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Decrypting the Central Mystery of Quantum Mathematics: Part 1. New Axioms Explain the Double Slit Experiment

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Abstract

This article proposes a solution to the double slit experiment of Quantum Mechanics. We attack the problem from a previously untried angle. Unsolved math problems must be attacked from unexpected angles because every conventional approach has already been tried and failed. Richard Feynman warned that the quantum world is such a strange place that humans can't understand it. There is empirical evidence of particles following zero energy waves backwards, although that is counterintuitive. Schrődinger waves carry zero energy: they carry probability amplitudes instead. In our proposed model zero energy Schrődinger waves emanating from every point on the target screen pass backwards through the two slits, interfere at the particle gun, and a particle randomly chooses which wave to follow backwards. Once that decision is made the particle follows its wave with a probability of one, through only one slit (it doesn't matter which slit) and inevitably strikes that point from which its wave emanates. This produces the same math and same pattern on the target screen. We propose three Axioms of the Theory of Elementary Waves (TEW) as a better platform for mathematics in this experiment than the Axioms of QM. This constitutes a paradigm shift.

Keywords Theory of Elementary Waves

Mathematics Subject Classification (MSC2010): 81Q65 Alternative Quantum Mechanics

Type (Method/Approach): This is the sixth article published in J.A.M. on the subject of the Theory of Elementary Waves. Elementary Waves are that part of physical nature where quantum equations live. Those equations provide a roadmap to the world of Elementary Waves, but unfortunately the map is written in hieroglyphs The double slit experiment provides a Rosetta stone, allowing us to begin to decipher the map: i.e. decrypt the math.

1 Introduction

A double slit experiment appears to be simple (Figure 1). A particle is fired from a gun, goes through two slits, and forms a wave pattern on a target screen. If we know which slit, then the pattern vanishes. Richard Feynman said that this embodies the "central mystery" of quantum mechanics (QM). No one has a solution that is widely accepted. Feynman spoke for the majority when he said QM cannot explain this experiment.[1, 2]

Double slit experiments are an application of applied math. This author's degree in mathematics is from Brown University, Providence, RI, USA. Often the first step in solving an unsolvable math problem is to get the right idea, even if you have no specifics about how the equations will work, leading to some kind of strategic vision and tactics about how to attack the problem.[3] This article has equations, but the right idea came from Little E. Little's 1993 image of particles following zero energy waves backwards.[4-5]

The approach taken here is so unconventional that it is challenging to explain it. This approach involves a change of Axioms, a paradigm shift, an entirely different way to understand Nature. Paradigm shifts historically have sounded like unintelligible gibberish to those trained in the old paradigm. When there are new Axioms, everything changes. A change of Axioms is similar to the collision of continents, as in the Assam-Tibet earthquake of 1950.

The idea of zero energy Elementary Waves is from the Theory of Elementary Waves (TEW) which we will explore in this article.[6-21]

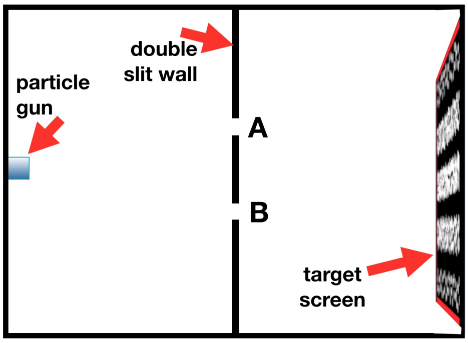

Figure 1: The double slit experiment appears to be simple: although we see a wave pattern, we cannot see whether the actual wave interference is located to the left or right of the barrier in the middle; we propose it is to the left.

An unsolved applied math problem cannot be untangled using conventional assumptions. Christopher Zeeman used to say "it is a mistake to read the research before tackling an insoluble mathematics problem, because it will slot your mind into the same groove everyone else is trapped in."[1]

Some people say the idea of particles following zero energy waves backwards is so preposterous that they find this article offensive. If our model is wrong, it might provoke the reader to create a better solution. An issue to remember is that there are NO other mathematical models for, nor explanations of the double slit experiment, other than the one presented here.

Could it be that this article is correct, and it is Nature that is arranged in an unimaginable way? That would be consistent with what Feynman and others have warned: the quantum world is so different that humans can't "get it." This article states the blunt truth about the quantum world. We claim the apparent weirdness comes from faulty Axioms. When we adopt better Axioms we do not find it to be weird.

If you ever bake something, if the final product is going to taste good, then the ingredients need to taste good before they are combined and cooked. If you want to produce Nature, then you need to start with good ingredients. If the ingredients are weird but the world of everyday experience is not, then you made a mistake in your Axioms.

This is the first of four articles that explain the proposed paradigm shift. The second article in this series will show that there is a mountain of experimental data that supports TEW. Although QM can explain all experiments, that is only true if you are willing to accept the idea that the quantum world is weird. The second article will re-analyze six published quantum experiments from mainstream scientific journals and show that the quantum world is not weird. If you change your Axioms, the quantum world is surprisingly similar to the world of everyday experience. The third article will present a solution to the Bell test experiments that is non-Einstein and non-QM. The fourth article will explore the work of Franco Selleri, focused on the medium in which Elementary Waves travel. The reason we will present four articles is that a paradigm shift is not easily described.[22-25]

1.1 Zero Energy Waves

As this author speaks to many different audiences, it is astounding how often audiences assert:

I. There is no such thing as a zero energy wave, and
II. If there were such a thing it could accomplish nothing.
III. Schrődinger waves do the heavy lifting in QM.

Do you see the contradiction? Schrődinger waves ARE zero energy waves! They convey probability amplitudes, not energy. The word "amplitude," used throughout this article, means the "square root of a probability."

1.2 Criticisms by Albert Einstein and John von Neumann

Albert Einstein proved the conventional QM view of a double slit experiment is wrong. If a particle leaves the gun, spreads out in space as a wave particle, penetrates the two slits, then at that instant when a dot appears anywhere on the target screen the entire Schrődinger wave everywhere needs to vanish instantly, faster than the speed of light. The dot means there is wave function collapse. Thus the wave particle has become a particle with a specific location. At that instant the entire Schrődinger wave everywhere must vanish, otherwise the residual parts of the wave could produce

[1] I. Stewart, op.cit.

a second dot, which would be impossible since only one particle left the gun. No one ever explained how the entire Schrődinger wave everywhere could instantly vanish, faster than the speed of light.[26-27]

John von Neumann stated another discomfort about the conventional view. Since the Schrődinger equation is deterministic, how did the randomness get into quantum mechanics?[28] When we develop a new model for the double slit experiment in this article, our model will solve the Einstein and von Neumann objections.

2 Graphs of the Double Slit Experiment

What does a QM Schrődinger wave look like in a double slit experiment? Based on a computerized model of such a wave passing through a barrier with two slits, we simulate what that animated probability density looks like over time.

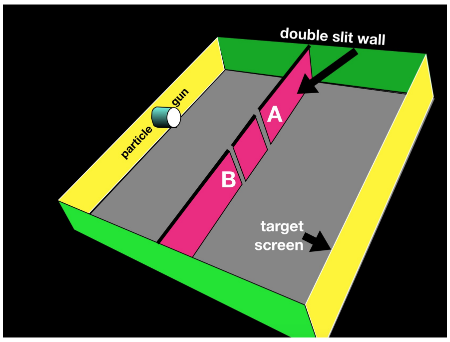

Figure 2: Double slit equipment viewed from a different angle.

According to QM the gun fires one particle (Figures 2 and 3), which is portrayed as a colorful probability density on the left of Figure 3.[29] The diagrams are based on screenshots from a computerized integration of the Schrődinger equation over a 100 x 100 grid, as the wave meets and moves past an infinitely tall barrier with two slits.

In Figure 3 we treat the double slit apparatus like a stretched limousine, with four double slit barriers instead of four seats, in order to simulate time lapse photography, one screenshot every ten seconds. As the probability density moves toward the center it broadens and loses height, then begins to ricochet off the double slit barrier causing a backwash. Most of the wave remains to the left of the wall, and sloshes backwards toward the gun. A minority seeps through the two slits. The time is given in seconds, which is extremely slow. This is an arbitrary timing determined by the computer simulation of a Schrődinger wave. It takes time for the computer to churn through a complicated differential equation, calculating 10,000 data points for every increment of time, and produce vivid pictures.

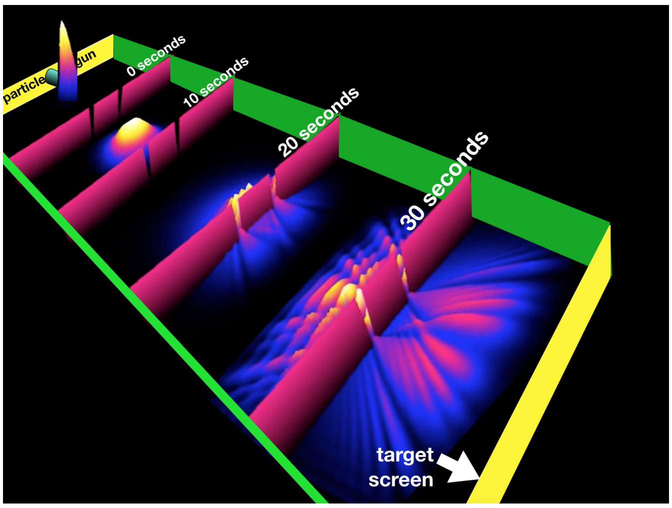

Figure 3: A probability density represents the Schrődinger wave at four different times as it moves across the apparatus. The apparatus looks like a stretched limousine: our way of presenting time-lapse photographs every ten seconds.

The final picture (Figure 4), shows that the Schrődinger wave finally reaches the target screen on the extreme right. The wave develops complex patterns with back waves, side waves, ripples and currents streaming through the two slits. Forty seconds is the end of the video.

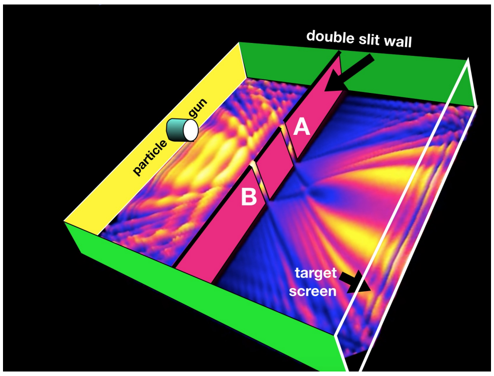

Figure 4: After 40 seconds the QM Schrődinger wave reaches the target screen on right, and fills the equipment with ripples and secondary waves sloshing around every which way.

Wave function collapse allegedly occurs if a dot appears anywhere in the apparatus in Figure 4. Einstein's comment means that no matter where a dot appears, even if it is on a sidewall rather than on the target screen, the entire Schrődinger wave everywhere, even on the gun side of the double slit barrier, must vanish faster than the speed of light. No one has ever explained how that could happen.

We will develop a completely different picture of Schrődinger waves, starting with a reformulation of the Axioms that are the foundation of our math. In our picture the Schrődinger waves travel in the opposite direction. Our model is not contradicted by Einstein's comment, and also gives a sensible answer to von Neumann.

3 Axiom # One. The timing of wave function collapse

If the Axioms of QM had provided a way to understand the double slit experiment, then there would be no need for this article. The fact that the double slit remains an unsolved math problem means that we have to re-evaluate the starting Axioms, so as to attack the problem from a different angle.

The term "wave function collapse" means the moment when a decision is made. The first Axiom of QM when pondering a double slit experiment is that wave function collapse occurs when a dot appears on the target screen. There is allegedly a cloud of probabilities (the particle could be anywhere), until that instant when abruptly it materializes at one specific location on the target screen.

This is consistent with standard QM teaching, that wave function collapse occurs when a measurement is made. In a double slit experiment that is when a dot appears on the target screen.

In order to solve the problem at hand we need to discard this Axiom and replace it with a new Axiom: wave function collapse occurs prior to when something is measured or observed.

"Wave function collapse" means that an operator such as $\hat{A}$, which has many eigenstates, $|\alpha_1\rangle$, $|\alpha_2\rangle$, $|\alpha_3\rangle$, $|\alpha_4\rangle$, . . . collapses to one specific eigenfunction such as $|\alpha_3\rangle$. The probability of eigenvalue α_n is $|\langle\alpha_n|\ \Psi\rangle|^2$. "Wave function collapse" means that something has irreversibly changed in Nature.

We will briefly review the three main reasons for the QM Axiom, and in each case argue that it is wrong.

3.1 Reason # 1

QM is said to be the science of atoms and subatomic particles. When you measure anything you change the system you are measuring. This is not a problem in the classical world. But in the quantum world measuring something disturbs it.

3.2 Why Reason # 1 is wrong

When we examine this "observer effect" in QM, we find it does not justify the doctrine that wave function collapse occurs when we measure something. It fails in the Heisenberg uncertainty principle, the Large Hadron Collider and in the Hiroshima atomic bomb.

The term "Heisenberg uncertainty principle" should be renamed the "Fourier transform uncertainty principle."

When Werner Heisenberg discovered his uncertainty principle in 1927, he ascribed it to a quantum observer effect. He spoke of a gamma ray flashlight. That explanation was later refuted. In a Fourier transform the time duration times the frequency bandwidth is always greater than or equal to some constant "n". In Heisenberg's equation $n = \hbar/2$ but in other Fourier transforms n takes a different value.

$$\triangle t \triangle f \geq n \tag{1}$$

This is true of waves in the classical world. If you listen to a piano string vibration for a small amount of time ($\triangle t$), you will have a large uncertainty about the frequency ($\triangle f$), and vice versa. Such an uncertainty principle is found in signal processing. Thus the uncertainty principle ($\triangle t \triangle f \geq n$), although true, does not support Heisenberg's claim that the quantum world is different than the classical world in terms of observer effect. The uncertainty principle applies whenever a Fourier transform is used.

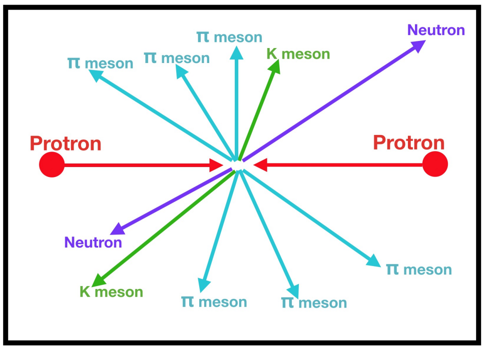

Figure 5: Two high speed protons collide in the Large Hadron Collider, causing wave function collapse in the center of this diagram; measurement is located around the periphery; therefore collapse precedes measurement.

The Large Hadron Collider contradicts the doctrine in question (Figure 5). The collider consists of a 27 kilometer torus of a tube 6.2 cm in diameter. Within the tube there is a vacuum and magnetic waves. A high energy collision occurs at the center of the tube, at which time there is wave function collapse. Figure 5 shows two protons colliding. Debris sprays out from that location and is measured around the periphery of the tube, at least 3.1 cm away. Measurement cannot cause the collapse, given what we just said. Collapse (at the center of Figure 5) precedes measurement (at the periphery) by picoseconds.

When an atomic bomb exploded over Hiroshima, things were forever different. If you think that explosion had anything to do with quantum mechanics, then you need to explain why it exploded even though no one observed or measured it. An airman named Russell Gackenbach took two photos with his personal camera, after the explosion on August 6, 1945. He was flying in a second aircraft named "Necessary Evil." Wave function collapse occurred in the first millisecond after the uranium reached critical mass. Measuring the atomic bomb did not cause wave function collapse because no one measured or photographed it until many seconds later. The photos were fuzzy pictures of a mushroom cloud, not measurements inside the "Little Boy" bomb at the millisecond when a cannon shot a cylinder of U-235 into a larger mass of U-235. So the Hiroshima bomb contradicts the quantum "observer effect."

3.3 Reason # 2

Because of the Bell test experiments. Over six decades tests of John Bell's ideas about QM have been pitted against Einstein's "local realism," all loopholes have been closed, and the results were decisive. Einstein lost.

3.4 Why Reason # 2 is wrong

It is widely but incorrectly assumed that the Bell test experiments mean that Bell's QM, with it's interpretation that particles are in a superposition until measured, has been proved to be true. The flaw in that logic is that there is a third option. TEW is the third combatant. Since Einstein has been defeated, it could be that either TEW or Bell is correct. TEW can equally well defeat Einstein's local realism. We have argued this in articles published in several peer reviewed scientific journals, and we will argue it in the third article in the current series.

The reader may not have heard that there is a third competitor. Overall the reaction of the quantum community to this news has been to ignore it. Powerful self-interest leads QM leaders to deny the idea that there is a third competitor. They prefer the claim that loophole-free Bell test experiments have decisively defeated Einstein, and therefore QM has a monopoly, which is an advantage in an environment in which there are scarce research funds.

TEW does not contradict QM vis-á-vis the Bell test experiments, because TEW is a "non-local" theory.[30-31] It has been known for decades that Bell test results can be explained by non-local arrangements. Although TEW is "non-local" it differs from QM in this respect: TEW says wave function collapse occurs *prior to* measurement.

To reiterate: in the third article in this series of articles, we will again show that TEW can explain the Bell test experiments. Therefore it is wrong to say that the Bell test experiments prove that wave function collapse occurs when you measure something.

3.5 Reason # 3

Because of a fluke of history. In order to develop equations we need to get our Axioms straight, and in order to do that we need to deal with "Reason # 3," which requires a brief glance at history. Our goal is to understand why QM has an incorrect Axiom that wave function collapse occurs when something is measured.

When QM originated in the 1920's a positivist philosophy prevailed in science, led by Ernst Mach and the Vienna Circle of philosophers in the years following 1918. That philosophy said that only our sense perceptions can be the foundation of science. Things that we cannot directly observe (such as atoms) do not exist. Scientific theories are merely instruments for making connections between observations. Since positivist philosophy says there is no physical reality behind the meter readings, therefore when you measure something you capture everything that exists.

3.6 Why Reason # 3 is wrong

Niels Bohr, Werner Heisenberg, and Wolfgang Pauli promoted the Vienna Circle's positivist philosophy. Bohr said, "There is no quantum world," meaning that only meter readings were real. QM was described as the mathematics of meter readings.

Realists, such as Einstein and Schrődinger stubbornly defended the idea that physical reality exists independent of the observer. They proposed that meter readings are telling you something about the physical reality behind the meter readings. They were a dissenting minority. Their ideas were ignored by the mainstream, who were the young geniuses who came from all over Europe to flock around Bohr in Copenhagen.

Bohr was inarticulate. His statements and writings were opaque. But he was the heart, the affectionate mentor of all the future leaders. He listened attentively and encouraged the young men. Einstein was a loner, detached from the next generation. He didn't have an emotional impact on the quantum elite. Scholars listened to Einstein about relativity, but dismissed him vis-á-vis quantum physics.

Bohr prevailed with his love of positivism. Einstein, who disliked that philosophy, was ignored.

That which is considered "scientifically true" does not necessarily reflect what empirical research shows. More often it is defined by the consensus of the scientific community. It was Bohr rather than Einstein who built the quantum community.

Franco Selleri said half the original founders of QM supported and half opposed the Copenhagen interpretation. But two generations later the overwhelming majority were dogmatically supporting the Copenhagen interpretation, including its assertion that wave function collapse occurs when something is measured. The reason for the dogmatism was the massive amounts of money poured into physics after World War II, so that the opinion of the people who controlled the purse strings became the dominant force. The "Copenhagen interpretation" of QM is: "Don't try to understand the quantum world, because you can't. Treat QM as abstract mathematics, and nothing else."[32]

Even today quantum leaders never doubt that wave function collapse occurs when something is measured. Anyone who questions that Axiom is classified as "not a scientist."

3.7 Axioms upon which mathematics is built

What we have been discussing concerns the Axioms that are the starting assumptions of mathematics. QM approaches the double slit experiment with an Axiom about the timing of wave function collapse and fails to explain this experiment.

All the experts agree on the Axiom that wave function collapse occurs upon measurement, and yet this writer, despite his best efforts, has not discovered ANY examples where this is true. We therefore challenge the QM experts, "Please advise us of one single instance in which it is clear that measuring something causes wave function collapse."

For the remainder of this article we will adopt the Axiom that "Wave function collapse **precedes** measurement." We propose to disconnect the timing of wave function collapse from the act of measurement. David Mermin dramatically stated the QM viewpoint when he said that science has proved that the moon only exists when people look at it.[33]

4 The Axiom Wars

To understand why this change of Axioms is so bewildering, it is helpful to remember how unnerving it is to be caught in the earthquake of seismic Axiom changes. The debate about the timing of wave function collapse is minor compared to the Axiom war that raged at the beginning of the twentieth century.

In 1905 David Hilbert proposed the Axiomatization of mathematics (similar to what Euclid had done for geometry). Kurt Gödel proved the incompleteness theorem, thereby derailing Hilbert's hope for Axiomatization. Hilbert and Wilhelm Ackermann fought back by proposing the *Entscheidungsproblem*. Alonzo Church and Alan Turing proved the undecidability theorem. The leaders of mathematics were devastated again. From their viewpoint nothing made any sense. Chaos prevailed in the world of Axioms!

Yet somehow out of that rubble, the age of computers was born in the 1940's. New Axioms had arrived. Johnny von Neumann could see it, but Hilbert and the old guard could not see it. Hilbert was von Neumann's teacher and mentor. No one else could have imagined that the destruction of the algorithms Hilbert wanted, would lead to the algorithms embedded inside today's computers.[34-36]

In summary: when there is a tectonic shift in Axioms, the leaders of math and science don't see it coming, and do not understand it. The new Axioms sound like nonsense to the leaders of yesterday. We might as well be uttering unintelligible gibberish as talking about wave function collapse occurring before measurement. When an Axiom convulsion occurs, mathematics is different thereafter. Everything is different after you change Axioms.

5 Particles follow waves backwards

The tools available to us to solve a double slit experiment would be vastly increased if it were possible that the detector (in this case the target screen) controls what happens inside the experiment. How could that be? If zero energy waves were coming out of the detectors, backwards through the experiment, and particles were following those waves backwards. This is a radically unconventional suggestion, difficult at first to imagine how this might work. We will discuss the "How?," later, but for now let's agree that such a discovery would increase the number of tools we could apply to solving the double slit enigma.

Nature can be tricky and deceptive, so it is wise be alert for surprises. We will now cite two experiments that establish the idea that particles can and do (sometimes) follow waves backwards.

5.1 A neutron interferometer experiment

A neutron interferometer experiment was published in *Physical Review* in 1992, the results of which could not be explained by QM, according to the authors (Kaiser, Clothier, Werner, etc, who were part of Helmut Rauch's highly respected team of neutron interferometer leaders).[37]

Neutrons were obtained from the upper left of Figure 6. The beam was split inside an interferometer into Ψ_1 and Ψ_2. An oscillating aluminum plate at the bifurcation caused Ψ_1 and Ψ_2 to vary in phase, so that when the beams re-combined at the right side of the interferometer, there was interference, which produced a sinusoidal curve seen by the detector (lower right). That sinusoidal curve can be seen in the middle of Figure 8, the top red cosine wave. In the first experiments there was no analyzer crystal in the lower right. There was a detector with nothing between it and the interferometer. The neutron beam went straight through to the ^3He detector in the lower right corner of Figure 6.

Bismuth is a metal of atomic number 83. It slows down neutrons and neutron waves. The experimenters put a sample of bismuth in the upper beam Ψ_2 but not in the lower beam Ψ_1. The samples varied from no bismuth to 2 mm, to 4 mm, etc. As they inserted more bismuth the upper wave packet was slowed relative to the lower wave packet, they didn't precisely overlap when the two beams recombined. There was a diminishing intensity of interference (progressively lower sinusoidal waves). When they reached ten or twenty mm of bismuth there was no interference detected (a flat line).

The data of which we speak can be seen in the middle column of Figure 8, with a flattening out of the red cosine wave as you go downward, corresponding to a fatter and fatter sample of Bismuth (the variable "D" increases). The same thing is visible in numbers in the middle column of Table 1.

Their interpretation was that the upper wave packet was so delayed that it never recombined with the lower wave packet, which had already departed from the interferometer. That is why they obtained a flat line with a fat sample of Bismuth.

They then repeated exactly the same experiments with one tiny difference. They inserted a nearly perfect silicon crystal: $\Delta\theta = 0.02^o$ full width at half maximum (FWHM), $\eta_A = 0.0035$ rad. This is the "Analyzer Crystal," shown as a thin green rectangle at an angle in the lower right of Figure 6, in front of the detector. This caused the exit beam of neutrons to deflect to the detector straight down (Figure 6). The nature of this crystal was to reduce the scatter of wavelengths of the neutron beam, so the Gaussian was narrower but had a taller peak at $\lambda = 2.345$ Angstrom in the center (Figure 7).

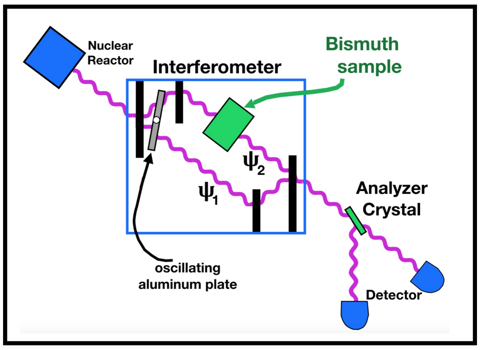

Figure 6: Equipment used by Kaiser et al, Neutron Interferometer *Physical Review A* (1992). A neutron interferometer experiment in which the interference is controlled by the presence or absence of an Analyzer Crystal placed in front of the detector (lower right). The black rectangles represent the four perfect silicon blades inside the interferometer. The detector (blue) in the lower right can be rotated so that the Analyzer Crystal (shown in green) is either outside the neutron beam, or in the center of the neutron beam, in which case we call the neutron beam "analyzed" and the neutrons refract straight down to the other position of the detector.

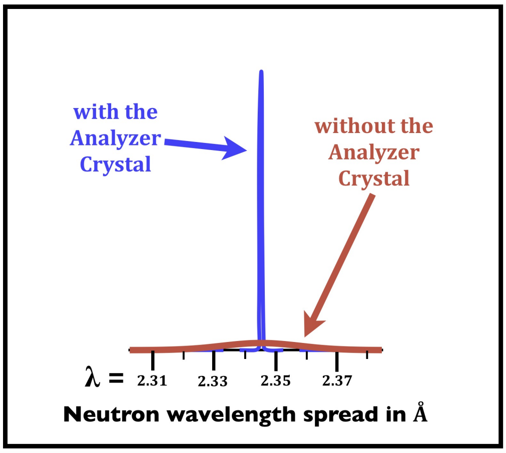

Figure 7: The impact of the ***Analyzer Crystal*** in front of the detector.

The expected effect was that the beam would penetrate better as it entered the detector. That should have had no effect on the interference inside the interferometer, because the analyzer crystal was outside and downstream.

To their astonishment the Analyzer Crystal restored robust interference up inside the interferometer. Even with ten or twenty millimeters of bismuth there was robust interference. Look at the right side of Figure 8. The sinusoidal waves oscillate wildly no matter how much Bismuth is used. The same thing can be seen in numbers in the right column of Table 1.

The researchers were mystified. They said they could not explain the results. They spoke of "Wheeler's smoky dragon," referring to a cartoon John Wheeler had published, showing a dragon hidden in the fog inside an experiment, then abruptly emerging from the fog to bite one of the detectors. This meant that unexplainable things sometimes happen in quantum experiments.

Table 1: Height of sinusoidal wave without & with Analyzer Crystal

#	Bismuth width	No Analyzer	With Analyzer
1	0.00 mm	100.0 %	100.0 %
2	2.09 mm	88.1 ± 1.3 %	97.1 ± 5.1 %
3	4.01 mm	57.3 ± 1.0 %	99.0 ± 4.8 %
4	12.26 mm	8.0 ± 0.8 %	89.6 ± 4.4 %
5	16.15 mm	1.8 ± 0.8 %	86.0 ± 4.8 %
6	20.08 mm	2.9 ± 0.6 %	95.2 ± 5.2 %

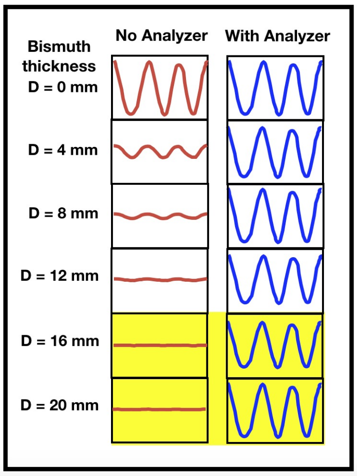

Figure 8: Left shows interference without an Analyzer Crystal, right is with. As D = width of the Bismuth increase, watch the yellow area. With 16 to 20 mm Bismuth all interference is gone for the middle column, but the right side (with an Analyzer Crystal) is still going strong. ***This means that the presence or absence of an Analyzer Crystal DOWNSTREAM from the interferometer, in front of the Detector controls the presence or absence of interference UPSTREAM, inside the interferometer!***

How can we make sense of this experiment? It is clear that the neutrons, which are particles, are starting in the upper left corner of Figure 6, and ending up by making the detector "Click!" If we make QM assumptions, each neutron should be a wave-particle, so the neutron waves should be traveling in the same direction as the neutrons. But the experimental results contradict such a common sense idea.

The experiment only makes sense if we make some wild assumptions. If the interference inside the equipment is controlled by the presence or absence of an analyzer crystal down in the lower right corner of Figure 6, then the analyzer crystal must be **upstream** from the interference! This only makes sense if zero energy waves are traveling in the opposite direction as the neutrons: starting at the detector, moving backwards through the equipment, and going up into the reactor where, from time to time, a neutron follows the waves backwards to make the detector "Click!"

Here are more details about the experiment. A wave packet had a width of 86.2 Angstrom. Bismuth at 20 mm would delay the wave packet by 435 Angstrom. So it is easy to see why a block of Bismuth would obstruct a wave packet, thereby obliterating any interference.

When the crystal was inserted the waves easily penetrated the Bismuth backwards. The effect of the Analyzer Crystal was to increase the coherence length of a wave packet from 86.2 Angstrom to 3450 Angstrom. In other words, the Analyzer Crystal caused the Elementary Waves to penetrate better, so as to cause the Bismuth to be invisible to the waves going backwards.

5.2 Elementary Waves

Is there other evidence of this kind of strange waves, which we will call "Elementary Waves"? By this we mean some hypothetical waves that travel in the "wrong direction," carry zero energy, and somehow entice particles to follow the waves backwards. If there were such a hypothetical wave, it could be useful in our effort to explain the double slit experiment.

5.3 The Purcell effect

The Purcell effect is the magnification of a quantum system's spontaneous emission rate by its environment. If an excited atom (such as a Rydberg atom) is put into a resonant cavity (•), the excited atom will decay hundreds of times faster and lose its excess energy (as a photon) if the width of the cavity is a multiple of the wavelength λ of the photon which the atom wants to emit. This was discovered in the 1946 by Edward Purcell.[38-41]

This means that the environment is conveying information about the diameter of the cavity into the atom:

$$(\bullet \leftarrow) \tag{2}$$

How is the cavity diameter known to the excited atom? How does this "nonlocal effect" work?

It cannot be quantum waves that convey the information, because until the atom decays, there are no quantum waves. Nor is it possible that the atom decays, emits a photon, the photon goes out into the environment and discovers it to be inhospitable, so it goes back inside the atom and the atom reverses the decay process backwards in time. That is a way of avoiding answering the question.

Information from the environment is traveling into the atom ($\bullet \leftarrow$) along with zero energy. The information ($\bullet \leftarrow$) and the photon ($\bullet \rightarrow$) travel in opposite directions. We choose the name "Elementary Waves" for this. The Elementary Wave carries zero energy. All the energy is in the photon following the wave backwards ($\bullet \rightarrow$).

We claims there are Elementary Waves everywhere, and some of them are amplified by echoing around inside a resonant cavity, but only if the wavelength of the wave λ is a multiple of the diameter of the cavity. The atomic decay is more likely if the impinging Elementary Waves are a multiple of the wavelength of the photon that the atom wants to emit, and if this wavelength is resonant (amplified) with the diameter of the cavity. If these wavelengths don't match up then the elementary (i.e. environmental) waves will present themselves to the atom as a feeble signal.

5.4 Three new Axioms

So far we have only begun to see how the Axioms might change a double slit experiment. We will give the reader a forewarning of what lies ahead. The Axioms of QM which we will eventually propose to discard are these:

A. Wave function collapse occurs when we measure something,
B. There is wave particle duality,
C. Waves travel in the same direction as particles.

We will eventually replace those with these Axioms:

A. Wave function collapse occurs *before* we measure something,
B. There is *no* wave particle duality,
C. Waves travel in the *opposite* direction as particles.

We are far from explaining how such a change of Axioms would work. But since Axiomatic change is the basic theme of this article, we want give the reader a map of what lies ahead.

5.5 The direction of time

Although Erwin Schrődinger, Oskar Klein and Walter Gordon assumed that waves and particles travel in the same direction, their equations work equally well if the waves travel in the opposite direction, with time always going forwards. Reversibility is characteristic of wave equations.

$$\left[(-i\hbar\nabla)^2 - \frac{(i\hbar\partial_t)^2}{c^2} + m^2c^2\right]\phi(x) = 0 \tag{3}$$

Klein-Gordon equation

Throughout this article time always flows forwards, never backwards. Some readers ask, "How could waves travel in one direction and particles in the opposite direction unless time goes both forwards and backwards?"

Let us clarify. If waves travel westward with time going forwards in our model, then particles travel eastward with time going forwards. If waves travel north-northeast with time going forwards, then particles travel south-southwest with time going forwards. Time never flows backwards in this article.

TEW has nothing in common with the pilot wave theory of Louis de Broglie and David Bohm, nor with John Wheeler and Richard Feynman's ideas about time reversal, nor with the Transactional Interpretation of John Cramer and Ruth Kastner. To understand this article it is best to temporarily forget those theories.[42-47]

6 Waves and particles travel in opposite directions

How would a double slit experiment work if there were "Elementary Waves" involved, traveling in the "wrong" direction, carrying no energy, and particles were following them backwards?

Figure 9 compares the Thomas Young and TEW pictures of the double slit experiment. They are skew symmetric. According to TEW (bottom half of Figure 9) the wave interference is located in proximity to the particle gun. The interference determines the amplitude with which a wave from any point α on the target screen impinges on the gun. The particle, sitting in the gun (bottom half of Figure 9), is bombarded by waves coming from every point of the target

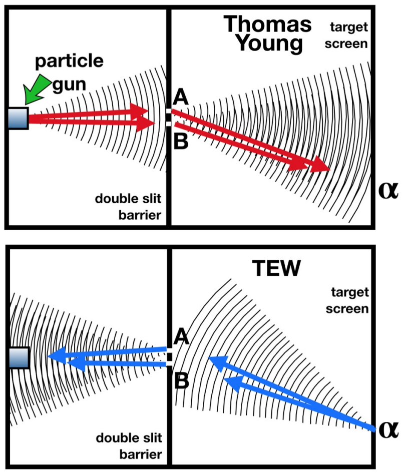

Figure 9: Contradictory ideas: Same wave interference going in opposite directions in a double slit experiment.

screen, each with a different amplitude. The particle (before it leaves the gun) makes a random choice of which wave to respond to, in proportion to the amplitude squared of that incident wave. Figure 9 raises a multitude of questions about how zero energy waves could have any impact. We will answer those questions below.

To give you a glimpse of what lies ahead, we will soon show that the variation in amplitudes of waves from different parts of the target screen, as they impinge on the gun, is the reason we end up seeing a wavelike pattern on the target screen in the final data. There are no plane waves in the model we are proposing.

6.1 The new double slit model has exactly the same math

We claim that the model shown at the bottom of Figure 9 has the same mathematics as the traditional model.

According to our model wave function collapse occurs at the gun. Particle follows the wave in the opposite direction as the direction of the wave. This idea originated with Lewis E. Little.[4-5]

After the particle makes its choice (after the gun is fired), no further wave interference has any effect on the particle. It follows its own wave backwards with a probability of one, through only one of the slits (it doesn't matter which slit) and inevitably makes a dot at that point α on the target screen from which its Elementary Wave is coming. After the gun is fired the particle's trajectory is pre-determined. Since there are no plane waves in our model, the particle has only one target (α) to go to.

If t = 0 is the time when the gun is fired, TEW wave interference occurs during the time $t \leq 0$ whereas the QM wave interference is when $0 \leq t$. TEW is a probabilistic system when $t \leq 0$, but a deterministic system when $0 \leq t$.

We will demonstrate that this model produces the same mathematics as the Thomas Young model.

6.2 Math of TEW and QM is the same: first illustation

What is the probability of a dot appearing at point α on the target screen according to QM (top half of Figure 9)? If **A** is the amplitude for a particle having come through slit **A**, and if **B** is the amplitude for it having come through **B**, then the probability is $|A + B|^2$ normalized (top half of Figure 9).

$$P(\alpha) = |A + B|^2 = |A|^2 + |B|^2 + 2|A||B|cos(\theta - \phi) \tag{4}$$

(we omitted the normalization factor $1/|A + B|$).

The TEW picture of the double slit experiment (bottom half Figure 9) is less familiar to our readers. The proposal is that every point on the target screen is always emitting zero energy waves that travel in all directions and at all frequencies at the speed of light. We call them "Elementary Waves." Later in this article we will argue that they are "Schrődinger waves." The vast majority of the waves from any point (such as α) can be ignored. The only relevant waves are the waves heading toward the double slit barrier with a wavelength λ that corresponds to the energy of the particle that will subsequently be fired from the gun.

The waves from one point (such as α) arrive at the two slits out of phase with one another (unless α is in the center of the screen). After they penetrate through the slits, the waves interfere with one another as they impinge on the gun (see lower left corner of Figure 9). Depending on whether that interference is constructive, destructive, or in between, the amplitude of the impinging wave varies.

A particle in the gun is bombarded by hundreds of different Elementary Waves

$$\Psi_1, \Psi_2, \Psi_3, \Psi_4, ...$$

one from each point on the target screen. By the word "hundreds" in this article we mean "a large whole number".

Operators act inside each wave. As we said before, "wave function collapse" means that an operator such as $\hat{A}$, which has different eigenstates, $|\alpha_1\rangle$, $|\alpha_2\rangle$, $|\alpha_3\rangle$, $|\alpha_4\rangle$, . . collapses to one specific eigenfunction such as $|\alpha_3\rangle$ at that that instant when the particle makes its choice which wave to follow backwards. We will sort out our confusing vocabulary (waves vs. operators) later.

After the particle makes that decision everything is deterministic. The particle no longer experiences any wave interference. It follows its particular trajectory with a probability of one.

Therefore the probability of a particle striking point α on the target screen is identical to the probability of a wave from point α striking the gun a few nanoseconds earlier. If **A** is the amplitude for a wave from point α having come through slit **A** to strike the gun, and **B** is the amplitude for it having come through slit **B**, then the probability of a wave from α striking the gun is $|A + B|^2$ normalized.

$$P(\alpha) = |A + B|^2 = |A|^2 + |B|^2 + 2|A||B|cos(\theta - \phi) \tag{5}$$

(we omitted the normalization factor $1/|A + B|$).

Our point is that ***equation 4 and 5 are identical***, illustrating how the mathematics of TEW is identical to quantum math. Later we will develop equation 56 and show that it also is equal to 4 and 5.

6.3 The math is the same: second illustration

Figure 10 shows the origin of Thomas Young's equation $m\lambda$ = d $sin\ \rho$. The angle ρ tells us where peaks will appear on the target screen. The variable "m" is an integer, λ is the wavelength, "d" is the distance between the two slits, ρ is the angle shown in the diagram, and "L" is the distance from the double slit barrier to the target screen. We assume that $L >> d$. Note that Figure 10 is "backwards" in that the waves are traveling in the opposite direction as what Thomas Young thought. Figure 10 shows that for every point α on the screen there is a difference in path length (d sin

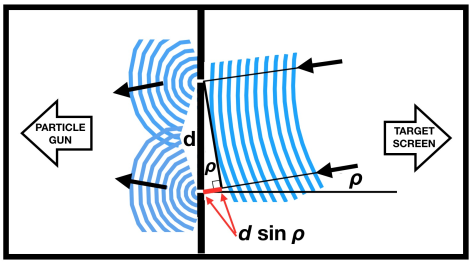

Figure 10: Thomas Young's equation ($m\lambda$ = d $sin\ \rho$); note that the waves are traveling in the opposite direction as what Young assumed.

ρ) between that point and each of the two slits, unless α is in the center of the screen. The point is, Young's equation is the same, no matter which way the waves travel, which illustrates that the math is the same even though the direction of the waves is reversed.

6.4 The math is the same: third illustration

As we have been saying, the pattern on the target screen will be the same whether the waves travel from left to right, or right to left. Add up the path length from the particle gun to slit A, plus the path length from there to point α, and subtract from that the path length from the particle gun to slit B, minus the path length from there to point α. We will call that number "X" ($X \in \mathbb{R}$), and we note that "X" is the same whichever way the waves are traveling. We will measure "X" in wavelengths λ. If we remove all whole numbers from "X," we are left with some fraction of a wavelength, and that fraction determines what is the phase of the wave in question when it hits its target. It is the phase of the wave that makes the pattern that you see on the target screen (see right side of Figure 1). This demonstrates that the math and pattern on the screen are the same, no matter which directions the waves travel.

With TEW there is a difference in path length from point α to each of the slits, which causes a difference in phase of the two waves ($\phi - \theta$) as they penetrate the two slits. Since the path length from each slit to the particle gun is the same, therefore the difference in phase that is determined at the slits ($\phi - \theta$), is invariant as the waves impinge on the gun. It is that phase difference that determines whether the interference at the gun is constructive (($\phi - \theta$)= 0 or π or 2π . . .) or destructive (($\phi - \theta$)= $\pi/2$ or $3\pi/2$ or $5\pi/2$ . . .), or somewhere inbetween.

Elementary Waves are unlike any other waves. For example, there are no plane waves in TEW.

The phase difference ($\phi - \theta$) of the two wings of the same wave impinging on the gun determines the amplitude with which that wave hits the gun. The amplitude squared at the gun is proportional to the probability that a particle will be triggered by that wave.

That in turn is the probability of a dot appearing at point α on the target screen. Why? Because if a particle is triggered, as we said before, it will follow that specific wave backwards with a probability of one, through one and only one of the slits (it doesn't matter which slit) and strike that point α from which its wave originates. That is a core assumption of TEW.

This phase difference ($\phi - \theta$) is the same whether the waves travel left to right, or right to left (top versus bottom of Figure 9). Therefore both QM and TEW give you the same math and the same pattern on the target screen.

6.5 Zero evidence of wave particle duality in the double slit experiment

In this model, wave function collapse occurs prior to measurement. It occurs when the particle is emitted, when the gun is fired. According to this model ***there is zero evidence of wave particle duality in the double slit experiment***.

This is important. When experts think about wave particle duality, it is almost always the double slit experiment that is in their mind. Consider this paragraph from the first page of Adam Becker's popular book *What Is Real?*[27]

"The objects in our everyday lives have an annoying inability to appear in two places at once. Leave your keys in your jacket, and they won't also be on the hook by the front door. This isn't surprising – these objects have no uncharted abilities or virtues. They're profoundly ordinary. . . . But atoms are prone to whimsy. A single atom, wandering down a path in a laboratory, encounters a fork where it can go left or right. Rather than choosing one way forward, as you or I would have to do, the atom suffers a crisis of indecision over where to be and where not to be. Ultimately, our nanometer Hamlet chooses both. The atom doesn't split, it doesn't take one path and then the other – it travels down both paths simultaneously, thumbing it's nose at the laws of logic."[2]

Becker then takes 360 pages to explore this idea. Unlike Becker, we think that a scientific approach would be to say, "If QM says something so illogical, then we must have made an error in our starting assumptions! Why are we assuming that waves and particles travel in the same direction, when this whole conundrum would dissolve if they travelled in opposite directions?"

Waves and particles cannot be identical if they are moving in opposite directions. In TEW waves can be in a superposition, but particles are ***never*** in a superposition. (This will have ramifications for the TEW concept of what happens inside a quantum computer circuit as discussed in the third article in this series.)

6.6 Assumptions of TEW

There is an assumption in TEW that at every point in space there are an infinite number of Elementary Waves traveling in all directions and at all wavelengths, at the speed of light. They carry no energy. No particle can move or even exist without being attached to at least one elementary ray, that it follows backwards. The particles carry all the momentum and energy. That assumption is embedded in our explanation of the double slit experiment.

6.7 Our reply to Einstein and von Neumann

When we prove (below) that these are Schrődinger waves traveling from the target screen to the particle gun (see Figures 11 and 12 bottom), then we will have answers for Einstein and von Neumann. To Einstein we say that after a particle has made a dot on the target screen there is no need for all Schrődinger waves to vanish. The Schrődinger waves no longer represent wave particles. They only represent waves. So there is no conflict between the location of the particle and the location of the Schrődinger waves.

To von Neumann we say that we have found the source of randomness in this experiment. It is the particle! We know from Brownian motion that particles are intrinsically random. As it is about to be fired, the particle makes a random selection among the hundreds of incident Schrődinger waves. Therefore there is no contradiction between QM being random and the Schrődinger equation being deterministic.

[2] op. cit. A. Becker, *What Is Real?*

7 Inventing a new TEW math

In this section we will conjure a new TEW mathematics out of thin air! Lewis E. Little discovered TEW,[7−9] but his proposal lacked a mathematical skeleton. He asked this author to develop appropriate equations. "After all, you have a degree in mathematics," he said. In this section we will build a skeleton.

The wave we want is not like any wave we ever met before. It needs to be a zero energy wave, traveling in what most people would consider to be the "wrong" direction, and somehow enticing particles to follow it backwards. It does not give rise to plane waves. Sometimes these "Elementary Waves" can be added into a superposition, but other times they cannot.

Our plan is to take a wave invented by Richard Feynman, turn it around so it travels in the opposite direction, and call it an "Elementary Wave." Feynman did the hard work. In the following discussion we will be taking mathematics that is implicit in Feynman's writing and making it explicit.

Richard Feynman's book ***QED*** (named after Quantum Electro-Dynamics) is his attempt to explain probability amplitudes to a lay audience that is math phobic. In chapter one he says that an amplitude moves out from a photon source, and blazes the trail that a photon might subsequently follow. This is a simple explanation of his path integral approach.[48]

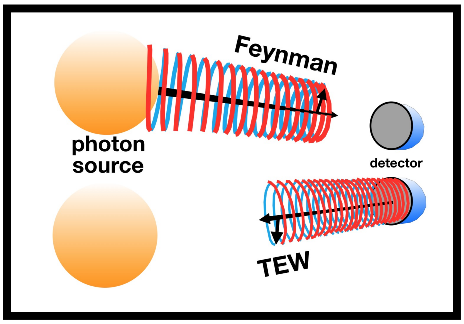

Figure 11: The top drawing represents Feynman's idea of an amplitude moving out from the photon source (• →). Attached to it is a small arrow spinning like the hand of a stopwatch (↑ ↗ → ↘ ↓ ↙ ← ↖ ↑ ↗ →) and therefore tracing a cylindrical helix (corkscrew) as it moves; the bottom drawing is identical except the whole apparatus starts at the detector and moves (• ← □) toward the photon source.

Feynman is pursuing a different goal than we are pursuing. Feynman's goal is to add up all the amplitudes for all possible paths from point A to point B, so as to arrive at the total amplitude that a particle will travel from A to B. Our goal is simpler. We want to picture a single probability amplitude as it travels out from a photon source in a straight line (Figures 11 top, and 12 top). Why? Because our proposal is hard for readers to learn, so we need to simplify everything as much as possible.

There are two different things moving out from the photon source in Feynman's book. First there are probability amplitudes carrying zero energy but establishing a path through space. Second there are photons that carry energy and might follow those paths.

Feynman's picture of an amplitude moving through Cartesian space is like someone going into the woods and making a path through the thicket. At a later date you might follow the path. If you do, the path contributes no energy to your hike. In this example you are the photon. All the energy comes from you. The path simply suggests which direction you might want to go. It is easier to follow the path than to bushwhack through the thicket. Therefore most people follow the path.

Feynman's "amplitudes" are statistical constructs defining the likelihood that a photon will travel along that path. Sometimes a photon follows that path, sometimes there are no photons on the path. The path in space is "real," even if there are no photons following it. To reiterate, it is the photon that carries all the energy and momentum. The path carries zero energy in Feynman's model, but the path is "real," he says.

7.1 Components of Feynman's model

Feynman's idea has several components. First there is a vector moving at light speed through space, defining the direction of the path (this is a long vector moving towards the detector (• → □), in the top half of Figures 11 and 12). There are also "little arrows" that Feynman discusses at length. As the "little arrow" spins it traces out a cylindrical helix or corkscrew.

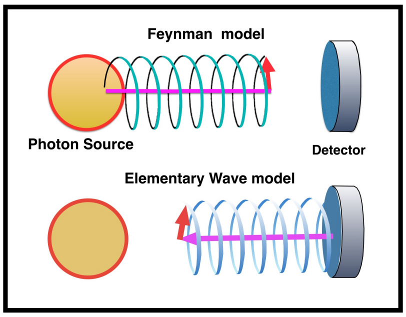

Figure 12: Here is a second snapshot comparing Feynman's and our concept of a probability amplitude.

These little arrows ($\nwarrow \uparrow \nearrow \rightarrow$) spin like the hand of a stopwatch, 36,000 rotations per inch (14,000 rotations per centemeter) for red light. The absolute length of these arrows ($\uparrow$) constitutes the amplitude of the particle taking that path. Each color of light has a different speed of rotation, Feynman says. The rotation constitutes the phase θ and the speed of rotation determines the wavelength λ and frequency f of a photon that might subsequently follow that path.

These little arrows spinning in Hilbert space ($\nwarrow \uparrow \nearrow \rightarrow \searrow$) are of the form $A = |A|e^{i\theta}$, where A is a complex vector. Complex vectors can be written in either of two equivalent formats: $a + bi$ or $A = |A|e^{i\theta}$. Euler's formula converts one into the other: $a + bi = |A|(cos\theta + i\ sin\theta)$. Throughout this article we use Feynman's format $A = |A|e^{i\theta}$ for complex numbers.

Although Feynman says these probability amplitudes are "real," he never says how the "little arrows" ($\uparrow$) in Hilbert space relate to a moving location (path) ($\bullet \rightarrow$) in Cartesian space. Nor did he ever ponder the question whether the probability amplitudes move centripetally ($\bullet \leftarrow$) or centrifugally ($\bullet \rightarrow$) We propose that they move centripetally ($\bullet \leftarrow \square$). That is a core assumption of TEW.

We will make some declarations that Feynman didn't make. The long vector pointing in this direction $\bullet \rightarrow$ (top half of Figure 11) is in Cartesian space, whereas the small arrow pointing in this direction $\uparrow$ is in Hilbert space. We might coin the term "Cart-Hilbert-isan space" for the hybrid. (That kind of bastardization of language is how you can tell I'm an applied mathematician and not a pure mathematician.)

The helix, being cylindrical, is like a straw. A fat straw is a tube that could carry a lot of fluid (a lot of photons). A thin straw is a tube for carrying a small flow of photons. The radius of the straw ($|A| \equiv$ the absolute length of $\uparrow$) is the amplitude for photons to flow in that direction ($\bullet \rightarrow \square$).

Our second declaration is that the probability amplitudes are moving in the opposite direction as what Feynman believed. This is shown in the **bottom** drawings of Figures 11 and 12, where the long vector ($\bullet \leftarrow \square$) shows the trajectory through Cartesian space. The elementary ray starts at the detector. Elementary rays and particles travel in opposite directions.

We will adopt the symbol Æ to denote such a contraption (portrayed in the bottom of Figures 11 and 12). The "contraption" looks like a cylindrical helix or corkscrew. This is an "elementary ray." The symbol Æ is pronounced "ash". One advantage of this letter from the Viking and Old English alphabets is that it is not a Greek letter, and therefore unlikely to be mistaken for a symbol from QM. An Æ lives in both Cartesian and Hilbert space, as we said.

Another advantage to using the symbol Æ is that this symbol appears on musical scores. We are writing the music of nature. The letter Æ is also the first letter of the term Ælementary Waves."

In any volume of space there is an infinite number of elementary rays (Æ 's), but a finite number of particles (in non relativistic, non-field theory QM). If there is a particle traveling in the opposite direction as the Æ then the symbol for the wave particle would be Æ+Π. ***The only thing that our detectors can see is a wave particle.*** We cannot see waves without particles (they have zero energy) nor can we ever see particles without waves (every particle is always attached to one wave or another: there are no "naked" particles). There can be no "duality" because the wave and particle are moving in opposite directions.

TEW is new. It has not yet developed relativistic field theories. We need more troops. If you are young and looking for a career where you can make a gigantic contribution, look no further. Seek us out.

Although we speak of an ocean of elementary rays in which we are immersed, the reality is humbling. We cannot see them. Our detectors cannot find them. As Einstein said, a wave that carries no energy might as well be a ghost that can't make itself known. The only reason we know about these waves is that we can see wave particles Æ+Π because the particles make our detectors "click." But the majority of Elementary Waves Æ are not attached to any particle and are therefore totally invisible, known only by inference.

Thus the entire structure of TEW is based on inference based on watching the behavior of particles. The particles incessantly dance about and thereby show us the invisible marionette strings that cause them to move.

De Broglie's thesis was correct and incorrect. Yes, there is always a wave associated with every particle. No, they don't travel in the same direction.

7.2 The purpose of an architectural drawing

Mathematical model making is like creating an architectural drawing to help a client understand what a building might look like, how it would feel as a living space, and whether it is worth investing money for its construction. This article seeks to sketch a different way of imagining the double slit experiment. If the client likes our architectural drawing then the client can anticipate what building materials would be needed, what building codes would be relevant and how the building might or might not fit into the neighborhood.

8 Probability amplitudes form a Hilbert space

Later, when we move all of Quantum Mathematics to a new platform (Section 10 of this article) we will focus attention on the idea that TEW has a Hilbert space and a Schrődinger wave. Therefore we will devote this Section to building a Hilbert space, and the next section to building a Schrődinger wave within the TEW environment.

In order to build a Hilbert space we focus now on the amplitudes (Feynman's "little arrows" (↖ ↑ ↗ → ↘ ↓ ↙ ← ↖ ↑ ↗ → ↘)) of the elementary rays. We propose that they form a Hilbert space. Each amplitude is of the form $A = |A|e^{i\theta}$.

$$A \in \mathbb{C} \tag{6}$$
$$|A| \in \mathbb{R} = \{x|x \geq 0\} \tag{7}$$
$$\theta \in \mathbb{R} = \{x|0 \leq x \leq 2\pi\} \tag{8}$$

8.1 A linear complex vector space

In ***QED*** Feynman discusses amplitudes from a light source impinging on a flat piece of glass (Figure 13 left), so that some of the original amplitude splits off as a reflection off the top of the glass, some of the amplitude is refracted off the bottom of the glass, and the remainder penetrates through the glass. The three divisions of the original stream add up to 100 % so there is conservation of amplitudes.

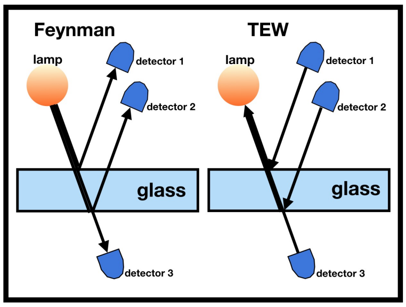

Figure 13: Light reflecting off a piece of glass on left, the opposite on the right. This establishes that amplitudes form a ***linear vector space V.***

From this we see that amplitudes can be subdivided. Since we have defined elementary rays as being the same thing (Figure 13 right) traveling in the opposite direction, it is evident that amplitudes can be added. Furthermore they can be multiplied by a scalar. If C is a complex number then

$$C \bullet A \in \mathbb{C} \tag{9}$$

Therefore these amplitudes form a ***linear vector space V.*** Our goal is to build a Hilbert space, so we need to define an inner product for our vector space V.

8.2 An inner product

We define the ***adjoint*** of a vector $A = |A|e^{i\theta}$ to be $A^* = |A|e^{-i\theta}$. A right-handed corkscrew has as an adjoint with a left-handed corkscrew, and vice versa.

Each particle can only follow an elementary ray with a frequency corresponding to the de Broglie frequency of the particle, which is based on the energy of the particle: $f = E/h$. Since energies typically are quantized into a spectra of E_n (where n = 0, 1, 2, 3 . .) therefore we can think of elementary rays as belonging to a family of corresponding frequencies f_n (where n = 0, 1, 2, 3 . .).

We can ***define an inner product***:

$$\langle A|\ B\rangle = \sum_n (A_n^*)B_n \in \mathbb{C} \tag{10}$$

So V is a ***complex inner product space.*** To keep things simple, we are only dealing with finite vector spaces at this time. We will not discuss $\langle A|\ B\rangle = \int dx(A^*(x))B(x)$. Our goal is to define V as a Hilbert space. There are several other hoops we must jump through.[49-52]

8.3 Properties of our inner product

Our inner product has five properties:

Here are properties and proofs that those properties exist:

1. Conjugate symmetry. $\langle A|\ B\rangle = \langle B|\ A\rangle^*$

Proof:

$$\langle A|\ B\rangle = \sum_n (A_n^*)B_n = \sum_n (|A_n|e^{-i\theta_n})(|B_n|e^{i\phi_n}) \tag{11}$$

$$= \sum_n (|A_n||B_n|e^{i(\phi_n-\theta_n)}) = \sum_n (|B_n|e^{i\phi_n}) \bullet (|A_n|e^{-i\theta_n}) \tag{12}$$

$$= \sum_n \langle (B_n)|\ A_n^*\rangle = \langle B|\ A\rangle^* \tag{13}$$

Q.E.D.

2. It has anti-linearity in the first vector

$$\langle (\alpha A_1 + \beta A_2)|\ B\rangle = \alpha^* \langle A_1|\ B\rangle + \beta^* \langle A_2|\ B\rangle \tag{14}$$

Proof:

$$\langle (\alpha A_1 + \beta A_2)|\ B\rangle = \sum_n (\alpha A_{1n} + \beta A_{2n})^* B_n \tag{15}$$

$$= \sum_n (\alpha^* A_{1n}^* + \beta^* A_{2n}^*)B_n = \sum_n (\alpha^* A_{1n}^* B_n) + (\beta^* A_{2n}^* B_n) \tag{16}$$

$$= \alpha^* \sum_n (A_{1n}^* B_n) + \beta^* \sum_n (A_{2n}^* B_n) = \alpha^* \langle A_1|\ B\rangle + \beta^* \langle A_2|\ B\rangle \tag{17}$$

Q.E.D.

3. linearity in the second vector.

$$\langle (A|\ \alpha B_1 + \beta B_2)\rangle = \alpha \langle A|\ B_1\rangle + \beta \langle A|\ B_2\rangle \tag{18}$$

Proof:

$$\langle (A|\ \alpha B_1 + \beta B_2)\rangle = \sum_n (A_n^*)(\alpha B_{1n} + \beta B_{2n}) \tag{19}$$

$$= \sum_n (A_n^*)(\alpha B_{1n}) + (A_n^*)(\beta B_{2n}) \tag{20}$$

$$= \alpha \langle A|\ B_1\rangle + \beta \langle A|\ B_2\rangle \tag{21}$$

Q.E.D.

4. The inner product of a vector with itself is positive definite,

$$\langle A|\ A\rangle = |A|^2 \geq 0 \text{ and } \langle A|\ A\rangle = 0 \text{ iff } A = 0 \tag{22}$$

Proof:

$$\text{If } A = 0 \text{ then all the } A_n = 0 \text{ since the } A_n \text{ are} \quad (23)$$
$$\text{all orthogonal, i.e. } \langle A_j | \; A_k \rangle = \delta_{jk}. \quad (24)$$
$$\text{But if } A \neq 0 \text{ then some } A_n \neq 0 \text{ and vice versa} \quad (25)$$
$$\text{which means } \sum_n (A_n^*) A_n \neq 0. \quad (26)$$

Q.E.D.

5. and the distance between two vectors is given by this distance equation

$$|A - B| = \sqrt{\langle (A - B) | \; (A - B) \rangle} \quad (27)$$

Proof:

$$\text{Plan: show both sides are equal to} \sqrt{(a_1 - b_1)^2 + (a_2 - b_2)^2}. \quad (28)$$
$$\text{Let } A, B \in \mathbb{C} \text{ and } a_1, a_2, b_1, b_2 \in \mathbb{R}. \quad (29)$$
$$A \equiv a_1 + a_2 i \text{ and } B \equiv b_1 + b_2 i \text{ then on the left hand side} \quad (30)$$
$$|A - B| = |(a_1 + a_2 i) - (b_1 + b_2 i)| = |(a_1 - b_1) + (a_2 - b_2) i| \quad (31)$$
$$\text{Which, by the Pythagorean Theorem} \quad (32)$$
$$= \sqrt{(a_1 - b_1)^2 + (a_2 - b_2)^2} \quad (33)$$
$$\text{And, on the right hand side, } \sqrt{\langle (A - B) | \; (A - B) \rangle} \quad (34)$$
$$= \sqrt{\langle ((a_1 + a_2 i) - (b_1 + b_2 i))^* | \; ((a_1 + a_2 i) - (b_1 + b_2 i)) \rangle} \quad (35)$$
$$= \sqrt{\langle ((a_1 - b_1) + (a_2 - b_2) i)^* | \; ((a_1 - .b_1) + (a_2 - b_2) i) \rangle} \quad (36)$$
$$= \sqrt{((a_1 - b_1) - (a_2 - b_2) i) \bullet ((a_1 - b_1) + (a_2 - b_2) i)} \quad (37)$$
$$= \sqrt{(a_1 - b_1)^2 - ((a_2 - b_2) i)^2} = \sqrt{(a_1 - b_1)^2 + (a_2 - b_2)^2} \quad (38)$$

Q.E.D.

These five properties prove that our inner product (Equation 10) is ***valid.*** So we have proved that we have a complex linear vector space V has a valid inner product. But more is required before we can declare this to be a Hilbert space.

8.4 Properties of our vector space V

We claim V has additional properties: it consists of a set that is ***separable*** because it contains a countable dense subset. Our equation $A = |A|e^{i\theta}$ can be thought of as belonging to a set of complex numbers $\{\mathbb{C}\}$. Each set of complex numbers contains a countable dense subset, namely the subset of rational real numbers times the subset of rational imaginary numbers.

V is also ***complete.*** It consists of sets of real numbers. Therefore every Cauchy sequence converges to an element in that Hilbert space. Every Cauchy sequence converges to something like $B = |B|e^{i\phi}$ where $|B|$ is a real number and ϕ is also a real number.

Because V is separable, complete and is a linear complex vector space with a valid inner product, therefore we declare that it is a Hilbert space.

8.5 Relationship between Hilbert and Cartesian spaces

Most treatises on QM assume that Hilbert space is abstract, with no direct relationship with the world of everyday experience. Some experts speak of "state space." No one ever draws a roadmap for how a student could travel from Cartesian to Hilbert space or back. Without a map, most students get lost. Students are bewildered and disoriented.

Our elementary rays (Æ) are pictured in the bottom half of Figures 11 and 12. They merge Hilbert and Cartesian spaces. The central vector moving out from the detector (← □) is in Cartesian space. It has a direction and a velocity (the speed of light). The other vector, at right angles to it (↓ ↙ ← ↖ ↑ ↗ → ↘)) is spinning like the hand of a stopwatch. Because it is moving through space at right angles to the plane of spin, as we said before, it traces the pattern of a corkscrew. It has a name: $A = |A|e^{i\theta}$. That vector and the cylindrical helix exist in Hilbert space, as we just proved. The radius of that cylindrical helix (the absolute length of ↓) defines the amplitude for photons moving in that direction.

This solves a problem that is rarely discussed. Where is Hilbert space located? Hilbert space is hidden in plain sight, inside Cartesian space. This is a roadmap that you can hand to students.

Our next step is to demonstrate that these are Schrődinger waves, because they obey the Schrődinger equation.

9 Schrődinger equation and elementary rays

The most famous quantum equation living in Hilbert space is the Schrődinger equation. We will work with a one-dimensional equation, where the “X” axis runs from point α on the target screen to the midpoint between the two slits, and then bends slightly to go to the particle gun. We now apply the Schrődinger equation to the Elementary Waves which we have been describing.[53]

$$i\hbar\frac{\partial\Psi}{\partial t}(x,t) = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial t^2} + V(x,t)\Psi(x,t) \tag{39}$$

This equation can be solved by separation of variables. We seek a solution of the form:

$$\Psi(t,x) = \xi(t)\Psi(x) \tag{40}$$

When we insert that equation into the Schrődinger equation we get:

$$i\hbar\Psi(x)\frac{\partial\xi}{\partial t} = \xi(t)\Big[-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x)\Psi(x)\Big] \tag{41}$$

Now we divide both sides by $\xi(t)\Psi(x)$ and we get:

$$i\hbar\frac{1}{\xi(t)}\frac{\partial\xi}{\partial t} = \frac{1}{\Psi(x)}\Big[-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x)\Psi(x)\Big] \tag{42}$$

Since the left hand side is dependent on “t” but not “x,” but the right hand side is dependent on “x” but not “t,” the two sides can only be equal if they both equal a constant, which we will call “E.” So we can take the left hand side and say:

$$i\hbar\frac{\partial\xi}{\partial t} = E\xi(t) \tag{43}$$

from which we derive:

$$\xi(0)exp(\frac{-iEt}{\hbar}) = \xi(t) \tag{44}$$

where $\xi(0)$ is a constant. And from the right hand side of equation 39 we get:

$$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x)\Psi(x) = E\Psi(x) \tag{45}$$

We now identify $\Psi(x)$ as a state of definite energy E. We can write:

$$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi_E}{\partial x^2} + V(x)\Psi_E(x) = E\Psi_E(x) \tag{46}$$

In the double slit experiment “potential energy” is irrelevant, so we can drop the term $V(x)\Psi_E(x)$ from the equation. This leads to the well known stationary eigenstate of definite energy E.

$$\Psi(t,x) = \xi(t)\Psi_E(x) = exp(\frac{-iEt}{\hbar})\Psi_E(x) \tag{47}$$

The term $exp(-iEt/\hbar)$ describes the phase spinning rapidly, because the reduced Planck’s constant $\hbar$ is in the denominator and is extremely small. In other words the cylindrical helices in Figure 14 are tightly wound, with a short wavelength λ. Feynman said they spin 36,000 times per inch for red light.

When we apply the Schrődinger equation to an elementary ray in the double slit experiment we define Ψ_E to be a constant:

$$\Psi_E(x) \equiv |A+B| \tag{48}$$

The reason we repeatedly use the term “A + B” is because we always have a picture in our mind (Figure 14). When the Elementary Wave from point α on the target screen goes through the two slits, we define the amplitude of the ray going through slit A to be “A” and the amplitude for the ray going through slit B to be “B”. Those are the elementary rays which we have been saying have phase θ and ϕ respectively at the two slits. As those rays travel toward the particle gun they have a combined amplitude of “A + B”.

Thus the stationary state for two elementary rays coming through the two slits in Figure 14 is:

$$\Psi(t,x) = exp(\frac{-iEt}{\hbar})|A+B| \tag{49}$$

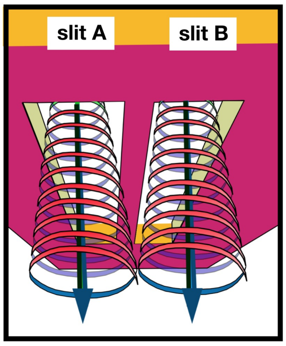

Figure 14: View from above of two branches of the same Elementary Wave penetrating the two slits, and heading toward the particle gun: they have amplitude A and B respectively.

We are talking about the wave that started at point α on the target screen. When it impinges on the particle gun, the probability that a particle will follow that Schrődinger wave backwards is the square of the Schrődinger wave, which is:

$$P(x) = |\Psi(t,x)|^2 \tag{50}$$
$$= |exp(\frac{-iEt}{\hbar})|A+B||^2 \tag{51}$$
$$= |exp(\frac{-iEt}{\hbar})|^2 \times |A+B|^2 \tag{52}$$
$$= |1|^2 \times |A+B|^2 = |A+B|^2 \tag{53}$$
$$= |A|^2 + |B|^2 + Re(AB^* + A^*B) \tag{54}$$
$$= |A|^2 + |B|^2 + |A||B|Re(exp(i(\phi-\theta)+exp(i\theta-\phi)) \tag{55}$$
$$= |A|^2 + |B|^2 + 2|A||B|cos(\phi-\theta) \tag{56}$$

This is the same as equations 4 and 5. Once again we have shown that the math is the same even when the waves travel in the “wrong” direction.

We have shown that the Elementary Waves that come from the target screen in a double slit experiment obey the Schrődinger equation. Obviously Schrődinger waves carry zero energy, because Schrődinger waves convey probability densities (or “probability amplitudes”), not energy.

The probability density for the Hamiltonian is a constant in the double slit experiment. The word “Hamiltonian” means

$$\hat{H} = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial t^2} + V(x) \tag{57}$$

10 Changing the platform of Quantum Math

Our initial goal was to develop a mathematics for the double slit experiment. In the process, we discovered that the Axioms of QM are deficient, even though quantum mathematics is awesome. In order to accomplish our goal we need to change the Axioms upon which the math is built. That is a daunting task.

Everyone is aware of the paradox: On the one hand quantum math is the most powerful science that humans have ever had, the source of our high tech economy, the source of silicon chips, MRI machines, tunneling microscopes, the internet, quantum computers, etc. On the other hand quantum assumptions lead to such a weird view of the world (witness Schrődinger’s cat) that something must be wrong. This paradox is like having a computer built on the platform of a silicon chip that has a flaw that makes it vulnerable to meltdowns and hackers. We plan to change to a different silicon chip. The goal of this section of our article is to change the platform upon which all of quantum math is constructed.

In computer science the platform refers to the hardware and operating system. It provides the framework within which software can be developed. When we change the platform we modify the environment and ground rules that define programming interfaces. TEW changes the rules of Nature, compared to how QM defined the rules of Nature. Nature doesn’t change, but our understanding of Nature changes.

How can we preserve the integrity of quantum math if we change the platform upon which that math rests? The term “QM” has two meanings, which we now split apart. On the one hand it means “quantum MATHematics.” On the other hand it means “quantum assumptions.” Our goal is to keep the first but discard the second.

We will use the term "quantum assumptions" to be synonymous with the following three propositions, which we call "Axioms":

A. Wave function collapse occurs when we measure something,
B. There is wave particle duality,
C. Waves travel in the same direction as particles.

We will use the term "TEW Axioms" which are the following three propositions:

A. Wave function collapse occurs ***before*** we measure something,
B. There is ***no*** wave particle duality,
C. Waves travel in the ***opposite*** direction as particles.

We plan to lift the house of quantum mathematics off its foundation, put the house on wheels, and roll it over to a different location, so as to relocate it onto TEW Axioms.

10.1 Axioms versus Postulates

The words "Axioms," "postulates" and "assumptions" are supposed to be synonyms. Yet we have stated three alleged "Axioms" of QM without even mentioning the "postulates of QM" that are stated in QM textbooks.

Here are the "six postulates of QM" as defined by Robert L. Jaffe:[54]

1. "The space of states is a vector space with an inner product.
2. "Every observable attribute of a physical system is described by an operator that acts on the kets that describe the system.
3. "The only possible result of the measurement of an observable A is one of the eigenvalues of the corresponding operator $\hat{A}$.
4. "When a measurement is made, the probability of obtaining eigenvalue α_n is $| \langle\alpha_n| \ \Psi\rangle |^2$.
5. "Immediately after the measurement of an observable A has yielded a value α_n, the state of the system is the normalized eigenstate $|\alpha_n\rangle$.
6. "The time evolution of a quantum system preserves the normalization of the associated ket."

These six "postulates of QM" do NOT state the most basic assumptions of QM. How would you classify the unconscious assumptions and biases that determine what you see and what you are blind to, even before you get to the first postulate?

For example, Thomas Jefferson wrote the first postulate of the American democracy: "All men are created equal." He never thought about the assumptions that shaped his thinking. By "men" he meant white males. If we were to move Jeffersonian democracy to a new platform, we would start with two Axioms preceding the first postulate:

A. Axiom 1. Women are people, not property.
B. Axiom 2. Slaves are people, not property.
C. First postulate: All people are created equal.

Here is another example: quantum experts assume, even before the first postulate that, "Wave function collapse occurs when we measure something." In this article we will call such an assumption, an Axiom. So in this article three Axioms of QM precede the six postulates of Jaffe.

For the purpose of changing the platform for all of quantum math, we have started by discarding the three QM Axiom, and replacing them with three TEW Axioms. Our goal is to change the platform in such a way as to preserve the integrity of quantum math, while discarding quantum starting assumptions.

This will require us to re-write some of Jaffe's postulates also.

10.2 Reconciling QM timeframe with TEW timeframe

The task of changing the platform of quantum math is daunting. We assume from now on that the platform consists of the three Axioms of TEW. But there are misfits between these Axioms and structural needs of quantum math. Not everything lines up comfortably, starting with discrepancies in the timeframes.

The timeframe that QM is interested in starts when the particle leaves the gun and ends with wave function collapse at the target screen. Assume t = 0 is the moment when the gun is fired. The QM timeframe is $0 \leq t \leq T_M$ where T_M is the **T**ime when the result is **M**easured (a dot appears on the target screen). TEW is interested in an earlier timeframe: before the particle leaves the gun. The TEW timeframe is $t \leq 0$.

We want to find the time when TEW and QM overlap, which is $t = 0$, because in order to change platforms we need to have a mutually agreeable time frame. Thus if we find any common ground it would have to be at that instant when the particle is in the gun, about to be fired, or beginning to be fired.

But even so, we anticipate problems. After the gun if fired QM assumes the particle is in a superposition with a wide open future, until it strikes the target screen. TEW assumes that the particle has become a projectile following a specific trajectory, after it leaves the gun. It is almost as if QM pictures the particle as having "free will" while TEW pictures the particle as being a robot with no "free will." QM claims the particle has neither position nor momentum when $0 < t < T_M$. The particle is smeared out like peanut butter, or a fog. TEW claims the particle has both position and momentum when $0 < t < T_M$, within the limits of the uncertainty principle.

10.3 Hilbert spaces and Schrődinger waves

There are other problems to solve, when we seek to create an interface between quantum math and the Axioms of TEW. QM assumes there is only one Hilbert space and one wave represented by one ket $|\Psi\rangle$ that "represents everything about the system." Within that ket there are several operators, corresponding to the several things we might measure, such as position, momentum or energy.

Up until now in this article, we assumed there are hundreds of Hilbert spaces for TEW, each with its own Schrődinger wave represented by $|\Psi_n\rangle$. That confusing description of TEW needs to change. Although we said that each point α gives rise to it's own Hilbert space H_n, with it's own Schrődinger wave $|\Psi_n\rangle$, is there any way to simplify that picture? (Remember what we said earlier: by the word "hundreds" in this article we mean "a large whole number".)

There is no difference between different points on the target screen, other than the amplitude each point has for being struck by a particle. Could we, therefore, treat all the hundreds of different Hilbert spaces and Schrődinger waves as being identical? The answer is yes, and no. Yes for Hilbert, no for Schrődinger.

When we combine the hundreds of Hilbert spaces (one for each point on the target screen), $H = \sum_n H_n$, the question is whether a conglomerate Hilbert space is different if it is composed of hundreds of subspaces. We claim that this is not a problem They are not actually "subspaces" in a mathematical sense. Many contain identical territory. They are redundant. The subspaces are not orthogonal to one another. When we stop speaking of "hundreds of Hilbert spaces" and speak instead of "one Hilbert space" all we are doing is changing our perspective and our way of speaking. Therefore, as of this moment, we declare $H = \sum_n H_n$. To use the notation we developed earlier, we should say $V = \sum_n V_n$ where V is linear vector space that is a Hilbert space.

Can we likewise simplify the Schrődinger wave(s)

$$|\Psi\rangle = \sum_n |\Psi_n\rangle ? \tag{58}$$

No! In TEW the Schrődinger wave is traveling in the opposite direction as the QM Schrődinger wave, and it also **remembers where it came from.** If it came from point α then it remembers that, and does not think it came from point β. Therefore if a particle selects that specific Schrődinger wave, the particle will target α and not β on the screen. This is a core issue for TEW. It is non-negotiable. Schrődinger waves from α versus β is the origin of the wave interference pattern on the target screen. As we move quantum math to the new platform, we need to assume the Schrődinger wave continues to have this property: loyalty to it's birthplace.

We've got a problem here! Consider (again) the first postulate of QM: "At each instant the state of a physical system is represented by a ket $|\Psi\rangle$, in the space of states. This is a Hilbert space."

We have to reconcile a corresponding core feature of TEW: "a $|\Psi_n\rangle$ remains loyal to it's birthplace in Cartesian space." The TEW ket is more rooted in everyday reality than is the QM ket floating away in the "space of states". Our ket is tethered. The difference between $|\Psi_n\rangle$ and $|\Psi_m\rangle$ in TEW is a difference in amplitude at the gun, and also a difference in future destiny on the target screen of the particle fired from the gun.

Here is how this author thinks about it. Both QM and TEW agree that we live in a world where everything effects everything else, like a world with invisible cobwebs stretching from everything to everything else. If a Schrődinger wave from point α is the wave that the particle in the gun randomly chooses, then the particle is instantly tied to point α by that invisible thread, which becomes the particle's trajectory.

As we move the house of quantum math onto its new platform, this is one of the changes that we have to make in the internal structure of quantum math.

10.4 Vocabulary as a problem!

We need to avoid some of the QM vocabulary. We cannot speak of the operator as an “observable” because we have demoted observation. Both “observable” and “measurement” are misleading words that leave readers confused about the importance of measurement. Measurement is NOT important. Whether we measure or don’t measure something, doesn’t matter! Nature can go on the same as always if we close our eyes, or die, or live in a different galaxy.

Instead of using the word “observable” we will recruit the word “operator” to work double duty, performing two jobs. First, an “operator” will be that which may eventually be observed, if it is Hermitian. We will define the word “operator” to mean “that which could eventually be measured,” and *also* to mean “that which acts on $|\Psi\rangle$ by changing a ket into another ket:”

$$\hat{A} : |\Psi\rangle \rightarrow |\Psi^a\rangle = \hat{A}\,|\Psi\rangle \tag{59}$$

10.5 Other issues

When the particle connects with the operator at $t = 0$ the only possible choice is an eigenvalue of the operator. The probability of the particle choosing eigenvalue α_n is $|\langle\alpha_n|\ \Psi\rangle|^2$.

From the instant when the particle leaves the gun the state of the system is normalized to eigenstate $|\alpha_n\rangle$. It doesn’t matter whether we measure it once or twice, we will always get the same eigenvalue α_n. Measuring it at the target screen is not important. If we did not measure it, nothing would change. The change at the particle gun precedes measuring it at the target screen.

The QM obsession with why the eigenstate comes out of superposition and becomes $|\alpha_n\rangle$, so that when we measure it a second time we again find α_n, that whole obsession is no longer relevant. We must discard Jaffe’s fifth “postulate of QM.” What we now say is that the eigenstate was $|\alpha_n\rangle$ even before we measured it the first time!

And now we reveal the mystery that QM has been obsessed with: Why does an operator collapse into one specific eigenvalue α_n? The answer is that the particle, about to be fired, is unpredictable. It selects which eigenvalue will prevail. This takes us back to our discussion with von Neumann. The source of “randomness” in QM is the particles themselves. If you want to know what a busy beehive looks like, watch a video of particles in sub-microscopic spaces undergoing Brownian motion!

11 Complementarity and Elementary Waves

Another aspect of the double slit experiment is the fact that the interference fringe pattern vanishes if we know which slit a particle passes through.

Bohr and others claimed that complementarity in the double slit experiment concerned human awareness. If we know which slit, then we cannot also see the interference pattern. There is a long, contorted, and useless discussion in the history of QM, concerning why human awareness is so important in Nature, as if Nature couldn’t exist without us. It’s narcissistic, egotistical, boring and ridiculous!

The phenomenon can be explained without invoking human awareness. We only know which slit if a detector is providing information. Our detector equipment emits a small amount of light (or energy) in order to be able to see the particle, and that energy causes the disruption. We will discuss this again when we discuss a Stern Gerlach experiment in the next article.

Someone might say “No!,” our tiny detectors could not disrupt the experiment, because the energy of our detectors is infinitesimal compared to the energy of the particle. The particle for example could be molecule of Buckminsterfullerene (C-60). The energy from our detector is insignificant compared to the energy of a moving Bucky-ball!

Our reply is that Elementary Waves convey NO energy! An infinitesimal amount of energy from the detector is greater than the zero energy of Elementary Wave. It clobbers the wave and causes disruption. Specifically, the energy destroys the ability of the wave through slit A to add to the wave through slit B into a superposition. We don’t know why, but we observe empirically that this is true. Once the Elementary Waves have been modified, we have modified the flight plan, and the Bucky-ball will change its behavior because it is following the new flight plan.

To say the same thing in different words: the elimination of an interference fringe pattern in a double slit experiment means that Elementary Waves through slits A and B no longer interfere with one another, i.e. the waves through the two slits can no longer be added into a superposition as they converge on the particle gun.

With Elementary Waves sometimes you can and sometimes you cannot add two waves together into a superposition. For example, waves originating from adjacent points on the target screen cannot be added together. There are no plane waves in TEW. Why is not clear. It is simply an empirical fact.

Similarly, if you expose waves to a source of energy as they pass through two slits, that destroys their superposition additivity.

In Nature the usual situation is that Elementary Waves cannot be added together into a superposition. Elementary Waves are everywhere, whereas wave interference is rare. When we look at a table we see a solid, rectangular object with no downstream ripples cascading off the edges.

The relevant question is not why a measuring device destroys superposition additivity. The question is why any Elementary Waves can ever be added together under any circumstances. We don't know the answer. That is the exciting thing about new science: there are a vast number of unanswered questions.

12 Could TEW be an "Interpretation" of QM

Since TEW and QM predict the same results for most experiments, are they somehow equivalent to one another? The answer is "No!" because we can design experiments for which they predict divergent outcomes (Figure 15).

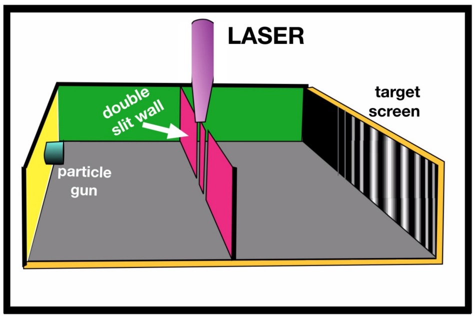

Figure 15: A laser closes one slit at $t = 0$; this causes there to be a wave pattern on the target screen, but one that is heavily skewed to the right.

It is important to design experiments for which TEW and QM predict different outcomes. This author has published three of which one is depicted in the picture above. Since TEW and QM give identical results in most experiments, we can only differentiate them if the experiment has a moving part. At time $t = 0$ (when the gun is fired in a double slit experiment) we can construct a boundary line between TEW and QM. If we have a device that can instantly slam the door on one slit at time t = 0. In this experiment, assume that one particle is fired at a time, followed by a pause.

Figure 15 shows that a laser has been placed on top of the far slit. The laser is designed to slam that slit closed at $t = 0 \pm 1ns$. Since Elementary Waves travel one foot (30.3 cm) per nanosecond, the distance between the double slit barrier and the gun needs to be more than one foot.

TEW predicts that the target screen will show a lopsided interference fringe pattern, (Figure 15). QM predicts that there would be NO wave pattern on the screen.

Why? There is a wave pattern on the target screen iff there is wave interference inside the experiment. If you close one slit at $t = 0$ then QM says you have eliminated all wave interference, whereas TEW says the wave interference occurred prior to $t = 0$.

If this experiment produced the results shown in Figure 15, then it would violate an iron-clad law of complementarity: that we cannot know which slit is used, **and** simultaneously see an interference fringe pattern!

13 Conclusions

We have proposed a radically different perspective on the double slit experiment, based on a change of Axioms. It amounts to a paradigm shift.[28] Probably there will be flaws found in our mathematics and contradictions in our logic. Einstein said, "Anyone who has never made a mistake has never tried anything new."

13.1 Impact of the new Axioms

With TEW you find Nature behaving in precisely the way you expect, with one exception. How could it possibly be that the Schrődinger waves are covertly moving in the "wrong" direction, the direction ***opposite*** to the flow of energy and momentum? It is insane! ***But here is the key to understanding this entire article: even though it is insane, it is true!***

Let's focus on that last sentence. Something is insane but true. It means that the truth is beyond what we can understand. This means that our Axioms have failed. The old Axioms prevent us from recognizing reality. In particular the Axiom that Schrődinger waves, energy and momentum all travel in the same direction. This is a familiar crisis in mathematics. Usually an insoluble math problem requires us to attack the problem from an unfamiliar angle, and that angle often requires that we discard our old Axioms and adopt new ones. The history of mathematics is replete with examples of such paradigm shifts.

Mathematics faced a similar crisis in 1936. In the program of Axiomatizing mathematics, David Hilbert and Wilhelm Ackermann proposed the Completeness Theorem of first order logic, the *Entscheidungsproblem*. They sought an algorithm that would take a statement of first order logic and answer "Yes" or "No" about whether the statement was universally true, i.e. whether the statement could be proved from Axioms.

In 1936 Alan Turing disproved the *Entscheidungsproblem*. He designed an "a-machine" ($automatic\ machine$) and proved that the machine was incapable of proving whether or not it would become trapped in an infinite loop. The infinite loop in question was the type of logical statement that is famous: "This statement is untrue," is a statement that can only be true if it is untrue, or vice versa.

Turing's a-machine constituted a proof that mathematics cannot be universally Axiomatized. It demonstrated the intrinsic limitations to an algorithmic logic. To followers of Hilbert it meant, "even though it is insane, it is true." They felt that mathematics had hit a brick wall.

This meant that the old quest for the Axiomatization of mathematics had come to the end of the line. As logical as it seemed at that time, it went off a cliff and self-destructed. Early in the 20th century this appeared to be unimaginable. Turing (and Church) had proved that the unimaginable was true.

Today it is a matter of indifference to us that mathematics cannot be Axiomatized. But we don't feel we can tolerate the idea that Schrődinger waves travel in the "wrong" direction. We won't lose sleep over the *Entscheidungsproblem* being wrong. But we might lose sleep over the "wrong" direction Schrődinger wave problem. We do not miss the universal Axioms that a previous generation of mathematicians could not imagine living without. In fact the disproof of the *Entscheidungsproblem* is so boring to us today that it might put us to sleep.

That is what it means to face a sea change in Axioms. It means that we toss the old Axioms in the trash and learn to live without them. It is like an alcoholic learning to live without alcohol. At first it feels impossible. But eventually we learn, one day at a time, that we don't need to be inebriated with the old Axioms, that life can go on, and is in fact improved.

When the dust settled the machine designed by Turing for this purpose was a fountain of productivity. It was recognized that the infinite loop limitation was only intrinsic to a Turing machine if the machine's memory consisted of a data tape. If one shifted to random access memory (RAM), suddenly the restrictions on what the machine could accomplish were unleashed. After that the sky was the limit for Turing machines. Computers have soared, limited only by Moore's law. This article you are reading was written on such a Turing machine.

Axiomatic changes occur in mathematics, and it is not the end of the world. Looking back at the devastating loss of the *Entscheidungsproblem* in 1936 it no longer bothers us at all. Meanwhile we celebrate the new Axioms, because now we live in the world of computers and the internet.

Similarly the idea that Schrődinger waves travel in the "wrong" direction is a crisis we will soon recover from, and we will discover that it is a good thing, because until we realized that fact, we were hobbled in our understanding of the quantum world. Now we are free!

Sober life at first looks impossible, but eventually we discover that it is enjoyable.

13.2 Benefits of the new Axioms

The positive sides of Schrődinger waves traveling in the "wrong" direction are staggering. We have doubled the size of Nature. To that half of Nature that conveys energy, we have added the other half that contains none. Both Hilbert space and Schrődinger waves have been changed from abstractions in the space of states, to something everywhere around us, visible if we open our eyes. We have changed the platform for all of quantum math, something no one ever imagined desirable or possible.

We have banished "weirdness" from QM! And we have disconnected "wave function collapse" from the act of measurement, thereby demolishing David Mermin's declaration that science has proved that the moon only exists when people look at it. We have created a new branch of applied mathematics, and therefore we have opened vast territories for future research by graduate students. We have given the specifics for experiments that have never been performed, for which QM and TEW predict divergent outcomes.

In the next article, we will show that six published quantum experiments can be better explained by TEW than by QM. In the third article in this series we will restructure our entire understanding of the Bell test experiments and quantum computers.

As we said before, when an earlier version of these ideas was presented at a meeting of the American Physical Society, the audience was encouraging. "No one else knows how to explain the double slit experiment," they said.

If the reader remains skeptical of our theory, here are three comments:

1. No one has an alternative explanation of the double slit experiment.
2. John von Neumann said that "elegance" is the sine qua non of mathematical truth. TEW is "elegant."
3. This article has given you a gift. We doubled the size of the world you live in! To that half of Nature that carries energy we added the other half of Nature that carries none. You have experienced both all your life. You see the world differently if you think there are zero energy Elementary Waves going out from your rods and cones, and photons are following them back. That is how you are seeing this sentence.

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