific double slit experiment, we are repeatedly dealing with electrons of the same energy E_n. That energy is a linear combination of the basis energies. The state of our system is $|Æ + \Pi\rangle = |\psi\rangle = \{\alpha_j\,|E_j\rangle\}$, where the $\{E_j\}$ constitute the basis energies, and α_j are the amplitudes for each of those energies.

4.3 Operators

We can define a linear operator $\hat{O}$ as a function that turns a ket into a ket: $\hat{O}\,|\,\psi\rangle = |\,\varphi\rangle.$ For example the position operator tells us the coordinates of the wave–particle in Euclidean or polar format. The energy operator $\hat{E}\,|\,\psi\rangle = \hat{E}\,|\,Æ + \prod\rangle$ tells us how much energy a wave-particle has if the ray Æ is connected with a particle ∏. All the energy happens to reside in the particle, none in the ray. The identity operator $\hat{\mathrm{I}} = \sum_i |\,\psi_i\rangle\langle\psi_i\,|$ turns a ket into itself $\hat{\mathrm{I}}\,|\,\psi\rangle = |\,\psi\rangle.$ We can use the apparatus $\langle\psi\,|\,\_\,|\,\psi\rangle$ to grind the rough, jagged edges off both sides of an operator, so as to obtain the expectation value: $\langle\psi\,|\,\hat{O}\,|\,\psi\rangle = \langle\hat{O}\rangle.$ [11]

4.4 Location of wave interference

Figure 1 shows that the probability amplitudes and the dots appearing on the target screen are identical between left and right: a different location for the same math (Equations 1 and 2). There is competition at the electron gun, among rays coming from all points on the target screen. The probability of any competitor being the one that triggers electron emission is proportional to the amplitude squared of that ray. If any one ray triggers an electron, the ballgame is over. The particle then follows its ray backwards with a probability of one, as we said before. No further interference has any influence on the particle. It doesn't matter which slit the electron uses. A dot will inevitably appear on the target screen at "X." The two theories are symmetrical and predict the same results.

For the past two centuries, physicists were thinking of wave interference in double slit experiments as being located in the wrong place. They were deluded. They were thinking about pseudo-interference (Figure 1-left), an illusion that occurs only in the minds of scientists, not in nature. The error goes back to Thomas Young's living room wall in London in 1800.[12] He thought of the interference as occurring in proximity to the wall. It never occurred to him that the interference was actually located in proximity to the pinhole in the shade on his window. Elementary rays were coming out of Young's living room wall, refracted through the double slit barrier, and interfering near the photon source. If a photon randomly decided to follow one ray backward, no further interference occurred. The photon followed its ray with a probability of one, and illuminated that point on the wall from which its ray had originated. Thus Young's conclusion was wrong. Young concluded that light was a wave, whereas TEW says there were no waves present in Young's living room, other than the elementary waves. The light that Young saw in an interference fringe pattern on his wall consisted of particles. Photon elementary rays Æ are waves, whereas photons are not waves.

Think about that last paragraph. We claim that Thomas Young was wrong in 1800. That means that TEW requires a paradigm shift in classical as well as quantum physics.

In TEW the particle has a trajectory, namely its elementary ray coming from "X" on the target screen (the red arrows in Figure 1-right). That is why there is no need for the concept of wavefunction collapse at the target screen. Probabilistic decisions that QM thinks are located at the detector, are actually located at the electron gun. The nature of that decision is that a particle randomly decides which elementary ray to respond to: i.e. which ray stimulates the particle's emission. Without wavefunction collapse at the target screen a lot of quantum weirdness vanishes: Schrödinger's cat, measurement theory, multiple universes, Wigner's friend, and David Mermin's proposal that "The moon only exists when people look at it."[13]

Unfortunately TEW brings some weirdness of its own. The premise is that everywhere in space, and in all inertial frames there are elementary rays of all frequencies, traveling in all directions at the speed of light. This is true in all inertial frames. They convey no energy. This is weird because we are immersed in an ocean of waves that we've never seen, never even noticed, like the "ghosts" of which Einstein spoke, but ghosts would disturb us more than this ocean of waves that we are submerged in. Particles follow these rays because that is how nature works. It would be impossible for a particle to follow no wave. All energy, momentum, electromagnetism and spin are carried by the particle. TEW does not ask how many angels can dance on the head of a pin, but does ask how many waves can dance on the head of a particle. Although that number is infinite, the particle is only wed to one: the particle is faithful to its partner with a probability of one. No promiscuity!

If you walk in the woods, the path contributes no energy to your hike. That's why elementary rays can be called pathways. But if you are walking on a path and the destination trailhead in front of you ceases to exist, and immediately your path vanishes from under your feet, then you can conclude that you had been walking on an elementary ray, now gone. Now you must bushwhack.

4.5 Why do electrons act different if we look at them?

There have been many experiments designed to determine through which slit an electron goes in a double slit experiment. If we know which slit then the interference fringe pattern vanishes, and vice versa: complementarity. TEW explains why this happens: because the coherence is lost between the two elementary rays $(Æ_A \text{ and } Æ_B)$ impinging on the electron gun. Without coherence, there is no interference in proximity to the gun (Figure 3–right), so there will be no interference fringe pattern on the target screen.

Consider the following experiment. Figure 3 shows a photon source that can shine a spotlight at an angle through at least one of the slits of a double slit experiment. An electron sharing that slit will disturb the photon traveling through the slit and that disturbance can be detected, telling us which slit the electron used. But if we know which slit, then the interference fringe pattern on the target screen vanishes. If the photon source is OFF (Figure-3 left), the interference fringe pattern is restored.

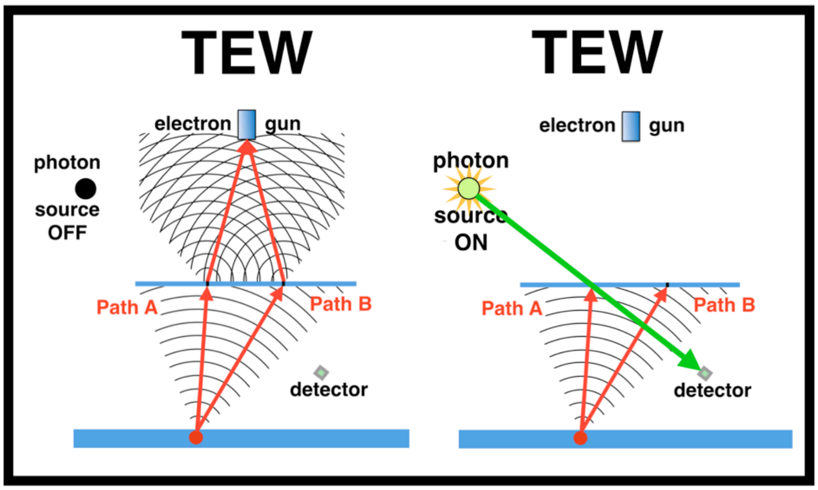

Fig 3: A photon source (left) is OFF then ON (right): it sends photons through slit A.

Note that all wave interference is absent from the right diagram (near the electron gun). The photon destroyed the coherence of the elementary ray through slit A vis-à-vis the one through slit B.

In Figure-3 a photon source can send photons through slit A, to determine which slit an electron uses. But when the light is on (Figure 3 right) it changes the elementary ray $Æ_A$ on Path A. That damaged ray is no longer coherent with its twin $Æ_B$ on Path B. As we said earlier, with no coherence, there is no interference as the rays $Æ_A$ and $Æ_B$ approach the electron gun (Figure-3 right). With no interference, there will be no interference fringe pattern on the target screen. This explains Feynman's enigma.

How exactly would a photon destroy the coherence of $Æ_A$ and $Æ_B$? We are not sure, but we can speculate. If a photon is modified by a nearby electron inside slit A, then the electron is modified in a reciprocal way $(\prod \longrightarrow \prod')$, which implies that the electron would need to be following a modified elementary ray $Æ'_A$. Suppose, for example, the energy of the electron is affected by the near collision with a photon. Then the frequency of $Æ'_A$ would be different, and would no longer match the frequency of $Æ_B$.

5. What Feynman diagrams tell us about elementary rays

If we want a picture of elementary rays, an obvious place to look is Feynman diagrams, which superficially appear to be pictures of particles moving about. We are immediately told that we are making the same mistake that students usually make when they first learn Feynman diagramming. The mistake is to pay attention to any one Feynman diagram, instead of recognizing that only when we integrate across all possible Feynman diagrams can we arrive at an amplitude. Feynman diagrams are a high volume business.

The output is an amplitude, not a picture of reality.

These diagrams were introduced in 1948 by Richard Feynman, as a visual catalog of a tangle of equations. Later they became ways to make such calculations. Today there is great diversity in how these diagrams are used, varying from one academic center to another. Sometimes they are used as doodles or rough sketches of an idea, without worrying about infinities or the need for renormalization. About the only thing there is consensus about is that you have to ignore any one diagram and integrate across an infinite number of them. If "n" is the number of Feynman diagrams included in a study, an amplitude is increasingly accurate as n increases toward infinity.[14]

The Feynman tradition is one of creative flexibility. These diagrams are so popular because a picture is worth a thousand words. One quarter of the human brain is devoted to vision. Most humans think better in pictures than in mathematical equations. Often even mathematicians think better in pictures!

Since the tradition encourages creative flexibility, the Feynman culture tolerates breaking rules. Students have broken the rule about ignoring any one single diagram, and we will do likewise. We are, after all, asking questions that no one ever asked before. We will look at one specific Feynman diagram and ask what the elementary rays were doing prior to and during the events portrayed.

Feynman did not design any way to diagram an elementary ray Æ that is traveling forwards in time on the same axis as a particle Π, but in the opposite direction. So we will temporarily ignore the countervailing direction of elementary rays.

In Feynman diagrams time is reversible: a positron is portrayed as an electron going backwards in time. In TEW time never goes backwards. Feynman was fascinated with backwards time since his early twenties, as evident in his article with John Wheeler about the Absorber Theory, in which time zig-zags backwards & forwards & backwards & forwards across twenty four pages of wave and radiation equations.[15] If we had the opportunity to talk with Feynman we might have convinced him that time reversal is unimportant, but it is a surrogate variable for the real issue, which is wave direction reversal. The wave equations are symmetrical if the direction of the waves is reversed, with time going forwards.

Figure 4 compares a traditional Feynman diagram (left), to a TEW view of that same event (right). The two diagrams are identical except for a multicolored background fabric on the right. This represents the empty elementary rays Æ that are always present in all locations, traveling in all directions. We limit our attention to three kinds of rays: those corresponding to an electron, positron and photon. You might ask how many species of rays live in the TEW zoo. The answer is seventeen: one corresponding to each particle in the Standard Model. In that case the electron rays and positron rays in Figure 4 would be variations of the same thing. Nevertheless, positrons don't go backwards in time.

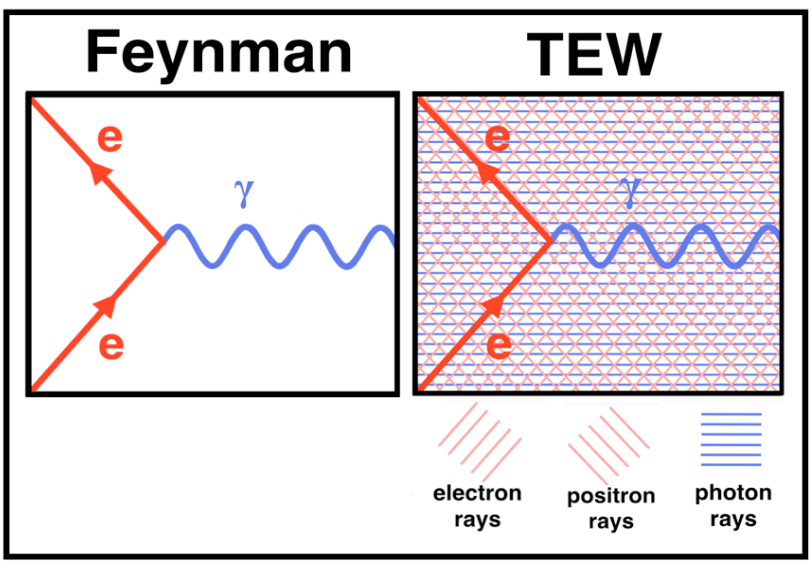

Fig 4. Comparing a Feynman and TEW view of the same particle annihilation and photon

In both diagrams of Figure 4 an electron (the red arrow from the bottom left) intersects a positron (the upper red arrow) and they mutually annihilate. Time goes to the right. The released

energy takes the shape of a photon γ (wave on the right). Everywhere in space there are zero energy elementary rays traveling in all directions (the multi-colored background fabric in right diagram).

Figure 4–left shows an electron and positron colliding in a mutual annihilation, and a photon γ emerging, carrying off the energy. Figure 4–right shows that the electron and positron were following elementary rays. Wherever the collision occurs, there is a photon elementary ray available for the quantum of energy to follow. At the vertex the energy quantum must decide which kind of elementary ray to follow. It might choose to follow a gluon or Z boson ray, rather than a photon ray. The same probabilistic decision at the vertex can be described in two ways: the energy quantum's choice of which kind of ray to follow is identical with its decision what kind of boson it will become.

Quantum physicists are practical people, interested in computing amplitudes. They scoff at our approach because if you add up all the possible Feynman diagrams we could produce, the resulting amplitude will be identical to the Feynman approach. This is a perfect example of why TEW and QM are partners. Computing amplitudes is not the kind of issue for which TEW is useful.

The Feynman approach is a theory of meter readings, not a theory of physical reality. It tells you that if an electron and positron are put into a black box, there is such-and-such amplitude of a photon emerging on the other side, as opposed to a different boson. It is a theory based on superposition, because wavefunction collapse occurs when a measurement is made. We are supposed to avoid thinking about what happens inside the black box. That thick fog called "superposition" obscures what happens at any specific vertex.

TEW tests hypotheses about the inside of the black box. If Feynman's is a theory of meter readings, ours is a theory of physical reality independent of the observer. At every vertex one specific thing happens: perhaps a common event, perhaps a rare event, involving either a virtual or real particle. But something definite happens. A positron-electron annihilation will produce one specific boson. If a photon emerges from the vertex, then a gluon or Z boson will not.

What is startling about our interpretation of Feynman diagrams is that we allow people to think the way they tend to anyway. Beginning students look at Feynman diagrams and assume it is a picture of physical reality. We say, "Yes, that is correct!" The Feynman tradition says, "No, that is wrong. This is only the beginning of an exhausting number of computations. You should calculate the amplitude of meter readings by integrating from here to infinity, and forget about physical reality."

6. Summary

Nonlocality and elementary rays are two names for the same thing. Which would a mathematician be more interested in? It is a no-brainer. Nonlocality is vague and nonspecific. Elementary waves require innovative math, some of which we have introduced above. The former is like groping in a fog. The latter invites mathematicians to have a field day.

6.1 Limitations of this article

This article says nothing about systems more complicated than a single particle. We have suggested new notation and new ways of thinking, some of which might prove useful, some of which might turn out to be worthless. TEW is a new approach, for which most of the basic science has not yet been developed. It does not have a century of the greatest geniuses of all time contributing to it, the way QM has. TEW has had only one genius: Lewis E. Little. There are undoubtedly sophisticated ways that quantum math can provide roadmaps to understand the bizarre world of elementary rays. What is new is that finally someone is trying to use quantum math to map physical reality independent of the observer.

This report leaves dangling threads that we cannot cover, lest this essay become unwieldy in length. A second article in this series is planned to tie up those loose ends. The most conspicuous loose ends are:

1. We need to prove our allegation that TEW is the only local realistic theory able to explain the Bell test experiments;
2. If there are waves that permeate space, most of which are independent of particles, what is the medium within which those waves move?
3. We need to prove our allegation that there is no empirical evidence supporting wave particle duality, contrary to what all the experts and textbooks claim.

6.2 Strengths of this article

QM and TEW would be perfect partners: one is a theory of observables (meter readings), the other the corresponding theory of physical nature independent of the observer. The theories are symmetrical, as we have shown in Figure 1 and Equations 1 and 2.

Other than TEW, there are NO alternative explanations of why quantum math uses amplitudes instead of the probabilities used throughout all other fields of science. Thus TEW stands out from its competitors in the following way: there are no competitors.

Furthermore, it is universally agreed that wavefunction collapse is an insoluble problem in quantum theory. Binney says that everyone agrees that there is something profoundly wrong, but no one can figure out how to fix it. Various proposals have been suggested, including parallel worlds, with no consensus. Measurement theory is a nightmare. When QM says that wavefunction collapse means that something actually changes in nature, they are venturing outside the boundary of competence of QM, which is observables. Physical nature independent of the observer is where TEW proves more useful than QM. TEW deals with wavefunction collapse efficiently: there is no such thing. What that means is that the particle has a definite energy or a trajectory before we detect it. The only thing that happens at the detector is that we discover what that is.

6.3 Wave particle duality

The fundamental dispute between TEW and QM is wave particle duality, which TEW views as worse than useless: it leaves physicists blind to how nature is organized. If wave particle duality were the bedrock upon which quantum math stands, then the entire edifice should collapse when we jettison it. But we showed in previous publications, that is not what happens. What happens is that quantum math stands solid.

The issue with wave particle duality is simple. It is an idea about physical nature independent of the observer. That is the kind of idea that QM should avoid discussing. Remember Schrödinger’s cat!

6.4 The history of QM

If we assume that TEW is correct, then it is easy to understand the history of quantum mechanics. For thousands of years it was debated whether light consisted of waves or particles. Throughout that debate everyone agreed on one thing: it traveled from the light source to the detector, not in the other direction. Therefore when Thomas Young, Einstein, and the founders of QM debated this issue, it never crossed their minds to ask whether the waves might be traveling in the opposite direction as the particles. The only example of such a peculiar idea ever being discussed was when ancient Greeks discussed the emission theory of vision. Aristotle thought that was ridiculous. He asked, “Then how do we see stars?”

Since the founders of QM assumed that particles and waves were going in the same direction, they could not figure out a coherent picture of nature. They chose to develop a mathematics to describe laboratory data, even though they had no picture of nature. The purpose of that math was to predict the outcome of experiments. For that purpose it functioned brilliantly.

In the twenty first century TEW arrived, offering a picture of physical nature that corresponds to quantum mathematics. But mainstream physics has little or no interest. Physics journals routinely reject articles on TEW, saying the articles have no scientific merit. The leading journal, *Science* rejected an article submitted electronically by this author in less than fifteen minutes, saying, “Not the kind of thing we publish.” There is a prejudice against TEW since it makes no sense from the viewpoint of the old paradigm, disturbs the status quo and threatens vested interests.

What would motivate anyone to pursue the thankless task of promoting TEW when the experts pay no attention, or say it is worthless? The answer is simple. It boils down to the question, “Who am I?” If the answer is “I am a mathematician interested in unconventional approaches to insoluble problems,” then enjoyment of TEW comes naturally. It is natural to want to share that thrill with others

7. Acknowledgments

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Author's biography with Photo

Dr. Boyd was born in 1943 in northern New Jersey, USA, the son of a factory worker family in which no one had ever been to college. As a teenager he and his cousin, Lewis E. Little, played three dimensional tic-tac-toe, and developed strategies for four dimensional tic-tac-toe. Boyd chose which college to apply to based on his cousin's advice about which one had the best applied math department. Boyd's undergraduate degree in mathematics was from Brown University in 1965, three years after Little graduated from Brown in physics. Boyd has Advanced degrees from Harvard, Yale and Case Western Reserve Universities, has served on the research faculty of the National Institutes of Health for seven years, and has been on the faculty of the Yale Medical School. His day job is as a physician. Boyd retired after a quarter century at Waterbury Hospital, Waterbury CT, a Yale teaching hospital at which he served as chairman of behavioral health and chairman of ethics. He has published in the *New England Journal of Medicine*, *Journal of Advances in Physics* and *Physics Essays*.

Lewis E. Little **Jeffrey H. Boyd**