

# On Maxwell's 1865 theory of aether: A step toward unity

Duncan W. Shaw<sup>a)</sup>

1517 Angus Drive, Vancouver, British Columbia V6J 4H2, Canada

(Received 19 March 2020; accepted 20 June 2020; published online 17 July 2020)

**Abstract:** This article proposes that James Clerk Maxwell's theory of the medium of aether, published in 1865, provides a significant step toward the unification of gravity, electromagnetism, quantum mechanics, and entanglement. © 2020 *Physics Essays Publication*.  
[<http://dx.doi.org/10.4006/0836-1398-33.3.256>]

**Résumé:** Cet article-ci propose que la théorie de l'éther de James Clerk Maxwell, publiée en 1865, soit une étape significative vers l'unification de l'électromagnétisme, de la gravité, de la mécanique quantique et de l'intrication.

Key words: Aether; Ether; Medium; Gravity; Electromagnetism; Quantum Mechanics; Entanglement; Condensation; Fluid State; Diffusion.

## I. INTRODUCTION

Scientists are always searching for what underlies and unifies the phenomena that surround us, from the stars that fill the universe, to the particles from which everything is made, and the mechanics that produce the phenomena we observe. Step-by-step we conceive ideas, develop technology, and carry out experiments that move us toward fundamental explanations that underlie and unify the various phenomena that rule the universe.

This article focuses upon one such step. It is James Clerk Maxwell's theory of the medium of aether that is set out in his treatise, *The Dynamical theory of the Electromagnetic Field*,<sup>1</sup> published in 1865.

In his treatise, Maxwell proposed fundamental equations of the electromagnetic field. This was a scientific breakthrough that unified electromagnetic radiation. Maxwell's equations are still in use today. They have stood the test of time.

In the same treatise, Maxwell also proposed a physical cause-and-effect theory of aether. He described aether as: "... 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)

The purpose of Maxwell's aether medium theory was to provide a physical explanation for his mathematics equations. Maxwell based his mathematics equations on his physical theory of aether. He said: (section 91)

"At the commencement of this paper, we made use of the optical hypothesis of an elastic medium through which the vibrations of light are propagated, in order to show that we have warrantable grounds for seeking, in the same medium, the cause of other phenomena as well as those of light. We then examined electromagnetic

phenomena, seeking for their explanation in the properties of the field, which surrounds the electrified or magnetic bodies. In this way, we arrived at certain equations expressing certain properties of the electromagnetic field."

The present article proposes that Maxwell's aether medium theory was and is a significant step toward unification of the phenomena of electromagnetism, gravity, entanglement, and quantum mechanics. While such extensive unification was clearly not Maxwell's intention (entanglement and quantum mechanics are concepts that were not developed until after Maxwell's era), this article contends that the proposed unification is the inevitable result of the aether medium theory he developed in 1865.

In support of this proposition, this article examines physical cause-and-effect concepts of electromagnetism, gravity, entanglement, and quantum mechanics, all based upon the theory of aether developed by Maxwell in 1865. It is proposed that Maxwell's medium of aether plays causative roles in each of these phenomena. It is argued that these causative links, when considered together, provide compelling evidence that Maxwell's aether theory unifies these phenomena.

In further support, this article examines the long-standing issue of whether electromagnetic radiation is waves through the medium of aether or the transmission of wave-particles called photons. It concludes that the waves-through-aether theory is preferable.

Maxwell's treatise initially met with general acceptance. However, while his equations remain in use to this day, his aether theory was essentially abandoned by mainstream physics. This was mainly due to: (1) the Michelson–Morley experiment in 1887 and other experiments that searched for aether drag on the Earth in its orbit around the Sun, but produced minimal results that came to be interpreted as proof that aether does not exist and (2) papers of Albert Einstein published in 1905 and 1909 that proposed his special theory of relativity, dismissed aether as superfluous and proposed that electromagnetic radiation consists of travelling quanta.

<sup>a)</sup>duncanshaw@shaw.ca

This article contends that the virtual abandonment of Maxwell's theory of aether was an error that effectively removed his theory from serious consideration in theoretical physics. It is proposed that Maxwell's theory be revived as a fundamental theory that provides physical underpinnings for the unification of electromagnetism, gravity, entanglement, and quantum mechanics.

It should be noted that in an earlier treatise, (*On Physical Lines of Force*, Philosophical Magazine, 1861–1862), Maxwell developed a different mechanical model of aether, one based upon vortices and complicated mechanics. That paper has been subjected to considerable criticism. In his 1865 treatise, upon which the present article is based, Maxwell expressly declined to use his 1861–1862 approach. (section 73) Likewise, the present author declines to use the earlier model.

## II. MAXWELL'S AETHER

The passages set out below from Maxwell's 1865 treatise provide in Maxwell's own words a summary and details of his aether theory.

Maxwell's summary:

- "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)

Maxwell's details:

- "The theory I proposed 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)
- "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)
- "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)

- "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)
- "The medium is therefore capable of receiving and storing up two kinds of energy, namely, the "actual" energy depending on the motions of its parts and "potential" energy, consisting of the work which the medium will do in recovering from displacement in virtue of its elasticity." (section 6)
- "The propagation of undulations consists of the continual transformation of one of these forms of energy into the other alternately, and at any instant, the amount of energy in the whole medium is equally divided, so that half is energy of motion, and half is elastic resilience." (section 6)
- "Now we know that the luminiferous medium is in certain cases acted on by magnetism; as 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)
- "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 of 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)
- "This velocity is so nearly that of light, that it seems we have a strong reason to conclude that light itself (including radiant heat, and other radiations if any) is an electromagnetic disturbance in the form of waves propagated through the electromagnetic field according to electromagnetic laws." (section 20)
- "In speaking of the Energy of the field, however, I wish to be understood literally. All energy is the same as mechanical energy, whether it exists in the form of motion or in that of elasticity, or in any other form. 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)

- “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)

In addition to the above expressly stated details, it is inferred that the parts and connections that comprise Maxwell’s medium of aether are structured cells that have the properties and capacities that Maxwell attribute to his parts and connections. Most of the properties Maxwell attributed to aether are known properties of atomic matter. They include the property of elasticity and capacities to form a medium, interact, vibrate, store and transmit energy, rotate, and collectively form patterns (polarization).

One further property that this article posits is that aether exists in separate states, including gaseous and liquid states. This proposition is drawn from the known states of atomic matter and in part from the works of Khaidarov<sup>2</sup> and Múnera.<sup>3</sup> The gaseous and liquid states of aether play roles in the proposed gravity model.

Note that the possibility of there being a solid state of aether is not used in this article except as speculation in the Looking Ahead section at the end of the article.

### III. ELECTROMAGNETISM

This section argues that aether as theorized by Maxwell underlies the phenomena of electromagnetism. Consider the broad array of electromagnetic phenomena, set out below, and note their consistency with Maxwell’s medium of aether. Most of the examples are drawn from the author’s article, *Reconsidering Maxwell’s Aether*.<sup>4</sup>

- Electric current. Maxwell’s aether is consistent with electric current being successive interactions (collisions and displacements) of aether cells within and along a conductor, propelled by electromagnetic force.
- Back surge of electricity. This is consistent with compressed aether cells snapping back from their distorted shapes into their normal shape when electric current is stopped. Compare this to compressed rubber balls springing back into their normal shape when the compressing force is removed.
- Magnetic fields that surround conductors. Aether cells as elastic structures bulge and shrink in line with the direction of electric current, but also bulge and shrink at right angles thereto, like ordinary rubber balls. The bulging and shrinking at right angles to the line of the applied force provide a simple explanation of why magnetic fields are orthogonal to electric current.
- Polarization. Maxwell’s reference to polarization patterns of iron provides an example of electromotive force forcing aether cells to assume positions vis-à-vis each other into collective patterns.
- Magnetism. The action of electromotive force on aether cells is a rational concept of the mechanism of the cause of magnetism.
- Electromagnetic radiation. Collisions and interactions of aether cells within the medium of aether are a rational explanation for the transmission of electromagnetic waves.
- Electromagnetic fields. Maxwell’s treatise explains electromagnetic fields—interactions of Maxwell’s parts and connections (aether cells) in his medium of aether.
- Frequencies and wavelengths. Structured aether cells that are capable of vibrating and doing so collectively with other aether cells offer a rational explanation for the broad spectrum of frequencies and wavelengths of electromagnetic radiation.
- Entanglement. The medium of aether as theorized by Maxwell is the proposed physical setting in which the correlations of electromagnetic characteristics observed in entanglement experiments occur (see Sec. V).
- Quantum Mechanics Theory. The medium of aether as theorized by Maxwell is the proposed physical setting of the quantum mechanics theory (see Sec. V).
- Dark matter. Given Maxwell’s propositions that the medium of aether permeates space and has “small but real density,” then Maxwell’s aether can be seen as a rational candidate for what is presently called dark matter.
- Dark energy. Given Maxwell’s propositions that the aether medium permeates space and is capable of a “vast variety” of motion that produces electromagnetic phenomena, the energy of these phenomena can be seen as a rational candidate for what is presently called dark energy.
- Induction. Interactions between aether cells and atomic matter present logical means for transferring energy from aether to atomic matter and from atomic matter to aether.
- Cosmic Background Radiation. The concept that space is occupied by a medium of aether that consists of aether cells that are vibrating with the energy of radiation that is being transmitted through them and the energy of interactions between the cells is consistent with the phenomenon of Cosmic Background Radiation and the observed temperature of 2.7 K in space.
- Interference. Constructive and destructive interferences are typical wave phenomena. It is generally believed that wave phenomena require a medium. Maxwell’s aether medium is a likely setting for interference that is observed to occur in a vacuum (the absence of atomic matter).
- Refraction. Refraction is the change of direction of electromagnetic waves when moving from one medium to another. Refraction is observed when waves enter and leave a vacuum. One can reason that observations of refraction in a vacuum indicate that the vacuum is in fact occupied by a medium, such as the medium of aether theorized by Maxwell.
- Lensing. Lensing occurs where light from a distant galaxy or cluster of galaxies bends as it passes by the sides of an intervening galaxy or cluster of galaxies. The existence of Maxwell’s aether medium provides a rational explanation for the phenomenon of lensing.

The above list of examples covers an extensive variety of electromagnetic phenomena. The examples are all consistent with Maxwell's theory of aether. When they are considered collectively, they raise a fair inference that the medium of aether as theorized by Maxwell plays causative roles in the phenomena of electromagnetism.

Note: In the Maxwell's Aether and the Gravity sections of this article, it is posited that aether exists in separate states, including the gaseous state and the liquid state. This proposition of separate states of aether has particular application to the cause of gravity. However, in regard to electromagnetism, the proposition of separate states of aether raises the question of what role or roles each state may play. The author is not aware of any experimental data that answers this question. However, it is proposed that gaseous aether plays the dominant role in the phenomena of electromagnetism. The rationale for this assumption is that the individual cells of gaseous aether, viewed as separate entities, are relatively close to each other compared to individual droplets of liquid aether, each one of which is probably composed of immense numbers of aether cells. The relative closeness of gaseous aether cells to each other makes it more likely that they will play the dominant role in the interactions that comprise the phenomena of electromagnetism.

#### IV. GRAVITY

The age-old question of whether there is a mechanical cause of gravity has not yet been answered with a theory that has gained general acceptance in the scientific community. In the words of Richard Feynman in *The Feynman Lectures on Physics*,<sup>5</sup> speaking on the cause of gravity:

“What about the machinery of it? All we have done is to describe *how* the earth moves around the sun, but we have not said *what makes it go*. Newton made no hypotheses about this; he was satisfied to find out what it did without getting into the machinery of it. *No one has since given any machinery.*”

The present article proposes a conceptual model of flowing aether as the cause of gravity. The gravity concept is drawn mainly from the author's articles, *The Cause of Gravity: A Concept*,<sup>6</sup> *Flowing Aether: A Concept*,<sup>7</sup> and *Outflowing Aether*.<sup>8</sup> The model is based upon aether as described by Maxwell in 1865. It is also based upon the proposition that aether, like atomic matter, exists in separate states, such as gaseous, liquid, and (perhaps) solid states.

Gaseous aether consists of separate detached aether cells. Liquid aether consists of groups of aether cells that have condensed together as droplets, much like individual H<sub>2</sub>O molecules condense together as droplets of liquid H<sub>2</sub>O. Droplets are orders of magnitude larger than the individual cells of gaseous aether. Solid-state aether—if it exists—does not play an active role in the proposed gravity model.

The model is as follows:

- The medium of aether is comprised of aether in two distinct states: (1) gaseous-state aether, that is, separate

individual aether cells, and (2) liquid-state aether, that is, groups of aether cells that form droplets of aether.

- Each state of aether collectively acts as a separate and distinctly different gaseous fluid.
- The gravity process is cyclic. It involves liquid-state aether moving from space into cosmic bodies and gaseous-state aether moving from cosmic bodies into space.
- Incoming aether collides with the matter of cosmic bodies. The collisions set off series of collisions within the matter of cosmic bodies. The collisions transmit the momentum of the inflow collisions into and throughout cosmic bodies.
- ***The transmission of the momentum of inflowing aether to the matter of cosmic bodies is posited as the direct cause of gravity.***
- The collisions of incoming droplets of aether with the matter of cosmic bodies vaporize droplets into individual gaseous-state aether cells.
- Gaseous-state aether moves into space by way of diffusion.
- In space, gaseous state aether condenses into liquid-state aether.
- Condensation is caused by the low temperature of space and triggering interactions (collisions) of outgoing aether cells with aether droplets or other particles.
- Movements of aether droplets into cosmic bodies and gaseous aether into space are caused by each state of aether seeking equilibrium of concentration.<sup>9,10</sup> When incoming droplets of aether strike the matter of a cosmic body, the collisions vaporize the droplets into gaseous state aether. This reduces the level of concentration of liquid-state aether in the vicinity of cosmic bodies. When gaseous-state aether travels into space and condenses into liquid-state aether, this reduces the level of concentration of gaseous-state aether in space. Thus, both states of aether are put into continuous states of disequilibrium of concentration. Each state of aether moves in the direction of its lower level of concentration, each seeking but never reaching equilibrium. Thus, the cyclic nature of gravity.
- The two states of aether travel through each other. The phenomenon of fluids moving through each other in opposite directions is described and explained in Batchelor's textbook, *An Introduction to Fluid Mechanics*,<sup>9</sup> as follows:

“Transfer of matter of a specific kind occurs in a fluid mixture of which the composition varies with position. We may suppose that the molecules belonging to one constituent of the mixture are marked in some manner. All molecules are in continual motion of a random kind, and as a consequence have a tendency to migrate away from any initial position. Then if at any instant the proportion of marked molecules immediately on one side of an element of surface drawn in the fluid is larger than that on the other side, random migration of marked molecules in both directions across the surface element will lead in general to a non-zero flux of marked molecules across the element, of such a sign as to tend to make the proportion of marked molecules more nearly equal on the

two sides. This non-zero flux of a constituent of the fluid due to migration constitutes *diffusion of matter*.”

- The same process is also described in Landau and Lifshitz, *Fluid Mechanics*, 2nd ed.<sup>10</sup>
- Gaseous-state aether cells and liquid-state droplets are different substances in the sense of being capable of flowing through each other. They are as different as gaseous-state H<sub>2</sub>O molecules that diffuse into the atmosphere and drops of liquid-state H<sub>2</sub>O that return to the Earth as rain.
- The proposed gravity model explains why gravity is a one-way force. The explanation involves the porous structure of atomic matter. Particles that comprise atoms and molecules—protons, neutrons, and electrons—are relatively small compared to the volume of space that an atom actually occupies. This implies that atoms are porous structures. The explanation also involves the proposition that individual aether cells are miniscule compared to the size of aether droplets. Given these factors, it stands to reason that small particles, such as individual aether cells, can pass on through the structures of atoms virtually unimpeded while, at the same time, the much larger liquid-state droplets can be significantly impeded by the structures of atoms. The result is that the momentum that incoming droplets exercise on atomic matter of cosmic bodies is greater than the momentum exercised by outgoing gaseous aether. On the assumption that aether droplets are orders of magnitude larger than single cells of gaseous-state aether, it stands to reason that the incoming collisional force exercised by aether droplets predominates over the outgoing collisional force exercised by individual gaseous aether cells. Visualize an ordinary fishnet. Minnows easily pass through the gaps in the net, while larger fish collide with the netting.
- The proposed gravity model provides an explanation for gravity being an accelerating force. The flow of aether from space converges as it moves toward a cosmic body. The convergence is caused by the area available for inflow constantly diminishing as the flow proceeds from the vast expanse of space toward the relatively small target of a cosmic body. This is an application of the Venturi effect that flow of a fluid accelerates as it proceeds through a narrowing channel. An analog is the acceleration of air that flows toward an ordinary household vacuum cleaner.
- The collisions of incoming aether droplets with the matter of cosmic bodies generates heat in cosmic bodies. However, the heat is compensated for by the cyclic nature of the gravity process. The outward diffusion of gaseous aether cells emits heat from cosmic bodies and carries heat back into space.
- The source of energy that drives the flows of aether is the constant movements and vibrations of aether cells and droplets and their elastic interactions (collisions and rebounding) within the medium of aether—the “motion and strain” of the medium, as put by Maxwell in his treatise. An analog is the energy of interacting molecules of air (Brownian movements and mean free paths) that cause air to push itself toward a vacuum cleaner and cause the

atmosphere to push itself from high pressure areas to low pressure areas.

## A. Observations

1. Note that every facet of the proposed gravity model is consistent with the details of the aether theorized by Maxwell and the proposition that aether exists in gaseous and liquid states. Note also that the elements of the gravity model are compatible with each other and with known phenomena of fluid mechanics.
2. There is an apparent anomaly of the force of gravity between the Sun and the Earth appearing to be virtually instantaneous. If, as many assume, gravitation between the Sun and the Earth is caused by waves or particles that travel between these bodies at the speed of light, one would expect a delay of about 8.3 min before their gravitational effects take hold. During this time, the Earth would travel for about 8.3 min in its orbit, and this would present an angular difference in the line of gravity. But that is not what happens. There is no such difference. The direction of the gravitational force between the Sun and the Earth is virtually in a straight line. Why is this so? The proposed model of the cause of gravity provides a simple answer. In the area of space that comprises our Solar System, incoming liquid-state aether from space flows predominantly toward the Sun. When the flow collides with the Earth and pushes the Earth toward the Sun, the direction of the momentum exerted by the flow is directly at the Sun. The fact that the force of gravity is in a straight line between the Sun and the Earth is significant. It is consistent with the proposed model of gravity as a pushing force; and it is inconsistent with gravity being caused by waves or particles that travel between cosmic bodies at the speed of light.
3. A characteristic of gravity is that gravitational acceleration applies equally to all objects, large and small and light and heavy. Experiments at the leaning tower of Pisa have proven this proposition. Equality of acceleration is consistent with gravity being caused by a flowing substance that carries objects with the flow. Visualize a river carrying different objects, such as big ships and little rafts. Both are carried at equal speed and equal acceleration, that is, the speed and acceleration of the river’s flow.
4. Does the gravity model violate the laws of conservation of energy and momentum? Based upon the cyclic nature of the gravity model, it is assumed that the amounts of incoming and outgoing energy and momentum are essentially equal and that the conservation laws are not violated. An essential element of the gravity model is that the outflow of energized gaseous aether replenishes the aether supply in space, including its energy and momentum. It is inferred that this process involves equilibrium, that is, inflows and outflows of aether essentially match each other in terms of the amounts of aether cells and their energy and momentum.

Is there proof of non-violation of the conservation laws? No, there is not, at least not yet. To the best of the author's knowledge there are no quantitative experimental data or theories that provide proof, one way or the other. This is not surprising. Numerous factors bear upon the energy and momentum levels of inflow and outflow. The factors include velocities, internal energy, viscosity, mass, temperatures, structural shapes, the states of the flows (gaseous, liquid or solid), their concentration levels, and their levels of diffusivity. The noted factors are drawn from Batchelor's *An Introduction To Fluid Mechanics*,<sup>11</sup> Chap. 1.6–1.9, with respect to flows of molecular matter.

5. Re aether drag. As cosmic bodies travel through space in their orbital paths, do they encounter aether drag? Based upon Maxwell's theory that posits that aether has real density and fills space, it follows that orbiting bodies must encounter aether drag. Would aether drag, then, deplete the supply of energy and momentum required to propel the flows of aether posited by the gravity model? The answer must be no. Energy and momentum lost to drag do not just disappear. They are subject to the laws of conservation of energy and momentum. The gravity model is cyclic. The model posits that the outflow of gaseous-state aether replenishes in space the energy and momentum that is requisite for the gravity system to work, and to do so in effect forever. This includes sufficient energy to counterbalance the energy that is consumed by drag.
6. Richard Feynman, in his *The Feynman Lectures on Physics*,<sup>12</sup> argued that a pushing theory of gravity (which the proposed model is) does not work because aether drag would slow down the Earth in its orbit and cause it to stop. Here is Feynman's reasoning:

“This particular idea has the following trouble: the earth, in moving around the sun, would impinge on more particles which are coming from its forward side than from its hind side (when you run in the rain, the rain in your face is stronger than on the back of your head!). Therefore, there would be more impulse given the earth from the front, and the earth would feel a *resistance to motion* and would be slowing up in its orbit. One can calculate how long it would take for the earth to stop as a result of this resistance and, it would not take long enough for the earth to still be in its orbit, so this mechanism does not work.”

The present author contends that Feynman's reasoning is incomplete. It does not take into account the fact that drag can be countered by acceleration. Consider a motor vehicle that encounters drag from the atmosphere through which the car is travelling. The vehicle's engine can provide acceleration that overcomes the drag and enables the vehicle to maintain its velocity. As long as the acceleration is equal to or higher than the energy that is lost to drag, the acceleration will enable the vehicle to maintain its velocity. In the proposed gravity model, acceleration of the flows of aether that cause gravity and set the orbital paths and velocities of cosmic bodies is provided by the

constant movements (Brownian movements) of aether cells and droplets within the aether medium—their collisions and the mean-free-paths of their rebounds. As long as that energy is equal to or higher than the energy that is lost to drag, cosmic bodies can maintain their velocities and remain in orbit.

Feynman argues that aether drag would not take long to bring the Earth's orbit to a halt. This argument does not take into account the fact that continuous acceleration can continuously counterbalance drag. Unlike the example of the motor vehicle that will stop when it runs out of fuel, the supply of energy that accelerates the flows of aether is essentially permanent. The gravity model posits that the supply of energized aether in space is constantly replenished by outflowing gaseous-state aether. And, in the broader context, energy and particles throughout the universe are supplied by emissions from stars, supernovae, and black holes.

Note that Feynman's argument is also addressed in the author's articles cited above at the start of the Gravity section.<sup>13–15</sup>

7. In his treatise, in one out of its 116 sections (section 82), Maxwell briefly considered whether his aether theory might have application to the “attraction” of gravity. He opined that energy is essentially a positive force and reasoned that it is impossible for space to have “negative intrinsic energy”. He said he could not understand how a medium can possess negative energy and concluded that he could go no further in his search for the cause of gravitation. He did not consider whether gravity might be a pushing force and did not consider whether his form of aether might do the pushing. One may fairly conclude that Maxwell's brief observations do not derogate from the cause of gravity model proposed in the present article. Indeed, Maxwell's observations that energy is essentially a positive force and that it is impossible for space to possess intrinsic negative energy are consistent with the proposition that gravity is a pushing force.

## V. ENTANGLEMENT AND THE QUANTUM MECHANICS THEORY

These two topics are dealt with together because both involve the same reasoning. It is proposed that the medium of aether as theorized by Maxwell provides the physical setting that produces correlations that underlie the phenomenon of entanglement. It is also proposed that the medium of aether is the physical underpinning of quantum mechanics. These propositions draw upon the author's article, *Aether Explanation of Entanglement*.<sup>16</sup>

While preparing the *Aether Explanation of Entanglement* article, it occurred to the author that Maxwell's aether medium might be the long sought-after physical setting of the quantum mechanics theory. After further research, the author amended the article to propose this concept.

### A. Quantum mechanics theory

The quantum mechanics theory was developed in the 1920s and is generally accepted by present-day physics for

its mathematics. While the mathematics of the quantum mechanics theory has been experimentally verified, there is still no accepted concept of the physical mechanics that underlie the quantum mechanics theory.

In 1935, Einstein *et al.*<sup>17</sup> concluded:

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

In 1986, John Bell in an interview<sup>18</sup> stated his view:

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...”

In 2005, Greenstein and Zajonc<sup>19</sup> said:

“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.”

## B. Entanglement defined

Entanglement is a phenomenon of quantum mechanics. It is evidenced by experiments that record correlations of electromagnetic characteristics (quantum states) emitted by power sources and received by receptors.

Entanglement is defined by Alistair Rae in his book, *Quantum Mechanics*, 5th ed.<sup>20</sup> (2008), as follows:

“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.”

Entanglement is also defined by John Cramer in *The Quantum Handshake: Entanglement, Nonlocality and Trans-actions*<sup>21</sup> (2016), as follows:

“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.”

## C. Entanglement experiments

In the entanglement experiments, the receptors are located at appreciable distances from each other. The characteristics (quantum states) that are recorded include momentum, angular momentum, polarization, energy, spin, rotation, torque, wavelengths, and frequencies. Where, based on probabilities, the recorded characteristics are found to accord with the laws of conservation of energy and momentum, the characteristics are considered as correlated. It is from the correlations that entanglement is inferred. The data produced by the experiments have been found to be consistent with the mathematics of the quantum mechanics theory.

An example of correlation is “spin-up” recorded at one receptor and “spin-down” at the other receptor. The expressions of spin-up and spin down denote opposite angular momentum.

Experimenters have sought physical cause-and-effect explanations for entanglement. They have been unable to find any. Indeed, some papers conclude that no physical explanation is possible.

To the best of the author’s knowledge, entanglement experiments have not addressed the proposition that the medium of aether theorized by Maxwell might be the physical setting that enables correlations to occur.

## D. The reasoning

Consider the following reasoning offered in support of the proposition that the medium of aether provides the physical setting that enables the correlations that underlie entanglement. The reasoning is drawn mainly from the author’s article, *Aether Explanation of Entanglement*.<sup>16</sup>

- The aether medium theorized by Maxwell fills space and permeates bodies. It follows that the aether medium permeates the places where entanglement experiments are carried out.
- Power sources in the entanglement experiments emit into the aether medium waves that carry electromagnetic characteristics produced by the power sources.
- The waves spread throughout the surrounding aether medium.
- The waves are series of interactions of aether cells that comprise the medium. The interactions involve displacements of the aether cells.
- The waves emitted by the power sources continuously transmit electromagnetic characteristics throughout the aether medium while the power sources are in operation.
- When the waves arrive at the receptors, they activate the aether cells that happen to be located at the receptors.
- The activated aether cells interact with the receptors and transmit to the receptors the characteristics of the waves emitted by the power sources.
- Waves emitted by the power sources continuously transmit electromagnetic characteristics throughout the aether medium while the power sources are in operation.
- The characteristics are correlated because the waves that transmit the characteristics pervade the aether medium at the time or times they are recorded by the receptors.

## E. Observations

1. Note that the above reasoning is entirely based upon physical cause-and-effect and Maxwell's 1865 aether theory. If the reasoning is correct, it counters the proposition that no physical cause and effect explanation of entanglement is possible.
2. Most scientists, including the present author, reject the concept of instantaneous communications at a distance. These views conflict with those of scientists who contend that the correlations data recorded by the receptors in the entanglement experiments can only be explained by instantaneous communications between the receptors. In the words of John Bell in his paper, *On The Einstein-Podolsky-Rosen Paradox*:<sup>22</sup>

"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."

Basing correlations upon the state of the aether medium resolves the conflict over instantaneous communications. It does so by eliminating communications, instantaneous or otherwise, between the receptors as the source of the correlation data.

3. There is an unmistakable relationship between certain electromagnetic phenomena that occur in a medium composed of molecules and the structure and shapes of the molecules. Such phenomena include refraction, dispersion, polarization, rotation of polarization, horizontal and vertical polarization, rotation of light, scattering of light, and angular momentum. Condon in *The Handbook of Physics*, 2nd ed.,<sup>23</sup> provides examples. Given that the same electromagnetic phenomena also occur in what we normally call a vacuum, that is, where atoms and molecules are removed, one may infer that the "vacuum" is a medium of structured aether cells that have the capacity to produce the observed electromagnetic phenomena.
4. Regarding the "spin-up" and "spin-down" data recorded in entanglement experiments, Maxwell's aether medium provides a rational explanation for the opposite angular momenta. Visualize an entanglement experiment with its power source situate between two receptors. Visualize the power source emitting the characteristic of angular momentum in all directions from the power source. The emissions that are in opposite directions, or even partially in opposite directions, will be recorded by the receptors as having opposite angular momenta. These "spin up" and "spin down" observations are consistent with the power sources causing rotation of the medium of aether that surrounds the power sources, similar to the electromagnetic field that rotates around a live conductor. Now, visualize a rotating wheel. Note that the upper half rotates in one direction while the lower half rotates in the opposite direction.

## F. Application to quantum mechanics

It is proposed that Maxwell's aether medium is the physical substance that not only explains entanglement, but also underlies the quantum mechanics theory. Given that entanglement is a phenomenon of the quantum mechanics theory, and given Maxwell's aether permeates space and matter and therefore permeates the entanglement experiments, it is inferred that the aether medium is a substance that provides the physical setting for not only the entanglement experiments, but also the phenomena of quantum mechanics.

## G. Why have the entanglement experiments not been based on Maxwell's aether theory?

It may seem odd that entanglement experiments do not appear to have addressed the question of whether Maxwell's aether medium theory provides a rational explanation for entanglement. It is suggested that the probable reason for overlooking Maxwell's aether medium is that Einstein's travelling quanta (photons) theory has become such a deeply held belief in theoretical physics, that physicists conducting entanglement experiments have not seriously considered that exploring the waves-through-aether theory might provide useful results.

## VI. MAXWELL'S AETHER VERSUS TRAVELLING PHOTONS

There is a clear conflict between the views of those who contend that electromagnetic radiation consists of quanta (photons) that travel from source to destination versus those who contend that electromagnetic radiation is waves transmitted through the medium of aether. This is one of the most fundamental issues in theoretical physics.

Conceptually, aether cells and photons have certain similarities. Both may be viewed as having the properties of particles and waves in the sense that both can transmit electromagnetic radiation (waves) and both can physically interact with atomic matter. One may fairly assume that aether cells and photons are structured in such a manner as to provide them with the capacity to transmit the vast variety of electromagnetic radiation.

Despite these similarities, aether cells and photons are conceptually and fundamentally different from each other. Aether cells form a medium within which they interact by elastic pulses (Maxwell's displacements), and by such means transmit electromagnetic radiation. The distances aether cells can travel within the aether medium are limited to the mean free paths open for travel between the cells that comprise the medium. In contrast, photons transmit electromagnetic radiation by physically travelling from the source of radiation to the point where the radiation is received. This includes photons travelling immense distances (billions of light years) from galaxies and clusters of galaxies all the way to the Earth where they strike the retinas of our eyes.



The concept that photons can travel from far-away cosmic bodies through light-years of distance to the Earth without being blocked by the countless cosmic bodies and the immense amount of other matter in space is highly problematic. We know, for example, from the shadows cast on Earth from sunlight, that our planet alone impedes the travel of light from our Sun.

The aether medium has compelling advantages. They include the fact that numerous electromagnetic phenomena are consistent with the medium of aether as theorized by Maxwell. See the Electromagnetism section above. Another advantage is that the medium concept has its constituent aether cells situated in close proximity to each other. This permits them to physically interact and produce electromagnetic phenomena, such as electromagnetic fields, electromagnetic radiation, and polarization. The medium concept permits electromagnetic radiation to be transmitted by series of interactions (elastic displacements) of its constituent aether cells.

Evidence that favors the travelling photons theory includes Einstein's photoelectric effect and the Compton effect, both of which are said to be evidence that photons travel from the source to destination. But the aether medium provides an answer to this evidence. The answer is that the "arriving" photons are in reality aether cells at or adjacent to the sites where the Einstein or Compton effects occur. Waves through the aether medium activate those cells and those cells cause the Einstein and Compton effects, giving the false impression that the aether cells were travelling photons. An analog is a moving ship causing waves that arrive at the seashore. The water that strikes the shore is water that was already situated by the shore before the waves arrived, not the water in place where the ship propagated the waves.

In conclusion, one must choose between the theories of two great physicists: James Clerk Maxwell and Albert Einstein. For the reasons stated above, this author's view is that Maxwell's waves-through-a-medium theory is preferable to Einstein's travelling quanta (photons) theory.

## VII. ABANDONMENT AND REVIVAL OF MAXWELL'S AETHER THEORY

Maxwell's theory of aether was essentially abandoned because of the Michelson–Morley experiment of 1887 and Einstein's papers on special relativity (1905) and travelling quanta (1905 and 1909). As Professor David Griffiths observed in his textbook, *Introduction to Electrodynamics*:<sup>24</sup>

"Special relativity has forced us to abandon the notion of ether and with it Maxwell's mechanical interpretation of electromagnetic fields."

In his "special relativity" paper, *On the Electrodynamics of Moving Bodies*,<sup>25</sup> published in 1905, Einstein opined that his special relativity theory rendered the concept of aether superfluous.

In his "blackbody radiation" paper, *On a Heuristic Point of View about the Creation and Conversion of Light*,<sup>26</sup> also published in 1905, Einstein posited that light is transmitted

by "quanta" that travel from their source to their point of reception, not by waves through aether.

In 1909, in a paper entitled *The Development of Our Views on the Composition and Essence of Radiation*,<sup>27</sup> Einstein rejected the aether theory and embraced the travelling quanta theory of light. He said:

"A satisfactory theory can only be reached if we dispense with the ether hypothesis. Then the electromagnetic fields that make up light no longer appear as a state of a hypothetical medium, but rather as independent entities that the light source gives off, just as in Newton's emission theory of light. As in that theory, space that is free of matter and radiation is truly empty."

As Einstein's reputation grew, so did the physics community come to accept the propositions that (1) there is no such thing as aether, and (2) electromagnetic radiation is transmitted by travelling quanta (now photons). This left no room for Maxwell's 1865 aether theory.

However, Einstein's stated views changed. In 1920, in a lecture given at Leyden University,<sup>28</sup> he reversed his view that aether is superfluous. He said:

"Recapitulating, we may say that according to the general theory of relativity, space is endowed with physical qualities; in this sense, therefore, there exists an ether. According to the general theory of relativity, space without ether is unthinkable; for in such space there not only would be no propagation of light, but also no possibility of existence for standards of space and time (measuring-rods and clocks), nor therefore any space–time intervals in the physical sense. But this ether may not be thought of as endowed with the quality characteristic of ponderable media, as consisting of parts which may be tracked through time. The idea of motion may not be applied to it."

The above assertion appears to be problematic. It is difficult to grasp how something can be "endowed with physical qualities", but not be "ponderable", not have "parts" and not be capable of "motion".

Numerous experiments and analyses now provide evidence of the existence of aether and indicate that the "no-aether" interpretation of the results of the Michelson–Morley and related experiments was and is wrong. Experiments provide evidence that aether flows into all sides of the Earth and that the Earth encounters aether in its orbital path around the Sun. These experiments include interferometry tests by Michelson and Morley,<sup>29</sup> Sagnac,<sup>30</sup> Miller,<sup>31</sup> Galaev,<sup>32,33</sup> and Munera,<sup>34,35</sup> coaxial cable tests by De Witte<sup>36</sup> and Cahill,<sup>37</sup> red shift tests by Pound, Rebka, Snider and Vessot *et al.*,<sup>38,40</sup> and light deflection tests by Nitikin.<sup>41</sup>

In addition, there are supporting analyses and resulting views of leading 20th and 21st century physicists that indicate that aether in some form or other must exist. These scientists include: Dirac,<sup>42</sup> Ives,<sup>43</sup> Allais,<sup>44</sup> Wolfram<sup>45</sup> ("nodes" or "cells"), Laughlin<sup>46</sup> ("stuff" and "relativistic ether"),

Cornille,<sup>47</sup> Cahill<sup>48</sup> (“quantum foam”), Wilczek<sup>49</sup> (“ether” and “grid”), and ‘t Hooft<sup>50</sup> (“cellular automata”).

There is a simple and rational explanation of the minimal results of the Michelson–Morley experiments. A significant portion of the aether medium envelops the Earth and travels together with the Earth in its orbit. In effect, the Earth is cocooned inside the aether envelope. The Earth and the aether envelope both encounter aether drag as they orbit together around the Sun. The aether envelope absorbs most of the aether drag and the Earth, being inside the envelope, absorbs only a small portion of the aether drag. In effect, the aether envelope shields the Earth from most of the collisions with the aether in the space through which the unit is traveling. As the Michelson–Morley experiments were carried out on the Earth, it follows that the aether envelope would have shielded those sites from most of the aether drag. Thus, the minimal aether drag results recorded in the experiments. An analog is the body of an automobile that shields its occupants from most if not all atmospheric drag. The passengers in the car of course feel virtually none of the drag. One might ask, however, whether shielding by the aether envelope would affect the Earth’s orbital velocity. As the Earth and the aether envelope travel as a unit, the Earth’s velocity must be subject to the drag absorbed by the aether envelope—just the same as the velocity of the car’s passengers is subject to the atmospheric drag absorbed by the car’s body.

#### A. Where are we today?

Despite the various experiments, analyses, and reasoning that support the existence of aether and the waves-through-a-medium concept, it appears that a majority of physicists does not accept the existence of aether and does accept the travelling photons theory of electromagnetic radiation. However, a significant minority is of the view that aether exists and that electromagnetic radiation is transmitted by waves through the medium of aether. Patrick Cornille, in his textbook, *Advanced Electromagnetism and Vacuum Physics*,<sup>51</sup> published in 2003, observes:

“A growing minority of physicists working today on the foundations of physics now seems to be ether-oriented. A new physics of the ether is emerging that in our opinion will much better explain and describe the constitution of matter and radiation. In this book, we will show that Newton’s third law is the key for a better understanding of physics. Moreover, the experimental proofs of Newton’s third law violations, which are reviewed in this book, demonstrate the existence of what Maxwell termed ‘the luminiferous aether.’ A serious revision of our understanding of the physical laws governing the universe now seems unavoidable.”

In summary, one may observe that the above-cited experiments, analyses, and reasoning that have entered the scientific scene subsequent to the 1905 and 1909 papers of Einstein provide compelling evidence that supports Maxwell’s theory of aether and its revival as a fundamental theory of physics.

## VIII. VERIFICATION

The entanglement experiments have produced an immense amount of data. The data have been interpreted on the premise that photons or other particles travel from the power sources to the receptors used in the experiments. These interpretations have failed to produce a physical explanation of entanglement.

To the best of our knowledge, the data have not been interpreted on the premise that the particles that were interacting with the receptors were aether cells that form the medium of aether that permeates the sites of the experiments. It is therefore recommended that the data generated by the entanglement experiments be subjected to analyses based upon the premise that the experiments were carried out in the setting of Maxwell’s aether medium. The analyses should indicate whether the data are consistent with or inconsistent with having been produced in the setting of Maxwell’s aether. In addition, the analyses may provide evidence that helps resolve the issue of travelling photons versus waves-through-aether.

A substantial advantage of this proposal is that the data already exist.

Richard Feynman, in *The Feynman Lectures on Physics*,<sup>52</sup> compared the mathematics of interference of electrons with the mathematics of interference of water waves in one-slit and two-slit experiments. He found the mathematics to be the same for both water waves and electrons. He said:

Yet, surprisingly enough, the *mathematics* for relating  $P_1$  and  $P_2$  to  $P_{12}$  (the electron experiment) is extremely simple. For  $P_{12}$  is just like the curve  $I_{12}$  of Fig. 1–2 [the water experiment], and *that* was simple. What is going on at the backstop can be described by two complex numbers that we can call  $\phi_1$  and  $\phi_2$  (they are functions of  $x$ , of course). The absolute square of  $\phi_1$  gives the effect with only hole 1 open. That is,  $P_1 = |\phi_1|^2$ . The effect with only hole 2 open is given by  $\phi_2$  in the same way. That is,  $P_2 = |\phi_2|^2$ . And the combined effect of the two holes is just  $P_{12} = |\phi_1 + \phi_2|^2$ . **The mathematics is the same as that we had for the water waves!** (It is hard to see how one could get such a simple result from a complicated game of electrons going back and forth through the plate on some strange trajectory.) (Emphasis added)

Note particularly Feynman’s observation that it is hard to see how one gets such a simple result from a complicated game of electrons. It is suggested that the result becomes simple if the analysis starts from the premise that both the electron experiment and the water experiment take place within a medium—the medium of aether in the electron experiment and the medium of water in the water experiment.

## IX. CONCLUSIONS

The proposal that Maxwell’s aether medium theory is a significant step toward unification of electromagnetism, gravity, entanglement and quantum mechanics is based upon

the causative roles his aether medium plays in regard to these phenomena.

In regard to electromagnetism, numerous electromagnetic phenomena are cited that are consistent with Maxwell's aether theory. When considered collectively, they infer that Maxwell's aether medium plays causative roles in the production and transmission of electromagnetic phenomena.

In regard to gravity, the proposed model provides logical physical explanations of how gravity is cyclic, why it is a one-way force, why it is a pushing force, why it is an accelerating force, why it acts upon all objects equally, and how it explains the anomaly of "instantaneous" gravity between the Sun and the Earth. The various elements of the model are consistent with Maxwell's description of aether and with the proposition that aether, like atomic matter, exists in gaseous and liquid states. The compatibility of the details of Maxwell's aether theory with the fundamental characteristics of gravity supports the proposition that Maxwell's aether plays causative roles in the process of gravitation.

In regard to entanglement, Maxwell's theory says that electromagnetic phenomena are transmitted through the aether medium by waves consisting of interactions of the parts and connections of the medium. Although Maxwell was not addressing the phenomenon of entanglement—it was not part of the physics scene until after Maxwell's era—his aether medium none-the-less provides a physical cause-and-effect explanation of the correlations of electromagnetic characteristics upon which entanglement is based. In effect, correlations recorded by the receptors are received from waves through the medium itself, not from particles sent from the power sources used in the experiments. Advantages of this concept include refuting the assertion that no physical explanation of entanglement is possible, and refuting the suggestion that entanglement involves communication between the receptors, instantaneous or otherwise. In addition, the aether medium concept provides a logical explanation of why the characteristics of spin-up and spin-down (opposite angular momentum) can be recorded by the receptors.

In regard to the quantum mechanics theory and the missing physical explanation of the theory, it is significant that entanglement is a quantum mechanics phenomenon. On the assumption that Maxwell's aether medium permeates space and matter and therefore is the setting of the entanglement experiments, it is a reasonable assumption that it also the setting of the phenomena of quantum mechanics.

The unity proposal is compatible with Maxwell's proposition that electromagnetic radiation consists of waves-through-a-medium of aether, and incompatible with Einstein's proposition that electromagnetic radiation consists of photons that travel from source to destination. This article sets out reasons why the waves-through-aether approach is preferable.

Maxwell's aether theory has gone through a period of being essentially abandoned. However, numerous experiments and interpretations of experiments now indicate that the Earth is orbiting through aether, and that aether is flowing into the Earth. In addition, many highly respected 20th and 21st century scientists, several being Nobel Prize

laureates, have expressed reasoned views that aether in some form or other must exist. It is fair to say that Maxwell's aether theory is now undergoing serious reconsideration by an increasing minority of scientists.

When one considers the details of Maxwell's theory, the individual elements of the subject phenomena, the compatibility of the details and elements with each other, the experiments that indicate that the Earth is orbiting through aether and that aether is flowing into the Earth, and the reasoned views of many prominent physicists, a compelling conclusion emerges: That Maxwell's aether plays causative roles in the phenomena of electromagnetism, gravity, entanglement and quantum mechanics. Therein lies the step toward unity that arises from Maxwell's aether medium theory.

As noted, it is of course true that the concept of entanglement did not exist in Maxwell's era. Nor did the quantum mechanics theory or the proposed model of gravity. Presumably, Maxwell did not have them in mind when he developed his theory of the medium of aether. However, this does not prevent Maxwell's aether medium theory from laying the theoretical foundation that later on proves to have broad applications. To Maxwell, one can fairly apply the expression: "On the shoulders of Giants..."

## X. LOOKING AHEAD

The resurrection of Maxwell's aether theory opens up pathways to far-reaching speculation. Here are a few possibilities.

A key element in the unity proposal is the concept that aether exists in distinct states, much like the gaseous, liquid and solid states of atomic matter. Although this article utilizes only the gaseous and liquid states of aether, one can speculate whether aether also exists in the solid state and, if so, what its role or roles might be. Might solid-state aether be material from which particles such as electrons, protons, and neutrons are constructed? Might it be material that forms the structural framework of atoms, the structure that holds nuclei and electrons in place and occupies the space that atoms occupy? Might solid-state aether provide structured "holes" that can be occupied by (combined with) electrons. Might solid-state aether be the material that physically connects atoms to each other as solids and provides the lesser bonding of liquids?

Going further afield, one might speculate whether the medium of aether as theorized by Maxwell provides the physical setting for the geometry of gravitation developed by Einstein in his general theory of relativity. Might Maxwell's aether medium be the material through which Einstein's predicted gravitational waves are transmitted? Might his aether medium be what provides friction or drag that causes the observed orbital shifts that underlie the gravitation mathematics that Einstein developed in his general theory of relativity? Might the inflow and outflow of gaseous and liquid aether that are proposed in this article as the cause of gravity be the cause of what the general theory describes as the warping of the fabric of space-time?

These speculations are but a glimpse of what may lie ahead if Maxwell's aether theory is resurrected and again

assumes a respected position as a significant theory in theoretical physics.

## ACKNOWLEDGMENTS

I wish to acknowledge the helpful observations of Adam Rain, David Rain, Ray Gallucci, Cameron Rebigso, George Coyne, and my wife, Pat Shaw.

- <sup>1</sup>J. C. Maxwell, *The Dynamical Theory of the Electromagnetic Field* (Wipfand Stock, Eugene, OR, 1996).
- <sup>2</sup>K. Khaidarov, <http://bourabai.ru/mechanics-e.htm> for "Aethereal Mechanics" (2004).
- <sup>3</sup>H. Múnera, *Should the Laws of Gravitation Be Revisited? The Scientific Legacy of Maurice Allais*, edited by H. Múnera (C. Roy Keys, Inc., Apeiron, Montreal, QC, Canada, 2011), pp. 385–422.
- <sup>4</sup>D. W. Shaw, *Phys. Essays* 27, 601 (2014).
- <sup>5</sup>R. Feynman, *The Feynman Lectures on Physics, The Definitive Edition* (Addison Wesley, Reading, MA, 2006), Vol. 1, p. 7–9.
- <sup>6</sup>D. W. Shaw, *Phys. Essays* 25, 66 (2012).
- <sup>7</sup>D. W. Shaw, *Phys. Essays* 26, 523 (2013).
- <sup>8</sup>D. W. Shaw, *Phys. Essays* 29, 4 (2016).
- <sup>9</sup>G. K. Batchelor, *An Introduction to Fluid Mechanics* (Oxford University Press, New York, 2000), pp. 28–29.
- <sup>10</sup>L. D. Landau, and E. M. Lifshitz, *Fluid Mechanics*, 2nd ed. (Elsevier Butterworth Heinemann, Oxford, UK, 2004), pp. 227–234.
- <sup>11</sup>G. K. Batchelor, *An Introduction to Fluid Mechanics* (Oxford University Press, New York, 2000), Chap. 1.6–1.9.
- <sup>12</sup>R. Feynman, *The Feynman Lectures on Physics, the Definitive Edition* (Addison Wesley, Reading, MA, 2006), Vol. 1, p. 7–10.
- <sup>13</sup>D. W. Shaw, *Phys. Essays* 25, 66 (2012), at p. 74.
- <sup>14</sup>D. W. Shaw, *Phys. Essays* 26, 523 (2013), at pp. 528–529.
- <sup>15</sup>D. W. Shaw, *Phys. Essays* 29, 485 (2016), at pp. 488–489.
- <sup>16</sup>D. W. Shaw, *Phys. Essays* 31, 29 (2018).
- <sup>17</sup>Einstein, P. Podolsky, and N. Rosen, *Phys. Rev.* 47, 777 (1935).
- <sup>18</sup>*The Ghost of the Atom*, edited by P. C. W. Davies and J. R. Brown (Cambridge University Press, Cambridge, UK, 1986), p. 51.
- <sup>19</sup>G. Greenstein and A. Zajonc, *The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics*, 2nd ed. (Jones and Bartlett, Sudbury, MA, 2006), pp. 149–185.
- <sup>20</sup>A. I. M. Rae, *Quantum Mechanics*, 5th ed. (Taylor & Francis Group, London, UK, 2008), p. 268.
- <sup>21</sup>J. Cramer, *The Quantum Handshake: Entanglement, Nonlocality and Transactions* (Springer, Cham, Switzerland, 2016), p. 173.
- <sup>22</sup>J. Bell, *Phys. Phys. Fiz.* 1, 195 (1964).
- <sup>23</sup>*The Handbook of Physics*, edited by E. U. Condon and H. Odishaw, 2nd ed. (McGraw-Hill Book Company, New York, 1967); pp. 6–112 to 6–130.
- <sup>24</sup>D. J. Griffiths, *Introduction to Electrodynamics*, 3rd ed. (Prentice-Hall, Inc., Upper Saddle River, NJ, 1999), p. 61.
- <sup>25</sup>A. Einstein, *Ann. Phys.* 17, 891 (1905).
- <sup>26</sup>A. Einstein, *Ann. Phys.* 17, 132 (1905).
- <sup>27</sup>A. Einstein, *Phys. Z.* 10, 817 (1909).
- <sup>28</sup>Einstein, *Ether and the Theory of Relativity* (Methuen & Co. Ltd., London, 1922) (in English).
- <sup>29</sup>A. A. Michelson, and E. W. Morley, *Am. J. Sci.* 34, 333 (1887).
- <sup>30</sup>M. G. Sagnac, *C. R. Acad. Sci.* 157, 710 (1913); *ibid.* 157, 1410 (1913).
- <sup>31</sup>D. C. Miller, *Rev. Mod. Phys.* 5, 203 (1933).
- <sup>32</sup>Y. U. Galaev, *Spacetime Subst.* 2, 211 (2001).
- <sup>33</sup>Y. U. Galaev, *Spacetime Subst.* 3, 207 (2002).
- <sup>34</sup>H. A. Múnera, D. Hernández-Deckers, G. Arenas, and E. Alfonso, *Proc. SPIE* 6664, 66640K (2007).
- <sup>35</sup>H. A. Múnera, D. Hernández-Deckers, G. Arenas, E. Alfonso, and, and I. López, "Observation of a non-conventional influence of Earth's motion on the velocity of photons, and calculation of the velocity of our galaxy," in *Progress in Electromagnetic Research Symposium (PIERS-2009)*, March 23–27, Beijing, China (The Electromagnetics Academy, Cambridge, MA, 2009), pp. 113–119.
- <sup>36</sup>R. De Witte, and R. Cahill, *Prog. Phys.* 3, 60 (2006).
- <sup>37</sup>R. Cahill, *Should the Laws of Gravitation be Revisited? The Scientific Legacy of Maurice Allais*, edited by H. A. Múnera (C. Roy Keys, Inc., Apeiron, Montreal, 2012), pp. 359–372.
- <sup>38</sup>R. V. Pound and G. A. Rebka, Jr., *Phys. Rev. Lett.* 4, 337 (1960).
- <sup>39</sup>R. V. Pound and J. L. Snider, *Phys. Rev. Lett.* 13, 539 (1964).
- <sup>40</sup>R. F. C. Vessot, M. W. Levine, E. M. Mattison, E. L. Blomberg, T. E. Hoffman, G. U. Nystrom, B. I. Farrel, D. Decher, P. B. Eby, C. R. Baugher, J. W. Watts, D. L. Teuber, and F. D. Wills, *Phys. Rev. Lett.* 45, 2081 (1980).
- <sup>41</sup>G. Nikitin, *Measurements of Variations in the Direction of Light Beam* (Bourabai Research Institution, Kazakhstan, Ru, 2004), translation into English by H. Holushko.
- <sup>42</sup>P. A. M. Dirac, *Nature* 168, 906 (1951).
- <sup>43</sup>H. Ives, *J. Opt. Soc. A* 43, 217 (1953); *The Einstein Myth and the Ives Papers* (Devin-Adair, Old Greenwich, CT, 1979), pp. 188–190.
- <sup>44</sup>M. Allais, *L'Anisotropie de L'Espace* (Clément Juglar, Paris, France, 1997), pp. 382–428.
- <sup>45</sup>S. Wolfram, *A New Kind of Science* (Wolfram Media, Champaign, IL, 2002), p. 475.
- <sup>46</sup>R. Laughlin, *A Different Universe* (Basic Books, Cambridge, MA, 2005), p. 121.
- <sup>47</sup>P. Cornille, *Advanced Electromagnetism and Vacuum Physics* (World Scientific, Singapore, 2003), pp. 180–184.
- <sup>48</sup>R. Cahill, *Process Physics: From Information Theory to Quantum Space and Matter* (Nova Science, Hauppauge, NY, 2005), p. 51.
- <sup>49</sup>F. Wilczek, *The Lightness of Being—Mass, Ether and the Unification of Forces* (Basic Books, New York, 2008), p. 74.
- <sup>50</sup>G. 't Hooft, *The Cellular Automaton Interpretation of Quantum Mechanics* (Springer, Cham, Switzerland, 2016).
- <sup>51</sup>P. Cornille, *Advanced Electromagnetism and Vacuum Physics* (World Scientific, Singapore, 2003), pp. 3–4.
- <sup>52</sup>R. Feynman, *The Feynman Lectures on Physics, The Definitive Edition* (Pearson Addison Wesley, San Francisco, CA, 2006), Vol. 3, p. 1–6.