The Quantum World Is Astonishingly Similar to Our World:

The Timing of Wave Function Collapse According to The Theory of Elementary Waves

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ABSTRACT

A consensus among quantum mechanics (QM) experts is that the quantum world is weird: so different from the classical world that humans cannot comprehend it. However, that apparent weirdness is an artifact produced by a faulty assumption about the timing of wave function collapse. If we change the assumption, we discover that the quantum world is astonishingly similar to our world: it looks familiar. Whereas QM assumes wave function collapse occurs when a measurement is made, the empirical data indicate that it occurs when a gun is fired, when a particle is emitted. This is the Theory of Elementary Waves (TEW). The new assumption solves two mathematical riddles that stumped John von Neumann: why does the Schrödinger equation change so abruptly at wave function collapse, and where does randomness come from. If the smooth functioning of a Schrödinger equation abruptly collapses into one specific eigenstate when a gun is fired, that is how the world of everyday experience works. The bullet that caused World War I is an example. That bullet, fired June 28, 1914, caused an abrupt collapse of the smooth probabilities of commerce and diplomacy. Thirty seven million people died. The Ottoman and Austrian empires crumbled and vanished.

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Foundations of quantum mechanics; probability amplitudes; Theory of Elementary Waves

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or QC174.2NT Wave Particle Duality

TYPE (METHOD/APPROACH)

The Theory of Elementary Waves is a rogue theory of the quantum world based on elementary waves, which are conceived as that part of nature that correspond to quantum equations. In this series of articles the author seeks to describe these elementary waves based on evidence from quantum experiments and quantum equations.

INTRODUCTION

If a person stands pointing a pistol at a target, and pulls the trigger, when does wave function collapse occur? When do all the different probabilities for that bullet collapse into one definite reality?

A. When the bullet hits the target? Or,

B. When the gun is fired?

Most people would answer B and modify it by saying the bullet might wobble during flight. Quantum experts insist that the only conceivable answer is A, in the quantum world.

Now consider changing the scale of observation. If we shrink the everyday world down to the subatomic size, at what point in that downsizing would the timing of wave function collapse jump from B to A? Either there is a discontinuity in how cause and effect operate as we downsize the scale, or else there is a discontinuity in human imagination as we diminish the scale.

Alternatively, imagine increasing the size of our model of the quantum world, until it is the same size as the world of everyday experience. If wave function collapse always occurs at the target in the quantum world, at what level of inflation would the location of wave function collapse jump from the target to the gun? Either there is a discontinuity in how cause and effect operate as we increase the size, or there is a discontinuity in human imagination as we inflate the scale.

1. The double slit experiment

QM experts cite the double slit experiment as proof that wave function collapse cannot be located at the electron gun. They erroneously believe it must be located at the target screen. According to their hypothesis each particle is a wave-particle that goes through both slits simultaneously, occupying a superposition of states until it reaches the target, whereupon the wave function collapses and a dot appears at only one place. Research evidence is cited from electrons fired one at a time, phthalocyanine molecules (1) and Buckminsterfullerene (2).

In this article we offer a different interpretation of those same experiments (3-18). We propose a model in which the waves are in a superposition but the particle is not. In our model the waves are traveling in the opposite direction as the particle. This arrangement makes the quantum world much more similar to our everyday experience, than is the case with QM.

When a particle is fired from a gun in the double slit experiment, it makes a wave-like pattern on the target screen. If wave function collapse occurs at the instant when it is fired, then the electron knows a lot of information about the environment by the time it is fired. It knows, for example, how to fly through only one slit and make an unusual pattern on the target screen. This implies that information was converging on the electron before it was fired.

Figures 1 to 3 are a simple model of how this happens. Waves carrying information radiate from every point on the target screen, penetrate backwards through the two slits, and interfere in proximity to the gun.

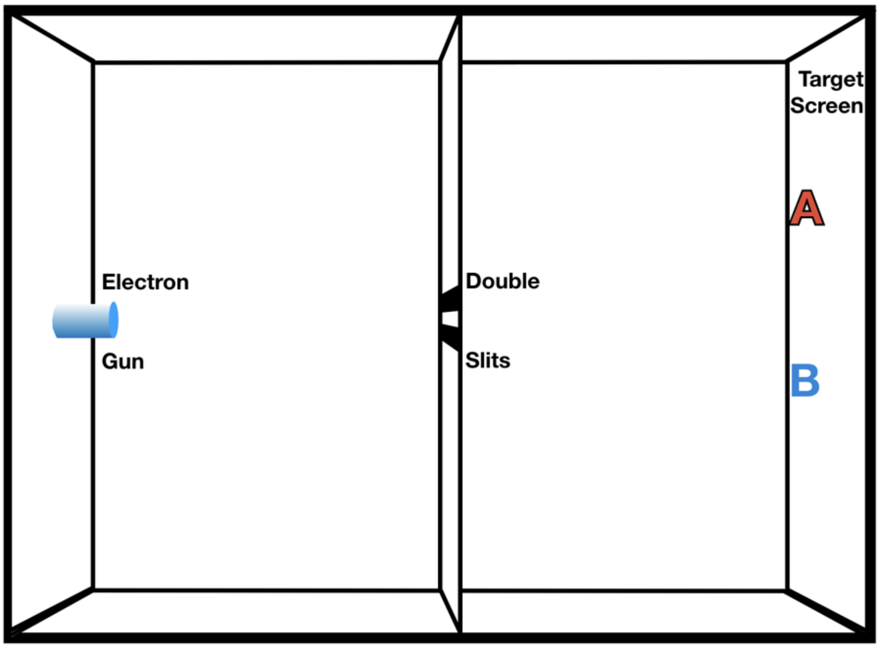

Figure 1: A double slit apparatus: electron gun on left, barrier in middle with two slit, and a target screen on the right, on which are located a red "A" and blue "B".

In Figure 1 there are two letters on the target screen, a red "A" and blue "B". Zero energy elementary waves emanate from those two points (and from all other points also). These waves consist of probability amplitudes, which will invite an electron to follow them backwards. Waves originate from every point of the target screen. We are using "A" and "B" to illustrate the mechanism.

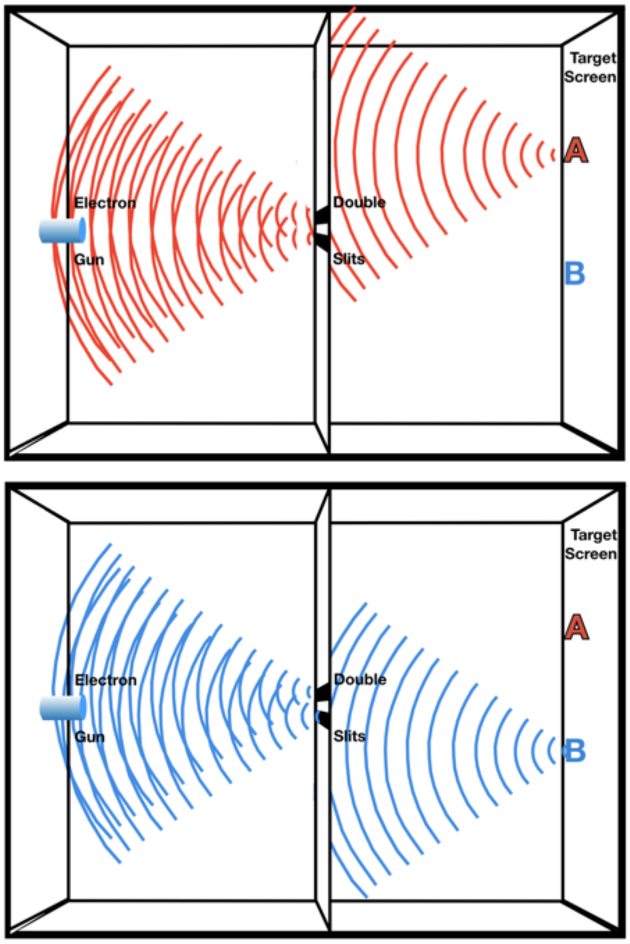

Figure 2: The top shows red waves emanating from “A”, causing constructive interference as they converge on the electron gun. The bottom shows blue waves emanating from “B”, causing destructive interference as they converge on the electron gun.

In Figure 2-top the peak of a red wave from “A” penetrates the upper slit just as the peak of the preceding wave from “A” penetrates the lower slit. Therefore the waves from “A” are in sync as they travel through the two slits and converge on the electron gun where they cause constructive interference: i.e. a lot of amplitude, resulting in an increased likelihood of the waves triggering an electron.

The peak of a blue wave in Figure 2-bottom penetrates the upper slit just as its trough penetrates the lower slit. Waves from “B” go through the two slits out of phase by π, and remain out of phase as they impinge on the electron gun where they cause destructive interference, so there is flat water (zero amplitude) at the electron gun. Therefore there is zero likelihood of those waves triggering an electron emission.

When fired at random, the electron will follow that specific elementary ray with a probability of one back to that point (the letter “A”) from which its wave emanates. It doesn’t matter which slit is used. Thus the area around “A” will be black in the final dataset, because of being randomly bombarded with electrons. The area around “B” will be white because when there is destructive interference at the gun, there is no amplitude, and therefore no electron will be fired, and therefore that area (“B”) will remain white in the final dataset. No electrons bombarded “B”.

Other points on the target screen vary in the type of interference they create at the gun (constructive, destructive, or intermediate), resulting in a variety of black, white and gray areas on the target screen. Figure 3-right shows the resulting target screen. Note that “A” is surrounded by black and “B” is surrounded by white, for reasons that we just stated.

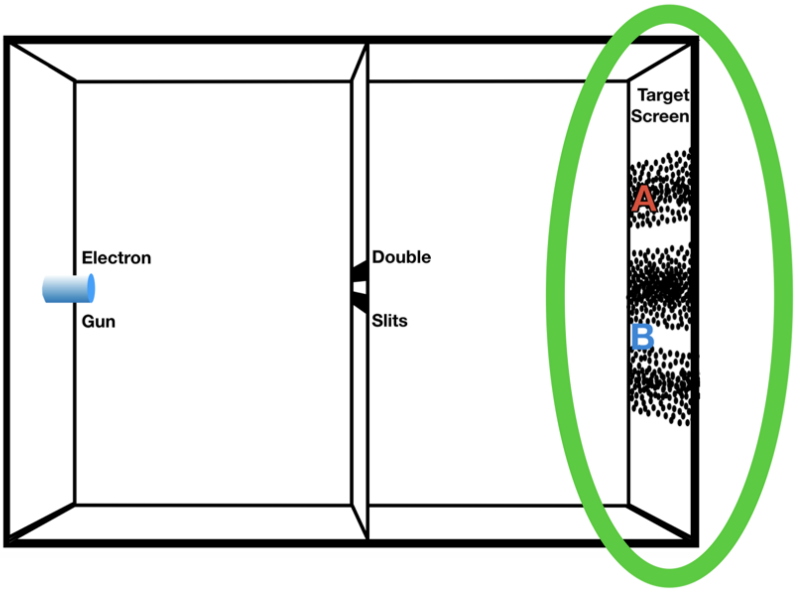

Figure 3: On the right, this shows the final dataset inscribed on the target screen by the electrons following elementary waves backwards.

Note that wave function collapse occurs at the electron gun in the double slit experiment. Based on the square of the amplitude of the elementary waves impinging on the gun, an electron decides at random which wave to follow backwards. When following that wave, it does so with a probability of one. After the electron is emitted, it is a deterministic process. It doesn't matter which slit the electron uses.

2. The quantum world and the world of everyday experience are similar

This model of how the double slit experiment works is parallel to the way that the world of everyday experience works. Consider the following example.

On June 28, 1914 a Serb student named Gavrilo Princip fired a pistol, assassinating Archduke Franz Ferdinand, the crown prince of Austria. In order for wave function collapse to occur when the gun was fired, information needed to be converging on the gun before the trigger was pulled. Gavrilo Princip looked up a crowded street and saw the Archduke, whose driver had made a wrong turn, approaching in an open automobile. Princip had a loaded pistol in his pocket and hated the Archduke. Waves carrying information about the Archduke traveled in the opposite direction as the bullet, before the bullet was fired.

3. This model solves riddles that stumped John von Neumann

This model of the timing of wave function collapse solves many mysteries. One of those mysteries is a chasm in the mathematics that has baffled mathematicians.

John von Neumann was stumped by the measurement problem (19). He assumed that wave function collapse occurred when a measurement was made (when a particle was detected, for example). That implied that the smooth and deterministic functioning of the Schrödinger equation suddenly collapsed into one specific eigenstate. It seemed unnatural to have such an abrupt chasm in the equations, moving from Schrödinger to a fixed single eigenstate abruptly, simply because a measurement was made. It was a riddle that von Neumann could not figure out. Nor could other quantum experts. It became known as the "measurement problem."

However, if wave function collapse occurs when a particle is fired, then the abrupt chasm in the equations makes sense. That is how nature works in our everyday experience. Let's return to Sarajevo on June 28, 1914. When Gavrilo Princip fired the pistol and killed the crown prince of Austria, it led to wave function collapse: all of Europe collapsed into World War I. Thirty seven million people died. All the probabilities and smooth expectations for commerce and diplomacy before June 28 were gone: vanished. The Ottoman and Austrian empires crumbled. It was a precipitous change.

This being the case, why is it hard to see that wave function collapse would bring a discontinuity into our probability equations? That is what happens when a gun is fired: things can abruptly change. Ask any assassin. That is how the real world works.

This way of thinking about the timing of wave function collapse solves another riddle that von Neumann could not solve: If you have deterministic equations governing before and after a measurement is made, then how did random chance and probabilities sneak into quantum mechanics? If there are two components of the mathematical model, and they are both deterministic, then how did the quantum world acquire the random unpredictability for which it is famous?

When we adopt a model of wave function collapse occurring at the particle gun, the number of components in our model increases from two to three. Before wave function collapse you have the elementary waves, which are deterministic Schrödinger waves. Then you have the electron making a random decision about which elementary wave to respond to. Then you have the deterministic trajectory that the electron follows back to the target screen.

The electron (or particle) is a machine governed by random chance, unpredictably jumping at the opportunity to follow one or another elementary wave backwards, in proportion to the square of the amplitude of that incident wave. You might say that particles, from a mathematical viewpoint, are randomization machines. They are the source of Brownian motion, which Einstein proved in 1905 to be random.

4. Scattering experiments tell us about elementary waves

Richard Feynman (20) describes various other scattering experiments that give us deep insight into wave function collapse, as shown in Figure 4.

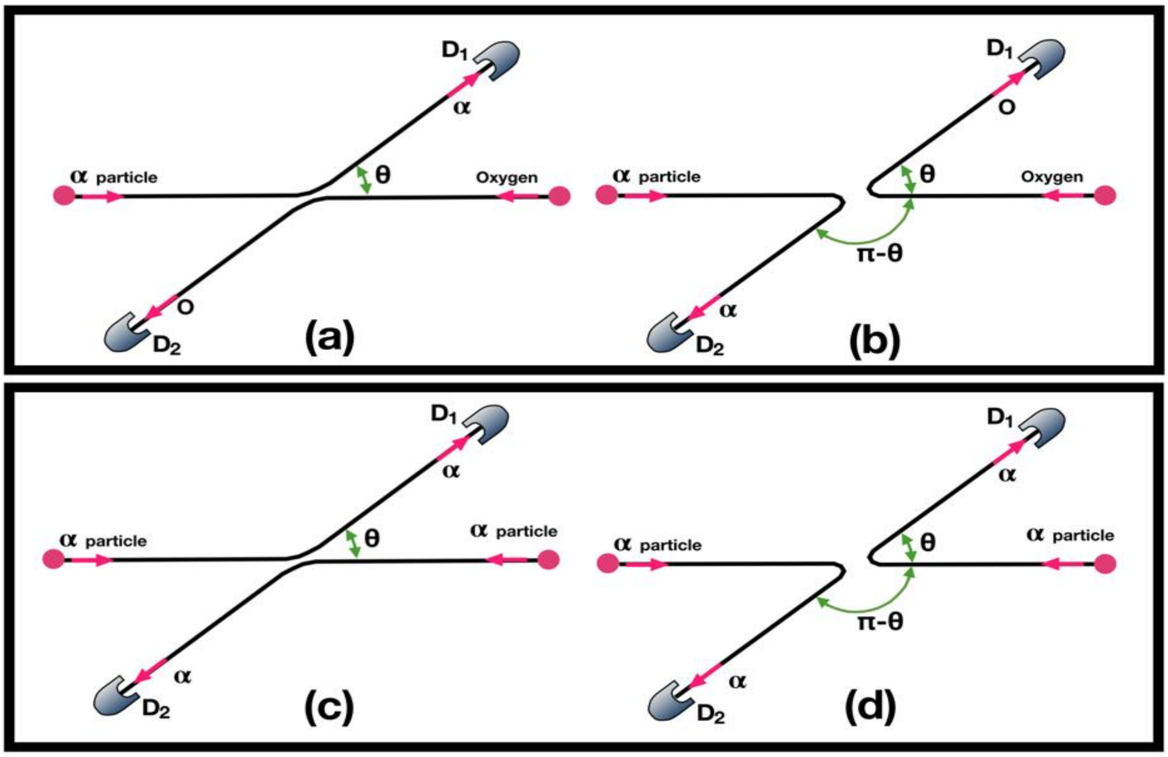

Figure 4: Scattering diagrams from Feynman: (a) and (b) show the two ways an alpha particle and oxygen atom can collide and scatter to detectors D_1 and D_2. Diagrams (c) and (d) show the two ways that two alpha particles

can collide and scatter to D_1 and D_2.

What Feynman is seeking to demonstrate in these diagrams is that it makes a difference whether the two particles are distinguishable or indistinguishable. The difference is how we handle the math. Suppose detectors D_1 and D_2 are designed to click, no matter what kind of particle hits them.

If an oxygen atom scatters at angle θ (Figure 4b, striking detector D_1), then an □–particle must have scattered at angle π – θ, striking detector D_2. So if f(θ) is the amplitude for □–scattering through the angle θ, then f(π – θ) is the amplitude for oxygen scattering through the angle θ. Thus the probability of having some particle hit detector D_1 is

$$|f(\theta)|^2 + |f(\pi-\theta)|^2 \qquad (1)$$

That illustrates the math when the particles are in principle distinguishable. You square the amplitudes before adding them. On the other hand, Figure 4c and 4d illustrate what happens when the particles are indistinguishable. Here an □–particle collides with another □–particle. A different math is required: add the amplitudes before you square them. In this case the probability of having some particle hit detector D_1 is

$$|f(\theta)+f(\pi-\theta)|^2 \qquad (2)$$

To illustrate how different equation 2 is compared to equation 1, Feynman suggests we set θ = π/2. In this case f(θ) = f(π – θ). Then the probability of some particle hitting D_1 if the particles are indistinguishable is

$$|f(\frac{\pi}{2})+f(\frac{\pi}{2})|^2 = |2f(\frac{\pi}{2})|^2 = 4|f(\frac{\pi}{2})|^2 \qquad (3)$$

whereas if the particles are distinguishable the probability is

$$|f(\frac{\pi}{2})|^2 + |f(\frac{\pi}{2})|^2 = 2|f(\frac{\pi}{2})|^2 \qquad (4)$$

meaning that it is twice as likely that an indistinguishable particle will hit D_1 as compared to a distinguishable particle.

This is a theme in Feynman's book: that the observer is involved in the results. If the observer knows, or could know whether it is an □–particle or an oxygen atom that strikes D_1, you will get one result. But if the observer does not know, and could not know what kind of particle it is, then you get a different result.

This kind of observer dependence infects anyone who believes that wave function collapse occurs when a particle is observed. It is a weird idea. It led David Mermin to say, "science has proved that the moon only exists when people are looking at it."

5. An elementary wave model of Feynman's scattering

Our thesis is that wave function collapse occurs when the particles are emitted, not when they are detected. This is illustrated in Figure 5.

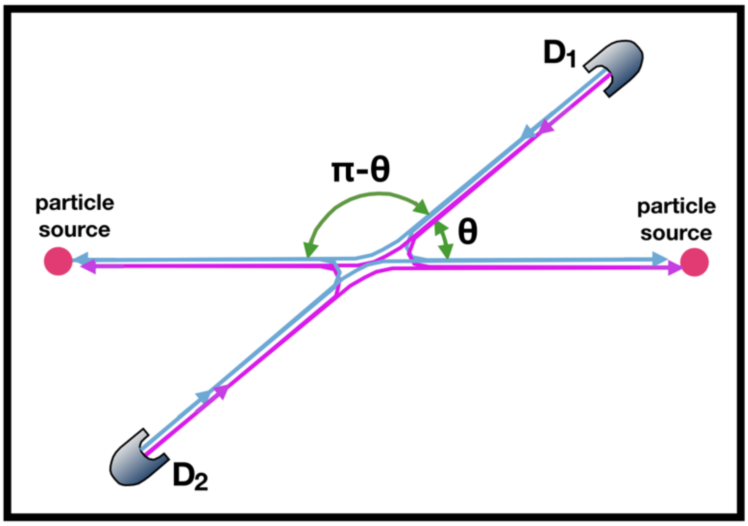

Figure 5: Changing Figure 4 to show the two elementary rays emanating from the detectors and scattering, in an experiment involving two particle sources.

Our thesis is that elementary rays flow from the detector, as shown in Figure 5. There are different kinds of elementary rays, two of which we display in blue and pink. There are more than two kinds of elementary rays, but for simplicity we limit ourselves to blue and pink. Both elementary rays scatter in both directions, so both of them are available at each particle source. We propose that an □–particle follows a blue elementary ray back to the detector, whereas an oxygen atom follows a pink elementary ray. This is intrinsic to the nature of those particles: □–particles always follow a blue, and oxygen atoms always follow a pink elementary ray.

The mathematics for these different color elementary rays is different. If two particles follow the same color elementary ray, then the probability of some particle striking detector D_1 requires that we add the amplitudes before we square them.

$$|f(\theta)+f(\pi-\theta)|^2 \tag{2}$$

On the other hand if two particles follow different color elementary rays then the probability of some particle hitting D_1 is the amplitude squared of one particle hitting D_1, plus the amplitude squared for the other particle.

$$|f(\theta)|^2 + |f(\pi-\theta)|^2 \tag{1}$$

Therefore the elementary ray model supports the same mathematics as the Feynman model, but wave function collapse is located at the particle source, not at the detector. The observer's knowledge does not affect the results.

6. Wave function collapse doesn't always happen at the particle gun

Let us review where we are in our discussion. We claim that wave function collapse occurs when a gun is fired, as we saw on June 28, 1914 when Gavrilo Princip fired a pistol, assassinating Archduke Franz Ferdinand and causing World War I. By "wave function collapse" we mean that all the probabilities for that bullet collapsed into one irrevocable reality when the gun was fired. Wave function collapse does not occur when a bullet hits its target. No one ever said, "The bullet was in a superposition and could have been anywhere; then when the wavefunction collapsed it just happened that the bullet appeared inside the brain of the Archduke."

We argue that our model from the real world can be reduced in size to a smaller and smaller scale, and it becomes a prototype for how wave function collapse works in the quantum world. No one else agrees with us about this. We have shown that in one scattering experiment cited by Richard Feynman, the mathematics of our model is the same as the mathematics of his model.

However, we need now to modify our model slightly, because of what the mathematics teaches us. Quantum equations provide a roadmap to how the world of elementary rays operates. It is difficult to decipher the map. In what we are about to say we will propose that wave function collapse does not always happen at the particle gun, sometimes it is modified as the projectile is en route to the target.

Consider what happens in Figure 5 if both particles are electrons. In the collision experiment they interact in a negative way. If they were both trying to occupy the same quantum state, that would be impossible because of the Pauli exclusion principle. In the scattering experiment they don't quite collide like that, but they do interact in a negative way. The phase of one electron and the phase of the other electron become opposite to each other. As a result, there is a different equation for the probability of an electron hitting detector D_1, which is:

$$|f(\theta) - f(\pi - \theta)|^2 \tag{5}$$

The minus sign in the center of this equation means that you subtract one amplitude from the other before you square them.

What we learn from this equation is that wave function collapse is not permanently decided when a gun is fired. It can be modified as the bullet follows its trajectory. Think of a bullet wobbling during its flight, and therefore behaving slightly differently when it approaches the target. In this scattering experiment one electron might have no influence over the distant electron when they are at their respective guns. But as they come close to colliding they interact in a negative way. They have a negative effect on each other.

Imagine a different scenario. Princip fired a pistol at the Archduke, but the bullet wobbled and missed the target. The Archduke escaped uninjured. Perhaps World War I would have been avoided!

7. Sometimes quantum experts speak plainly

Finally we consider a higher energy collision. Two protons are smashed into each other at terrific speed. According to Feynman, you might get the following products from this collision: two K-mesons, six π-mesons and two neutrons (see Figure 6).

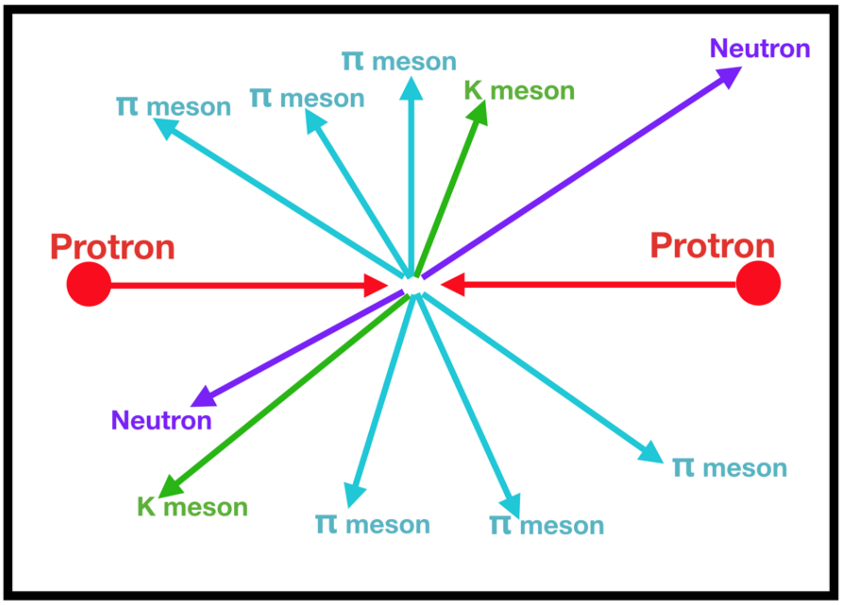

Figure 6: A high-energy collision of two protons.

Such an experiment forces quantum physicists to focus on the collision, and say something like, "A high-energy collision of two protons produces two K-mesons, six π-mesons and two neutrons." Such a statement is remarkable, because they are describing wave function collapse at the instant of the collision, when these byproducts came into existence. Under such circumstances the experts abandon the charade about particles only existing when they are detected. The particles came into existence long before they were detected. Everyone agrees about that. The double-talk is gone.

The bottom line is that such a collision forces quantum physicists to be honest and admit that particles exist before they hit a detector. They exist (i.e. wave function collapse occurs) from the pico-second when the collision occurred. This example proves that even QM experts can speak plainly, and avoid their preferred language of obfuscation.

8. Where are the elementary waves in the macroscopic world?

A central theme in this article is the continuity between the quantum world and the world of everyday experience: one scales up or down into the other. That implies that something like elementary waves should be part of our everyday experience of nature. Yet when scientists look at nature at the macroscopic scale, they only find things that have energy or mass. Where are the zero energy elementary waves? Do scientists have a bias that leaves them blind to phenomena that involve no energy?

Nature consists of two domains:

1. The domain with energy;
2. The domain without energy.

Until now science has only been interested in that half of nature that has energy. The other half invades our consciousness via quantum mathematics. Since scientists have no interest in things that are devoid of energy, they have been unable to see any relationship between quantum equations and nature. The Copenhagen interpretation says there is no such thing. (21)

The domain of nature without energy is the realm of elementary waves. These waves are highly ordered and follow the precise rules of quantum math. In any amount of space there are infinite number of them, traveling in all directions, at all wavelengths, at the speed of light. They have been present since the Big Bang.

Half of your body is composed of particles and energy. The other half is composed of elementary waves that provide the shape and orderliness of your body, but convey no energy.

These elementary rays are similar to luminiferous ether. It is erroneously believed that such ether was disproved by the Michaelson Morley experiment of 1887, and that the nail was pounded in the coffin by Einstein's theory of relativity. But that is revisionist history that does not fit the facts about luminiferous ether.

The fact is that Hendrik Lorentz (1853-1928), who was a quarter century older than Albert Einstein (1879-1955), built the "Lorentz equations" to transform space and time to fit the Michaelson Morley data. Einstein adopted Lorentz equations into his special relativity.

Nevertheless, Lorentz' picture and Einstein's picture of ether were slightly different from one another. With Lorentz ether there is an absolute frame of reference, which is the only frame of reference within which the speed of light is the same in both directions. When you think of an absolute frame of reference, think of the Cosmic Microwave Background. The CMB is stationary.

The only data available to Einstein was that the round trip speed of light (reflected off a mirror) is always the same. Einstein declared by fiat that the speed of light is the same in both directions, although he had zero evidence to support that fiat. With Lorentz' ether the speed of light in one direction differs from the speed of light in the opposite direction, but the round trip speed of light is always the same. Only in the absolute frame of reference is the speed of light the same in both directions.(22-24)

The two men respected each other and exchanged friendly letters as long as they were both alive. Their subtle disagreement about the nature of luminiferous ether did not cause hostility. Over the decades physicists remembered Einstein's and forgot Lorentz' view of ether for the obvious reason that Lorentz ether conveys no energy, and physicists ignore anything without energy, no matter how important it is.

Lorentz' ether came to light decades later, when the Italian physicist Franco Selleri (1936-2013) emphasized it. Selleri published more empirical research on elementary waves (although Selleri had them traveling in the wrong direction) than anyone else. He recognized that these waves exist in a medium, and that medium he describes as "Lorentz ether at rest." Selleri states several reasons that Lorentz' ether is correct and Einstein's ether is not. Selleri developed his own theory of relativity, which he called "weak relativity". His theory is known and respected in Europe.(22-27)

There is room here for a book on Selleri's theory of relativity, and Selleri has written that book in Italian (27). I have a partial translation of two chapters into English, thanks to my friend Dominick Scaramuzzino. But otherwise Selleri's book is not available in English.

The bottom line is that if a person stands pointing a pistol at a target, and pulls the trigger, wave function collapse occurs when the gun is fired. Furthermore, all observers in all spaceships, no matter how fast they are moving, would agree on the simultaneity of that event.

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Author' biography with Photo

Jeffrey H. Boyd was born into a working class family in 1943 in New Jersey, USA. He is the first member of his family to graduate from college. He has been in dialogue with his cousin, Lewis E. Little, for 60 years. Boyd's undergraduate degree in mathematics was from Brown University in 1965. He has advanced degrees from Harvard, Yale and Case Western Reserve Universities, and served on the faculty of the National Institutes of Health in Bethesda, Maryland for a decade. His day job is as a psychiatrist, which is fortunate because he comes at quantum mechanics without indoctrination in the latest fads in physics, and without the need to seek funding for physics research. If you read Adam Becker's book, *What is real?*, you realize the extent to which physics has been corrupted by money from government and industry. That is not true of Boyd. Boyd retired after a quarter century at Waterbury Hospital, Waterbury CT, a Yale teaching hospital at which he served as Chairman of Behavioral Health and also Chairman of Ethics. He specialized in treating the chronically mentally ill, most of whom were indigent or homeless. He published research in the areas of epidemiology, psychiatric diagnoses, firearms suicide, and wrote a book about how to live with debilitating illness: *Being Sick Well*. He has published research in the *New England Journal of Medicine*, *Journal of Advances in Mathematics* and *Physics Essays*. He gave scholarly lectures on TEW at the American Physical Society more than a dozen times. If you ask what motivates Boyd, the answer is that he feels a duty to speak. If he makes mistakes, he trusts the scientific community to correct his errors. At age 75 professional rewards are not relevant as a motivating factor. What is relevant is the question, Did I fulfill my duty before I died? He expects to die at age 125, and hopes TEW will prevent his brain from developing Alzheimer's.

Dr. Jeffrey H. Boyd, 2018