

AETHER EXPLANATION OF ENTANGLEMENT

Duncan W. Shaw a)

1517 Angus Drive, Vancouver, BC, Canada, V6J 4H2.

ABSTRACT

This article proposes that the medium of aether as described by James Clerk Maxwell in 1865 offers a rational explanation of the phenomenon of entanglement. It also provides a rational underlying physical base for the quantum mechanics theory.

RÉSUMÉ

Cet article soutient l'hypothèse que l'existence de l'éther, comme l'a décrit James Clerk Maxwell en 1865, offre une explication rationnelle au phénomène de l'enchevêtrement. Cette existence de l'éther constitue par ailleurs une base physique, rationnelle sous-jacente à la théorie de la mécanique quantique.

Key words: entanglement, correlation, polarization, aether, aether cells, ether, quantum mechanics, photons, instantaneous action-at-a-distance.

I. INTRODUCTION

In his 1865 treatise, *The Dynamical Theory of the Electromagnetic Field*,¹ James Clerk Maxwell proposed equations that apply to electromagnetism. The equations have stood the test of time and remain today as fundamental bedrock physics. In the same treatise Maxwell set out a theory of aether -- a sub-atomic substance that fills space and permeates bodies -- as the physical foundation of his equations.

a) duncanshaw@shaw.ca

While Maxwell's equations live on, his underlying theory of aether has fallen into disuse.

The present author, in an article published in 2014, *Reconsidering Maxwell's Aether*,² contends that Maxwell was on the right track: that aether in fact exists and is likely the common denominator of most if not all electromagnetic phenomena -- including entanglement.

Entanglement is associated with the quantum mechanics theory. Numerous experiments have been carried out aimed at finding an explanation of entanglement. Experimenters have searched for an explanation that accords with ordinary physical cause and effect (also called "local realism"), but they have not succeeded. Indeed, they have generally concluded that local causes of entanglement are impossible.

This article proposes that the medium of aether as described by Maxwell offers a rational explanation of the phenomenon of entanglement. The article also proposes that Maxwell's aether provides a rational physical foundation for the quantum mechanics theory.

The subject of this article was originally entanglement alone. However, it became apparent to the author that the proposed explanation of entanglement potentially has application to the underlying physical foundation of the quantum mechanics theory. Thus, the article has been expanded to cover both these subjects.

II. ENTANGLEMENT

Entanglement is not simple to define. The following definitions, while somewhat different from each other, provide some idea of the nature of entanglement.

John Cramer, in *The Quantum Handshake: Entanglement, Nonlocality and Transactions*³(2016):

“**Q:** What is meant by ‘entanglement’?”

“**A:** Entanglement is a term coined by Schrodinger to indicate that the quantum state of one particle depends on some details of the quantum state of the other particle. Entanglement often occurs because two entangled particles are emitted by the same source, and some conservation law, e.g., energy, momentum, or angular momentum conservation, can only be preserved if the particles have values of that quantity that are correlated.”

George Greenstein and Arthur Zajonc, *Modern Research on the Foundations of Quantum Mechanics*⁴ (2006):

“The EPR thought experiment deals with a source that sends out two particles with opposite spins. We can write their state as:

$$\Psi = \frac{1}{\sqrt{2}} [(\uparrow)_1(\downarrow)_2 + (\downarrow)_1(\uparrow)_2] \quad (6.1)$$

“Here the subscript **1** describes the first particle and the subscript **2** describes the second. Equation (6.1) says that the state is a superposition of two terms: the first term describes particle **1** with spin up and particle **2** with spin down, and the second term describes the opposite case.

“This is an entangled state.”

Alistair Rae, *Quantum Mechanics: Fifth Edition*⁵ (2008):

“In quantum mechanics, the word “entanglement” refers to a quantum state of two or more particles, where the probabilities of the outcome of measurements of one of them depend on the state of the other -- even though there is no interaction between them.”

Louisa Gilder, *The Age of Entanglement: When Quantum Physics Was Reborn* ⁶
(2008):

“Any time two entities interact, they entangle. It doesn’t matter if they are photons (bits of light), atoms (bits of matter), or bigger things made of atoms like dust motes, microscopes, cats, or people. The entanglement persists no matter how far these entities separate, as long as they don’t subsequently interact with anything else – an almost impossibly tall order for a cat or a person, which is why we don’t notice the effect.

“But the motions of subatomic particles are dominated by entanglement. It starts when they interact; in doing so, they lose their separate existence. No matter how far they move apart, if one is tweaked, measured, observed, the other seems to instantly respond, even if the whole world now lies between them. And no one knows how.”

One may draw from the above definitions and from experiments that entanglement involves sub-atomic particles that are connected and therefore entangled. Entanglement is evidenced in experiments by correlations of various characteristics of sub-atomic particles. The characteristics include momentum, angular momentum, various states of polarization, levels of energy, spin, rotation, torque, wavelengths and frequencies. Where the characteristics accord with the laws of conservation of energy and momentum, the characteristics are said to be correlated. It is from correlations that entanglement is inferred.

III. LACK OF UNDERLYING PHYSICAL CONCEPT OF QUANTUM MECHANICS

A significant problem facing physicists searching for the cause of entanglement is that the quantum mechanics theory, while endowed with effective mathematics, does not have a generally accepted underlying physical concept of how it works. Consider the following observations from a broad selection of scientists:

Albert Einstein, D. Podolsky and N. Rosen, the "EPR" paper, *Can Quantum-Mechanical Description of Physical Reality be Considered Complete?:*⁷

“We are thus forced to conclude that the quantum-mechanical description of physical reality given by wave functions is not complete.”

John Bell, in an interview:⁸

Q. “What evidence is there that quantum theory is in any way unsuccessful in explaining everything we have to explain?”

A. “Well, it does not really explain things; in fact the founding fathers of quantum mechanics rather prided themselves on giving up the idea of explanation. They were very proud that they dealt only with phenomena: they refused to look behind the phenomena, regarding that as the price one had to pay for coming to terms with nature. . . .”

Richard Feynman, *QED: The Strange Theory of Light and Matter:*⁹

“Quantum electrodynamics ‘resolves’ this particle duality by saying that light is made of particles (as Newton originally thought), but the price of this great advancement of science is a retreat by physics to the position of being able to calculate only the probability that a photon will hit a detector, without offering a good model of how it actually happens.”

Alastair I. M. Rae, *Quantum Mechanics*: 10

“Defining reality in the context of quantum mechanics is quite a different matter. We have emphasized throughout this book that the wave function is not to be considered as physical, but as a mathematical object from which the possible results of experiments and their relative probabilities can be deduced.”

Bryan Cox and Jeff Forshaw, *The Quantum Universe (and why anything that can happen, does)*: 11

“. . . any explanation of the double-slit experiment requires that the electrons ‘interfere with themselves’ when they pass through the slits, and to do that they must in some sense be spread out. This therefore is the challenge: build a theory of point-like particles such that those same particles are also spread out. This is not as impossible as it sounds: we can do it if we let any single particle be in many places at once. Of course, that may still sound impossible, but the proposition that a particle should be in many places at once is actually a rather clear statement, even if it sounds silly. From now on, we’ll refer to these counterintuitive spread-out-yet-point-like particles as quantum particles.”

George Greenstein and Arthur G. Zajonc, *The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics*: 12

“Quantum mechanics has correctly reproduced the results of experiment. But has the theory explained to us how indivisible particles manage to pass through two slits at once? It has not.”. . .

“Quantum theory has therefore succeeded in reproducing the results of experiment. But has it provided us with any understanding of the results? It has not. Indeed, it is quite impossible to visualize what has been going on in these experiments. They present us with an intolerable state of affairs, one which appears to violate the very principles of elementary logic.” [high-lighting added]

IV. ENTANGLEMENT EXPERIMENTS

Numerous experiments have explored entanglement.¹³ Most of the entanglement experiments have involved the emission of particles called photons. Some have included electrons, neutrons, protons, ions, atoms and molecules. Receptors placed in various positions have recorded data of characteristics of particles that interact with the receptors. The characteristics have included momentum, angular momentum, polarization, energy levels, spin, rotation, wavelengths and frequencies. The recorded data have provided evidence of correlations between the characteristics of the particles interacting with the receptors. From the correlations, entanglement of the particles has been inferred.

The ingenuity of the experimenters has been remarkable. The experiments have employed emission of successive photons, pairs of photons, different types of sources of photons, separated sources of photons, various positions of and distances between receptors, various timing of analyzers, use of polarizers, use of entanglement swapping, and use of optical fibers for transmission of photons. This is not an exhaustive list, but it illustrates the high level of ingenuity that has been brought to bear in the experiments.

The dominant result of the experiments is that the data recorded through the detectors have uniformly been in conformity with the predictions of quantum

mechanics. However, it is important to appreciate that the predictions of quantum mechanics are, in large part, in terms of probabilities. Thus, where recorded data and predictions are in accord 60% of the time, it follows that the data will not accord with predictions 40% of the time. As stated by physicists Tony Hey and Patrick Walters: ¹⁴ “The position of arrival of a single electron is thus inherently unpredictable: we can only make statements about relative probabilities of arrival for the electron.”

Here are some further observations on entanglement experiments:

- The experimenters have searched for a mechanical cause-and-effect explanation of entanglement. They have not yet found any such explanation.
- Entanglement experiments have generally been conducted and interpreted on the basic premise of the quantum mechanics theory that photons physically travel from the emission source to the receptors.
- To the best of the author’s knowledge, entanglement experiments have not addressed Maxwell’s aether theory as a potential explanation of entanglement or as an underlying physical foundation of the quantum mechanics theory.
- To the best of the author’s knowledge, entanglement experiments have not been based upon the proposition that the particles that interact with the detectors might be aether cells that are located adjacent to the receptors and are activated by electromagnetic waves transmitted through the medium of aether.

The failure of the experiments to find a mechanical explanation has led to speculation that entanglement may be triggered by instantaneous communication between the receptors. In 1964, John Bell in his paper, *On The Einstein Podolsky Rosen Paradox*, ¹⁵ described this line of reasoning:

“In a theory in which parameters are added to quantum mechanics to determine the results of individual measurements, without changing the statistical predictions, there must be a mechanism whereby the setting of one measuring device can influence the reading of another instrument, however remote. Moreover, the signal involved must propagate instantaneously, so that such a theory could not be Lorentz invariant.”

In the 1970s and 1980s, entanglement experiments produced correlations of opposite direction angular momenta and opposite direction polarizations detected at the receptors used in the experiments. ^{16,17, 18,19} These phenomena occurred in experiments where the power sources were located between the receptors. The energy levels of the angular momenta were observed to be equal and the energy levels of the opposite polarizations were observed to be equal and therefore in conformity with the principle of conservation of momentum.

A proposition made in numerous entanglement papers is that no “local-realist” (direct mechanical cause-and-effect) theory can explain entanglement. One of these papers, *Going Beyond Bell’s Theorem*, ²⁰ was authored by D. M. Greenberger, M. A. Horne and A. Zeilinger and published in 1989. The paper sets out what has come to be known as the Greenberger-Horne-Zeilinger (GHZ) argument. The GHZ paper observes that photon spin measurements are constant at plus-1 or minus-1, despite the measurements being taken over a broad spectrum of receptor angles. The paper concluded that the spin measurements can not be explained by a local deterministic (direct cause-and-effect) model of entanglement.

Subsequent papers based upon the GHZ argument have come to the same conclusion. ^{21, 22, 23}

A pair of GHZ papers, published in 2008, ^{24, 25} dealt with experiments that used two separate independent sources of photons and a process called entanglement swapping. The papers concluded that the use of separate sources of photons and entanglement swapping rule out “realistic local theories” of entanglement.

It is significant that none of the GHZ papers have addressed Maxwell’s aether theory as a potential cause of entanglement or as a potential physical base of the quantum mechanics theory. The GHZ papers will be discussed below in the subsection, **The Greenberg-Horne-Zeilinger (GHZ) Papers.**

A paper that considered a form of aether as a possible local cause of entanglement is entitled *Dirac’s Aether in Relativistic Quantum Mechanics.* ²⁶ The authors, N. C. Petroni and J. P. Vigièr, proposed that aether as conceived by Paul Dirac – a substantially different form of aether than Maxwell’s aether -- might explain the correlations of entanglement. They based their proposal on the proposition of instantaneous communication between the receptors, ²⁷ a concept that is rejected by most scientists, including the present author. Because of the use of instantaneous action-at-a-distance, it is respectfully suggested that Petroni-Vigièr proposal does not present a logical explanation of entanglement.

It is remarkable that entanglement experiments have not specifically addressed Maxwell’s aether theory as a possible physical explanation of entanglement and of the quantum mechanics theory. One may speculate that this is because: (1) the Michelson-Morley experiment in 1887 and other similar experiments are said to prove that aether does not exist; (2) Einstein, in his special relativity paper in 1905 opined that aether is superfluous; and (3) the quantum mechanics theory, which was developed in the 1920s, is based upon the premise of travelling photons and therefore excludes Maxwell’s waves-through-aether theory. Answers to these points are provided below in the section entitled **RESUSCITATION OF MAXWELL’S AETHER.**

V. MAXWELL'S AETHER THEORY

The author's article, *Reconsidering Maxwell's Aether*,²⁸ contends that aether as described by Maxwell in fact exists and underlies electromagnetic phenomena. The present article proceeds on this premise.

Elements of Maxwell's aether theory, upon which this article relies, are set out in Maxwell's own words in the following passages in his treatise, *The Dynamical Theory of the Electromagnetic Field*:²⁹

- “The theory I propose may therefore be called a theory of the *Electromagnetic Field*, because it has to do with the space in the neighbourhood of the electric or magnetic bodies, and it may be called a *Dynamical Theory*, because it assumes that in that space there is matter in motion, by which the observed electromagnetic phenomena are produced.” [section 3]
- “There is always, however, enough of matter left to receive and transmit the undulations of light and heat, and it is because the transmission of these radiations is not greatly altered when transparent bodies of measurable density are substituted for the so-called vacuum, that we are obliged to admit that the undulations are those of an ethereal substance, and not of the gross matter, the presence of which merely modifies in some way the motion of the ether.” [section 4]
- “We have therefore some reason to believe, from the phenomena of light and heat, that **there is an ethereal medium filling space and permeating bodies, capable of being set in motion and of transmitting that motion from one part to another**, and of communicating that motion to gross matter so as to heat it and affect it in various ways.” [section 4] [High-lighting added]

- “We may therefore receive, as a datum derived from a branch of science independent of that with which we have to deal, **the existence of a pervading medium, of small but real density**, capable of being set in motion, and of transmitting motion from one part to another with great, but not infinite, velocity.” [section 6] [High-lighting added]
- “Hence the parts of this medium must be so connected that the motion of one part depends in some way on the motion of the rest; and at the same time these connections must be capable of a certain kind of elastic yielding, since the communication of motion is not instantaneous, but occupies time.” [section 6]
- “Now we know that the luminiferous medium is in certain cases acted on by magnetism; for Faraday discovered that when a plane polarized ray traverses a transparent diamagnetic medium in the direction of the lines of magnetic force produced by magnets or currents in the neighbourhood, the plane of polarization is caused to rotate.” [section 8]
- “. . . we must admit the existence of a motion in the medium depending on the magnetization, in addition to the vibratory motion which constitutes light.” [section 8]
- “According to the theory which I propose to explain, this “electromotive force” is the force called into play during the communication of motion from one part of the medium to another, and it is by means of this force that the motion of one part causes motion in another part.” [section 10]
- “But when electromotive force acts on a dielectric it produces a state of polarization of its parts similar in distribution to the polarity of the parts of a mass of iron under the influence off a magnet, and like the magnetic polarization,

capable of being described as a state in which every particle has its opposite poles in opposite conditions.” [section 11]

- “Here, then, we perceive another effect of electromotive force, namely, electric displacement, which according to our theory is a kind of elastic yielding to the action of the force, similar to that which takes place in structures and machines owing to the want of perfect rigidity of the connexions.” [section 12]
- “The energy in electromagnetic phenomena is mechanical energy. The only question is, Where does it reside? . . . On our theory it resides in the electromagnetic field, in the space surrounding the electrified and magnetic bodies, as well as in those bodies themselves, and is in two different forms, which may be described without hypothesis as magnetic polarization and electric polarization, or, according to a very probable hypothesis, as the motion and the strain of one and the same medium.” [section 74]

The next two passages are Maxwell’s summaries of his aether theory.

- “It appears therefore that certain phenomena in electricity and magnetism lead to the same conclusion as those of optics, namely, that there is an ethereal medium pervading all bodies, and modified only in degree by their presence; that the parts of this medium are capable of being set in motion by electric currents and magnets; that this motion is communicated from one part of the medium to another by forces arising from the connections of those parts; that under the action of these forces there is a certain yielding depending on the elasticity of these connections; and that therefore energy in two different forms may exist in the medium, the one form being the actual energy of motion of its parts, and the other being the potential energy stored up in the connections, in virtue of their elasticity.” [section 15]

- **“Thus, then, we are led to the conception of a complicated mechanism capable of a vast variety of motion, but at the same time so connected that the motion of one part depends, according to definite relations, on the motion of other parts, these motions being communicated by forces arising from the relative displacement of the connected parts, in virtue of their elasticity.”** [section 16] [High-lighting added]

In the present article, the “parts and connexions” of Maxwell’s aether are considered as aether cells. The concept of cells or corpuscles provides a necessary structural basis for the elasticity property of Maxwell’s parts and connexions. As stated in the present author’s article, *Reconsidering Maxwell’s Aether*: 30

- “It is postulated ‘ad hoc’ that aether consists of tiny non-rigid subatomic cells that have the property of elasticity, the capacity to vibrate, and the ability to attach to and detach from each other. The postulated cells are considered as the same as the parts and connections that comprise Maxwell’s aether. The cells are identical in structure.
- “It is speculated that elasticity enables aether cells to expand and shrink, twist and untwist, and vibrate when they interact with other aether cells and with ordinary matter. It is also speculated that attachment permits aether cells to act as organized groups. Detachment permits the cells to change their positions relative to one another. Collectively, these properties allow propagation of electromagnetic phenomena.”

VI. PROPOSED EXPLANATION OF ENTANGLEMENT AND PROPOSED PHYSICAL FOUNDATION OF QUANTUM MECHANICS THEORY

A. The Substance of the Proposal

The following proposal is based upon the aether theory of James Clerk Maxwell in his treatise, *The Dynamical Theory of the Electromagnetic Field*. The proposal is not presented as a certainty – rather, it is presented as a rational cause-and-effect approach to entanglement and a rational physical foundation of the quantum mechanics theory.

It is proposed that Maxwell’s theory of aether explains entanglement and, in doing so, provides the underlying physical foundation that is presently missing from the quantum mechanics theory.

Sound simple? In concept, yes. However, in terms of what takes place within the medium of aether, it is not simple. Just like Maxwell’s equations cover the gamut of electromagnetic phenomena, such as radiation, magnetism, electricity, induction, refraction, interference, polarization, electric and magnetic fields, so the physical foundation of Maxwell’s equations must be capable of producing the same phenomena. 31

The proposal pits two fundamentally different concepts against each other. On the one hand, the quantum mechanics theory is based upon the proposition that particles called “quanta” or “photons” travel at the speed of light, have the property of waves and constitute electromagnetic radiation. On the other hand, the Maxwell theory is based upon the proposition that subatomic particles called aether cells form a medium that pervades space and the bodies that occupy space. The cells interact elastically and their interactions constitute electromagnetic radiation.

It is the latter concept – the aether medium concept – that this article suggests is the preferable approach to explaining entanglement and to providing the underlying physical basis to the quantum mechanics theory.

The question of whether electromagnetic radiation is a wave through the medium of aether or a particle that travels from source to destination is one of the most fundamental issues in theoretical physics. This issue has been the subject of debate since the era of Newton and Huygens, and it still is.

A fundamental premise of the proposal is Maxwell's description of aether as a sub-atomic substance that permeates space and the bodies that occupy space. This proposition is meant literally. The premise of aether permeating space and bodies applies everywhere that entanglement occurs and everywhere the phenomena associated with the quantum mechanics occur. Of particular importance to the proposal is the proposition that the medium of aether permeates the sites of the entanglement experiments.

From the proposition that aether is all-pervasive, one may infer that aether cells must be located in or by the receptors used in entanglement experiments. One may also infer that these aether cells may be activated by waves emitted from the power sources used in the entanglement experiments.

Consider the analogy of a ship passing by the seashore. While the waves from the ship proceed to the shore, the water in the vicinity of the ship remains essentially in place. The water that strikes the shore is the water that was already in the vicinity of the shore when the waves were emitted.

Maxwell's aether consists of "parts and connexions". In this proposal they are called "aether cells". They have small but real density. They are structured and have the property of elasticity. The properties of structure and elasticity are elaborated upon in the section below, **Structure and Elasticity**.

Another fundamental Maxwell premise is that aether cells collectively form a medium. In the aether medium, the constituent cells are connected (Maxwell's "connexions"), much like the molecules of a fluid are connected. Through the

connections, the motion of one part of the aether medium depends on the motion of the rest of the medium.

Aether cells are the fundamental stuff of electromagnetic phenomena. Aether cells vibrate, store and release electromotive force, transmit electromagnetic waves, transmit momentum and polarize into collective patterns. In regard to the proposition that aether cells are fundamental to electromagnetic phenomena see the **Molecule Analog** section below.

Electromotive force is the means by which the motion of one part of the aether medium can cause motion in other parts of the medium. Electromotive force also causes aether cells to polarize; that is, to assume set positions in relation to each other -- to form collective patterns.

Based upon Maxwell's theory of aether, one can visualize aether cells operating in conjunction with each other --as parts of a medium -- a medium that produces the vast array of electromagnetic phenomena. It is the connections and interactions within the medium that cause the correlations observed in the entanglement experiments. It is the correlations that constitute entanglement.

B. Entanglement Experiments

The proposal now turns to entanglement experiments. Entanglement and the quantum mechanics theory were not part of the science scene in Maxwell's lifetime -- the 19th century. But that does not mean that his aether theory should be confined to that era, especially considering that the equations that he developed, based upon his aether theory, have endured to this day and continue to be applied -- 152 years later.

The reasoning in this subsection is premised upon the existence of aether as conceived by Maxwell. Phenomena observed in entanglement experiments will be considered to see whether they are consistent with and can be explained in the setting of Maxwell's aether theory.

Consider the phenomenon of superposition.

Assume the following: The power sources used in the entanglement experiments – the sources that emit photons – emit electromotive force and electromagnetic waves. The emissions of electromotive force and waves are transmitted into the aether medium setting. The electromotive force and waves transmit into the medium characteristics derived from the power source. The transmitted characteristics include such matters as levels of energy, momentum, angular momentum, spin, vibrations, frequencies and wavelengths, patterns of polarization, rotations and torque. Interactions between aether cells spread the characteristics throughout the aether medium. The characteristics derived from the electromotive source are added to the characteristics the aether medium may already have.

One can draw from this scenario that the phenomenon of superposition is consistent with it occurring in the medium of aether as theorized by Maxwell.

Consider the analog of a ship travelling through a body of water. The movement of the ship transmits waves into the water medium. The ship's waves have characteristics that include direction, size, momentum, shape and frequency. The characteristics of the ship's waves are set by the size, velocity and shape of the ship and the ship's interaction with the water. These characteristics are superposed upon the characteristics of the water already has. This phenomenon may be readily observed by watching a ship's waves interact with waves that are already on the water.

The ship analogy is based upon a real physical medium – water. This suggests that a real physical medium is likely a necessary element of the phenomenon of superposition.

Consider now the phenomenon of correlations.

Correlations are the key element of entanglement experiments and involve numerous characteristics of the particles that interact with the receptors. Correlations are evidenced by data recorded by the receptors. It is from recorded data that inferences are drawn that particles that interact with the receptors are correlated. It is from correlations that entanglement is inferred.

Examples of characteristics that may be correlated include angular momentum, states of polarization, spin, rotation, torque energy levels, wavelengths and frequencies recorded at one receptor that being comparable to energy levels, wavelengths, frequencies recorded at another receptor. Correlations are said to occur when the receptors record similar levels of energy or momentum at the receptors. Another example is comparable momenta of particles that interact with the receptors.

The phenomenon of correlations is consistent with Maxwell's aether theory. In the setting of Maxwell's aether medium, correlations may be viewed as arising from connections and interactions of aether cells. As stated by Maxwell, the "parts" of the aether medium are so connected that the motion of one part depends on the motion of the rest. Correlations may also be viewed as arising from polarization of the aether medium; that is, causing aether cells to collectively form into structured patterns. In the words of Maxwell, polarization distributes the parts of aether "like parts of a mass iron under the influence of a magnet." It is the connections and interactions of aether cells that spread the levels of energy and momentum throughout the aether medium and cause the aether cells to act together in unison.

These methods of correlation – connections, interactions and polarization of aether cells -- are consistent with and dependent upon Maxwell's premise of aether being a physical medium.

Consider now angular momentum and circular polarization.

Angular momentum and circular polarization are significant because they uniquely lend themselves to being explained by the setting of Maxwell's aether.

Angular momentum. In entanglement experiments that involve central sources of power, angular momenta are recorded as "spin-up" or "spin-down", but not both. Put another way, angular momenta that are recorded at one receptor are in the opposite direction of angular momenta recorded at the other receptor. J. G. Cramer in his book, *The Quantum Handshake; Entanglement, Nonlocality and Transactions*, describes this phenomenon. ³²

"A two-photon cascade in which the atom as a whole begins and ends with no net angular momentum (i.e., no rotational motion) and no change in parity (the mirror-symmetry of the system is unchanged) is of particular interest, because the cascade produces an entangled pair of photons that have correlated polarizations due to angular momentum conservation."

Circular polarization. Circular polarizations corkscrew in opposite directions, but they combine to form linear polarizations. In Cramer's words: ³³

"There is another polarization basis, *circular polarization*, in which the electric field corkscrews through space to the right or left as the light wave moves forward. Circular polarization can be produced by superimposing states of vertical and horizontal linear polarization with appropriate phase,

and linear polarization can be produced by superimposing left and right circular polarization.”

In regard to both angular momentum and circular polarization, George Greenstein and Arthur Zajonc in their book, *The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics*, said: ³⁴

“Note that the total change in the angular momentum of the atom is zero. Thus the two photons must have opposite angular momenta. But the spin angular momentum of a photon is related to its polarization state. The spin of a photon can only be aligned parallel or antiparallel to its direction of motion; parallel alignment corresponds to right-handed circular polarization, antiparallel to left-handed circular polarization. The two photons need not be emitted in opposite directions, but if we select those that are, conservation of angular momentum now requires that their handedness be the same. Therefore, they must have the same polarization: both right- or both left-circularly polarized (Figure 6-2).”

The quantum mechanics theory does not provide a physical cause-and-effect explanation for these phenomena. The waves-in-a-medium approach -- Maxwell's aether theory -- does provide a rational explanation -- as follows:

The initial premise is that sites of entanglement experiments are permeated by the medium of aether. A power source emits electromotive force and electromagnetic waves into the surrounding aether. The characteristics of the emissions in all directions from the power source are the same. The implication is that the characteristics emitted in one direction will be the opposite of the characteristics emitted in the opposite direction. Thus, in regard to the characteristic of angular momentum, the angle of the momentum exerted in one direction is opposite to the angle of momentum exerted in the opposite direction.

By the same reasoning, the state of polarization of the aether on one side of the power source will be the same as the state of polarization of the aether on the other side of the power source, but the directions of circular rotation will be opposite.

Visualize a stone that is dropped into a pool of water. The energy of the falling stone causes waves to proceed outwards in all directions. Assume that the stone is rotating horizontally when it strikes the water. Because the stone is rotating, the directions of opposite sides of the circumference of the stone will be opposite to each other. (Observe the opposite directions of rotation of the top and the bottom of a wheel.) The rotation will impart angular momentum to the water in all directions on the horizontal plane – the Coriolis force. Therefore, the angular momentum transmitted to the water from one side of the stone’s circumference will be in the opposite direction of the angular momentum transmitted from the other side of the stone’s circumference.

This explanation is based upon there being a medium – water in the case of the falling stone and aether in the case of entanglement experiments – that provides a physical setting for the phenomena of opposite angular momenta and opposite circular directions of polarization that are observed in entanglement experiments.

The stone-striking-a-pond analogy goes further. The above reasoning is based upon “ideal” conditions of the pond being calm and the stone rotating horizontally. Assume, now, that the conditions are different. The stone may be rotating vertically. It may be rotating on any given plane. It may be moving at any given velocity. It may be travelling on any given trajectory. And, the water medium may not be calm. It may have waves. It may be flowing. It may be eddying. When the stone strikes the water, the principle of superposition applies. This reasoning opens up a vast array of cause-and-effect permutations and combinations, including of course the various correlations of characteristics encountered in entanglement experiments.

The scenarios discussed in this subsection illustrate how phenomena observed in entanglement experiments can be rationally explained by considering them in the setting of Maxwell's aether theory. The explanations depend upon there being a medium with constituent parts that act in conjunction with each other.

C. The Greenberg-Horne-Zeilinger (GHZ) Papers

The first of the GHZ papers, *Going Beyond Bell's Theorem*,³⁵ published in 1989, was concerned with the apparent anomaly of plus-1 and minus-1 photon spin measurements taken over a broad spectrum of receptor angles. Greenberg, Horne and Zeilinger concluded that these measurements could not be explained by any "local deterministic" model of entanglement.

The paper did not consider the possibility that Maxwell's aether medium might provide an explanation. The paper did not deal with the issue of whether the broad spectrum of correlations may be the result of the cohesive effect of connections and interactions of aether cells in the medium of aether.

Subsequent GHZ papers^{36,37,38} came to the same conclusion -- that the experiments eliminated any local deterministic explanation of entanglement.

The last two of the cited GHZ papers^{39,40} dealt with separate sources of photons, a process called entanglement swapping, and the use of more than two receptors. As with the earlier GHZ papers, they concluded that they eliminated any "realistic local theories" of entanglement.

It is suggested that the GHZ experiments and papers cannot be taken as eliminating Maxwell's aether medium as a rational explanation of entanglement and a rational physical foundation of quantum mechanics. The reasons are: (1) the GHZ papers reporting on the experiments did not deal with or even mention Maxwell's aether

theory nor any similar aether medium; (2) all the experiments were premised upon the travelling photon concept; and, (3) the papers dealing with the use of separate sources of photons, entanglement swapping and the use of more than two receptors did not deal with the proposition that the areas of the experiments may be permeated by aether.

D. Where Do Emitted Particles Go?

On the assumptions that: (1) the power sources used in the entanglement experiments emit particles, and (2) the receptors interact with aether cells that are already in place by the receptors, the question arises: What happens to the emitted particles?

The proposed answer is that the particles proceed into and become part of the aether medium. This assumes of course that the emitted particles, whether they be called photons or quanta, are in fact aether cells. This may be a difficult concept for those who are of the view that the emitted particles travel from source to destination at the speed of light. However, when one considers that both concepts, travelling photons and waves through a medium, involve particles that in their own manner vibrate, transmit waves and interact with neighboring cells at or about the speed of light, the idea that they may in fact be identical particles starts to make sense. Indeed, this may ultimately provide the key to resolving the fundamental issue of whether light is travelling particles or waves through a medium.

On the assumption that emitted particles become part of the aether medium, might some of the particles come into contact with the receptors? Given that the sources of the emitted particles are in close proximity to the receptors, it seems likely that some of the emitted particles will come into contact with the receptors and, when activated by waves from the source, interact with the receptors. This does not mean that these are “travelling particles” in the quantum mechanics sense of travelling

through space at the speed of light. Rather, they are simply part of Maxwell's aether medium that happens to be close-by the receptors.

Picture again the moving ship. Instead of passing by offshore, this time the ship is moving close-by a dock. In this scenario, it seems most likely that some of the water that the ship is passing through will be physically pushed into and come into contact with the dock.

E. Molecule Analog

Maxwell's description of aether as a real substance is supported by electromagnetic phenomena in media composed of molecules. The word "molecules" is used in the sense of including atoms and similar entities. There is an unmistakable relationship between the structure and shapes of molecules and electromagnetic phenomena that occur in a molecular medium. The phenomena include refraction, dispersion, polarization, rotation of polarization, horizontal and vertical polarization, rotation of light, scattering of light, and angular momentum. These relationships are addressed in the works of E. U. Condon in *The Handbook of Physics*, 2nd ed. ⁴¹

Condon's articles provide examples of structures or shapes of molecules that directly affect states of polarization and other electromagnetic phenomena. From this, one may infer that a medium -- one made up of structured particles -- is a pre-requisite for these phenomena to occur. Given that electromagnetic phenomena occur in what we normally call a vacuum (where molecules are essentially non-existent), one may infer that the "vacuum" is in fact a medium comprised of structured particles that have the capacity to produce electromagnetic phenomena -- particles such as aether cells.

Here are a few illustrative examples of the relationship between molecular structure and electromagnetic effects. The passages are taken from Condon's article, *Molecular Optics*:⁴²

- “The molecular interpretation of the Kerr effect is based on recognition that the individual molecules of the medium are anisotropic. Without an applied electric field the molecules are oriented at random, and so the anisotropic properties are lost on the average. The applied electric field acts to produce a partial statistical orientation so that now the anisotropic properties of individual molecules no longer average out completely, giving rise to the observed birefringence.”
- “Optical activity, or optical rotatory power, is the property of some media of rotating the plane of polarization of linearly polarized light. It is due to a natural circular double refraction of the medium in which the normal modes of polarization are right and left circularly polarized waves.”
- “The simplest kind of molecule capable of showing rotatory power is one containing a single asymmetric carbon atom, that is, a carbon atom to which four different groups are attached.”
- “A great many naturally occurring organic compounds show optical rotatory power in solution or in the liquid state. In these cases the rotatory power has to be a structural attribute of individual molecules, . . .”

F. Structure and Elasticity

Structure and elasticity are related in the sense that elasticity is derived from flexible structures. Maxwell applied this reasoning to the elasticity of the

“connexions” element of his aether theory. Rubber balls, elastic bands and tuning forks are examples of the relationship of structure to elasticity.

Consider a rubber ball that is struck by a bat. The force of the bat will cause the ball to shrink from front to back and expand at its sides. In the next instant, elasticity will cause the ball to elongate from front to back and shrink at its sides.

Picture the ball being surrounded by other balls. When the first ball is struck, the blow will push the ball into the ball that is ahead of it. At the same time, the expansion of the sides of the first ball will cause it to strike the balls that are adjacent to its sides. These collisions will transmit momentum from the first ball to the ball that is ahead of it and to the balls at the sides of the first ball.

Note that the transmissions of momentum emanating from the front of the ball and the sides of the ball are perpendicular to each other – much like the forces of electricity and magnetism.

Now, replace the rubber balls with aether cells. Apply electromotive force (a form of mechanical energy) to an aether cell. One can expect that the aether cell will react in the same manner as the rubber ball. The electromotive force will cause the cell to shrink from front to back and expand at its sides. In the next instant the cell will expand from front to back and shrink at its sides.

Add to the picture aether cells surrounding the initial cell. One can expect the same elastic reactions, the same collisions, and the same orthogonal transmissions of momentum as in the rubber ball analog.

Consider now the shape of aether cells. Assume that aether cells may not be perfect spheres, that they may be structured asymmetrically. (See the **Molecule Analog** subsection above.) Based upon this assumption, asymmetric aether cells could well

account for angular momentum, rotating patterns of polarization, rotating electromagnetic radiation and rotating magnetic fields.

The reasoning in this subsection is of course speculative. But, it is based upon ordinary cause and effect. It is supported by the fact that it provides a rational physical explanation for the orthogonal nature of electric and magnetic forces and the phenomena of angular momentum and rotation.

G. Summary

Maxwell's aether medium provides a rational explanation of entanglement and a rational underlying physical foundation of the quantum mechanics theory. The aether medium enables correlation of electromagnetic characteristics. The characteristics include the various states of polarization, transmission of the immense variety of waves, momentum and its various angles, and the various phenomena of electricity and magnetism. The ship and stone analogies support the waves-in-a-medium concept and the direct cause-and-effect approach to entanglement. The examples set out in the **Molecule Analog** subsection support the proposition that there is a medium in the so-called vacuum. The **Structure and Elasticity** subsection describe in a direct cause-and-effect manner roles that structured and elastic aether cells can play in entanglement and in the quantum mechanics theory. The aether medium provides a physical foundation for all this to occur. The particles that comprise the medium act in concert with each other. In doing so, the particles are in the entangled state.

The falling-stone and travelling-ship analogs provide an explanation of how energy that is emitted into a medium from a centrally located source-- such as the electromotive sources used in the entanglement experiments -- can account for the particular characteristics of opposite angular momentum and opposite polarization.

The proposed explanation of entanglement and physical base of the quantum mechanics theory does not involve instantaneous communication between receptors. The state of the aether medium is already in place when the interactions between the particles and the receptors occur. The receptors simply record the medium's state at the particular moment(s) that the medium is interacting with the receptors. Communication between the receptors plays no part in the proposed explanation of entanglement. Thus, the idea of instantaneous action-at-a-distance has no relevance to the proposal.

One may draw the following conclusions:

1. Maxwell's theory of the medium of aether provides a rational explanation of entanglement.
2. Maxwell's aether theory presents a rational mechanical cause-and-effect picture of the underlying physical reality that is presently missing from the quantum mechanics theory.
3. Communication between the receptors plays no part in entanglement. This eliminates the suggestion of instantaneous communication between the receptors.

VII. RESUSCITATION OF MAXWELL'S AETHER

Maxwell's aether fell into disuse for a number of reasons. The Michelson-Morley experiment in 1887 and other experiments failed to demonstrate substantial levels of aether drag on the Earth in its orbit around the Sun. In 1905, Einstein's Special Relativity paper ⁴³ opined that aether was superfluous. With the growth of Einstein's reputation, his view came to carry extraordinary weight. In the 1920s, quantum mechanics was developed and has since become mainstream physics. Its premise of travelling photons is arguably inconsistent with Maxwell's aether theory.

The argument that the Michelson-Morley and similar experiments negate the existence of aether is countered by the proposition that aether that surrounds the Earth largely shields the surface of the Earth (where the experiments have taken place) from orbital aether drag – much like the body of a car shields the passengers from the friction of the air the car is driving through.

Einstein's statement that Aether is superfluous runs counter to his own opinion, expressed in 1920, that aether is essential to electromagnetic radiation.⁴⁴ It also is contradicted by numerous leading physicists, including Dirac,⁴⁵ Ives,⁴⁶ Allais,⁴⁷ Wolfram,⁴⁸ Cornille,⁴⁹ Laughlin,⁵⁰ Cahill⁵¹ and Wilczek,⁵² who have expressed the view that aether in some form or other must exist.

As for the argument that the travelling photons of the quantum mechanics theory conflict with the waves-through-aether theory of Maxwell, the fact that the quantum mechanics theory has no generally accepted underlying physical explanation of how it works undermines the force of any suggestion that the quantum mechanics theory falsifies Maxwell's aether theory.

VIII. CONCLUSIONS

Consider the following:

James Clerk Maxwell, one of the most accomplished scientists in the history of science, developed his aether theory as the underlying physical basis for his electromagnetism equations; Maxwell's equations have stood the test of time – over 150 years; the quantum mechanics theory does not yet have an accepted underlying physical rationale that explains how the theory works; entanglement experiments that are premised upon the concept of travelling photons have failed to find a local cause-and-effect explanation of entanglement; and entanglement experiments have not been premised upon there being an aether medium such as described by Maxwell.

Maxwell's aether theory offers a physical cause-and-effect explanation of entanglement and of quantum mechanics: aether as theorized by Maxwell is a sub-atomic substance; it consists of "parts and connexions" (aether cells) that are interconnected; electromagnetic phenomena are produced by movements and interactions of aether; aether pervades space and the bodies that occupy space; and, from the premise that aether pervades space and bodies, one may infer that aether exists at the sites of the entanglement experiments.

The waves-through-aether theory of Maxwell is consistent with the propositions that: electromagnetic waves activate aether cells that are adjacent to the receptors used in the experiments; activated aether cells interact with the receptors; and interactions between wave-activated aether cells and the receptors are consistent with the experimental assertions that the arriving particles are emitted photons.

The waves-through-aether theory of Maxwell is consistent with electromotive force and waves transmitting characteristics of the power sources into the aether medium; these characteristics being added (superposed) to those already in the aether medium; connections and interactions of aether cells correlating characteristics within the aether medium; and by these means, aether cells being entangled.

The aether cells and medium elements of Maxwell's theory are supported by various analogies, including: circular waves emanating from a stone falling into a pool of water; superposition of waves from a ship moving in the medium of water; orthogonal forces from a bat striking a rubber ball; electromagnetic phenomena produced by molecular media; and the requirement of physical structure to support the property of elasticity. All these are based upon the premise that they require a physical medium in order to occur.

It is contended that the overall weight of these considerations supports the proposition that Maxwell's aether provides a rational cause-and-effect explanation of entanglement and provides a rational underlying physical base for the quantum mechanics theory.

References:

- 1 J. C. Maxwell, *The Dynamical Theory of the Electromagnetic Field* (Wipf and Stock Publishers, Eugene, OR, 1996).
- 2 D. W. Shaw, *Phys. Essays* **27**, 601 (2014).
- 3 J. C. Cramer, *The Quantum Handshake: Entanglement, Nonlocality and Transactions* (Springer International Publishing AG, Switzerland, 2016) pp. 173-174).
- 4 G. Greenstein and A Zajonc, *The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics*, 2nd ed. (Jones and Bartlett Publishers, Inc., Sudbury, MA, 2006) p. 149.
- 5 A. I. M. Rae, *Quantum Mechanics*, 5th ed. (Taylor & Francis Group, LLC, Boca Raton, FL, 2008) p. 268.
- 6 L. Gilder, *The Age of Entanglement: When Quantum Physics Was Reborn* (Alfred A. Knopf, New York, 2009) p. 3.

- 7 A. Einstein, D. Podolsky, N. Rosen, Phys. Review. **47**, 777 (1935).
- 8 *The Ghost in the Atom*, Ed. By P.C.W. Davies and J.R. Brown, Cambridge University Press, Cambridge, (1986), p. 51.
- 9 R. Feynman, *QED: The Strange Theory of Light and Matter* (Princeton University Press, Princeton, NJ, 1985} p. 37.
- 10 (Ref. 5, p. 287).
- 11 B. Cox and J. Forshaw, *The Quantum Universe (and why anything that can happen, does)* (Da Capo Press, Boston, MA, 2012) pp. 27-28.
- 12 (Ref. 4, pp. 149-185).
- 13 (Ref. 3, pp. 30-37 and chapter 6).
- 14 Tony Hey and P. Walters, *The New Quantum Universe* (Cambridge University Press, Cambridge, UK, 2003) p. 160.
- 15 J. Bell, Physics, **1**, 195 (1964).
- 16 C. A. Kocher and E. D. Commins, 18 Phys. Rev. Let. 575 (1967).
- 17 S. J. Freedman and J. F. Clauser, 28 Phys. Rev. Let. 938 (1972).
- 18 A. Aspect, P. Grangier and G. Roger, 49 Phys. Rev. Let. 91 (1982).
- 19 A. Aspect, J. Dalibard and G. Roger, 49 Phys. Rev. Let. 1804 (1982).
- 20 *Bell's Theorem, Quantum Theory, and Conceptions of the Universe*, edited by M. Kafatos (Kluwer Academic, Dordrecht, The Netherlands, 1989) pp. 73-76.
- 21 D. M. Greenberger, M. A. Horne, A. Shimony and A. Zeilinger, Am. J. Phys. **58**, 1131 (1990).
- 22 D. M. Greenberger, M. A. Horne and A. Zeilinger, Physics Today **46**, 22 (1993).
- 23 J.-W. Pan, D. Bouwmeester, M. Daniell, H. Weinfurter and A. Zeilinger, *Nature* **403**, 515-519 (03 February 2000).
- 24 D. Greenberger, M. Horne and A. Zeilinger, Phys. Rev. A **78**, 022110-1 (2008).
- 25 D. Greenberger, M. Horne, A. Zeilinger, and M Zukowski, Phys. Rev. A **78**, 022111-1 (2008).
- 26 N. C. Petroni and J. P. Vigiier, Found. Phys **13**, 253 (1982).
- 27 (Ref. 26, p. 274).
- 28 (Ref. 2).
- 29 (Ref. 1)

- 30 (Ref. 2, p. 603).
- 31 (Ref. 2, pp. 604-606)
- 32 (Ref. 3, pp. 31-32).
- 33 (Ref. 3, p. 30).
- 34 (Ref. 4, p. 151).
- 35 (Ref. 20, pp. 73-76).
- 36 D. M. Greenberger, M. A. Horne, A. Shimony and A. Zeilinger, *Am. J. Phys.* **58**, 1131 (1990)
- 37 D. M. Greenberger, M. A. Horne and A. Zeilinger, *Physics Today* **46**, 22 (1993).
- 38 J-W. Pan, D. Bouwmeester, M. Daniell, H. Weinfurter, and A. Zeilinger, *Nature* **403**, 515 (2000).
- 39 D. Greenberger, M. Horne and A. Zeilinger, *Phys. Rev. A* **78**, 022110-1 (2008).
- 40 D. Greenberger, M. Horne, A. Zeilinger, and M Zukowski, *Phys.Rev. A* **78**, 022111-1 (2008).
- 41 *Handbook of Physics, 2nd Edition*, edited by E. U. Condon and Hugh Odishaw, (McGraw-Hill Book Company, New York, NY, 1967), pp. 6-112 to 6-130 and pp. 6-3 to 6-12.
- 42 *Handbook of Physics, 2nd Edition*, edited by E. U. Condon and Hugh Odishaw, (McGraw-Hill Book Company, New York, NY, 1967), pp. 6-120 to 6-123.
- 43 A. Einstein, *Annalen der Physik* 17 (1905) 891; English translation: <http://www.fourmilab.ch/etexts/einstein/specrel/www/>.
- 44 A. Einstein, *Ether and Relativity*, address on 5 May 1920 at the University of Leiden (English translation published by Methuen & Co. Ltd., London, 1922)
- 45 P. A. M. Dirac, *Nature* **168**, 196 (1951).
- 46 H. Ives, *J.O.S.A.* **43**, 217-218 (1953); *The Einstein Myth and the Ives Papers* (The Devin-Adair Company, Old Greenwich, CT, 1979) pp. 188-190.
- 47 M. Allais, *L'Anisotropie de L'Espace* (Clément Juglar, Paris, 1997) pp. 382-428.
- 48 S. Wolfram, *A New Kind of Science* (Wolfram Media, Inc., Champaign, IL, 2002) p. 475.
- 49 P. Cornille, *Advanced Electromagnetism and Vacuum Physics* (World Scientific Publishing Co., PTE, Singapore, 2003) pp. 180-184.

- 50 R. Laughlin, *A Different Universe* (Basic Books, Cambridge, MA, 2005) p. 121.
- 51 R. Cahill, *Process Physics: From Information Theory to Quantum Space and Matter* (Nova Science Publisher, Inc., Hauppauge, NY, 2005) p.51.
- 52 F. Wilczek, *The Lightness of Being – Mass, Ether, and the Unification of Forces* (Basic Books, New York, 2008) p. 74.