ARTICLE REVIEW BY LESLEE KULBA

Original Article:
C. Monstein and J. P. Wesley, "Observation of Scalar Longitudinal Electrodynamic Waves," *Europhysics Letters* 59, No. 4, pp. 514-520.

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Evidence of Scalar Longitudinal Waves

Monstein and Wesley believed that derivations from Maxwell's equations required the existence of scalar electrodynamic waves. To test for a longitudinal component of an oscillating electric field, they constructed a mechanical polarizer and measured its ability to affect signal absorption. They observed that the signal was effectively blocked when the polarizing rods were parallel to the direction of propagation, and practically unaffected when it was perpendicular. To see if this longitudinally-propagated component was a wave, they tested it for adherence to the inverse-square law and the law of reflection. The case for the former law was persuasive, and the latter looks hopeful, but requires experimental refinements.

C. Monstein and J. P. Wesley published experimental results in support of the existence of longitudinal electrodynamic waves in *Europhysics Letters*, 15 August, 2002.[1] Theoretically, they addressed the physical interpretation of the fact that the scalar potential is a solution to both Laplace's equation, in the context of electrostatics, and the inhomogeneous wave equation. Experimentally, they generated sufficient data, in their opinion, to validate the existence of scalar waves. They further asserted that there is no theoretical foundation for the belief that longitudinal electrodynamic waves cannot exist.

Theory

Monstein and Wesley began their theoretical argument for the existence of longitudinal electrostatic waves with the Laplacian operator,

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\,, \tag{1}$$

which has many applications in physics. It basically relates the second derivative (rate of change in change) of a property at a point to the degree to which that property is manifest at that point relative to neighboring positions. For example, one well-known equation,

$$\nabla^2\Phi = \frac{\partial^2\Phi}{\partial x^2} + \frac{\partial^2\Phi}{\partial y^2} + \frac{\partial^2\Phi}{\partial z^2} = -4\pi\rho\,, \tag{2}$$

expresses the scalar potential, Φ, of an electrostatic field, in terms of ρ, charge density. It can be interpreted to mean that the scalar potential at a point is intensifying (diminishing) at an accelerating rate if it is lower (higher) in magnitude than the average scalar potential of all points surrounding it.[2]

When delays due to the propagation rate, c, of the electrostatic field are taken into consideration, the equation becomes

$$\nabla^2\Phi - \frac{\partial^2\Phi^2}{\partial t^2 c^2} = -4\pi\rho. \tag{3}$$

This is a form of the wave equation, generally expressed as

$$\nabla^2\Phi = \frac{\partial^2\Phi^2}{\partial t^2 v^2}\,, \tag{4}$$

and can be derived from Maxwell's equations.[3]

In their experiments, Monstein and Wesley applied a uniformly oscillating charge to a spherical surface. The spherical symmetry of the charge distribution allowed it to be treated as if it had arisen from a point source. Using the equation for the equivalent charge density from a pulsating point source, the scientists solved Eq. (2) for Φ, getting

$$\Phi = q\sin(kr - \omega t)/r \tag{5}$$

The sine term indicates that Φ is a periodic function, or wave, and by definition, Φ is scalar. Scalar potential waves are also known as longitudinal electric field waves.

Experimental Evidence

In previous work, contrary to established views, Monstein argued that longitudinal electrodynamic waves are routinely passed from one capacitor plate to the other. This is usually

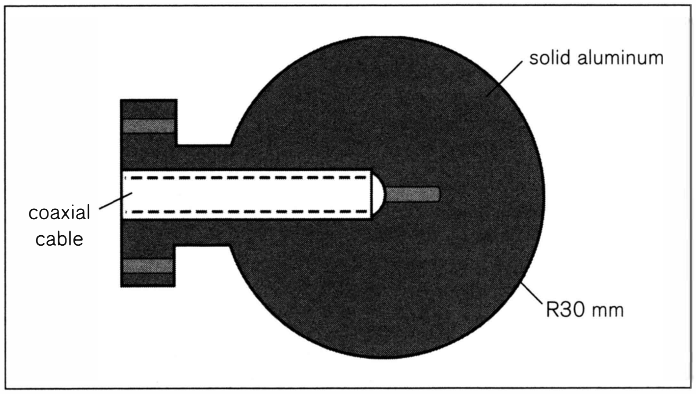

FIGURE 1 Schematic of ball antenna.

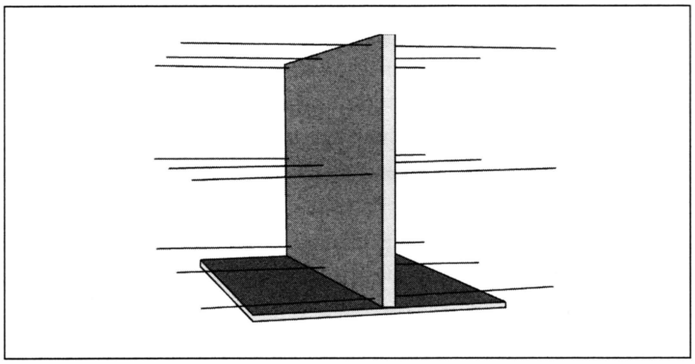

FIGURE 2 Rotatable polarizer, consisting of an array of nine brass rods, each $\lambda/2$.

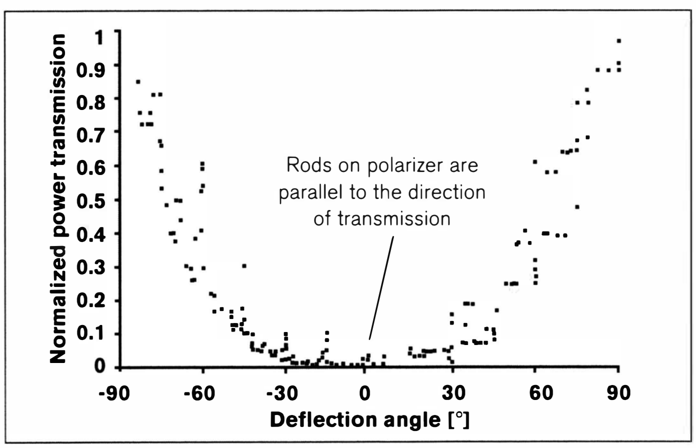

FIGURE 3 Transmission of longitudinal waves through the polarizer as a function of polarizer angle.

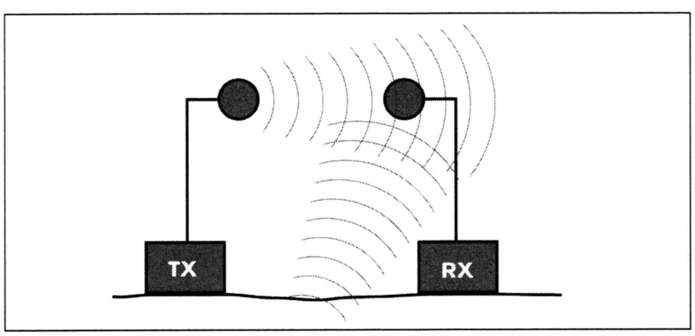

FIGURE 4 Schematic of transmitting station (TX) and mobile receiving station (RX) showing how the receiver picks up both the directly transmitted wave and a wave reflected off the earth.

not verifiable because the spacing between parallel capacitor plates is typically much less than one wavelength. Monstein, therefore, conducted an experiment in which he measured energy flow as he gradually increased the separation between two capacitor plates, from just under to beyond one wavelength. His findings were consistent with theoretical models for longitudinal waves.

In the present investigation, Monstein and Wesley devised an elegant experiment to test for longitudinal electrodynamic waves. They used a 6-cm-diameter, solid sphere made of aluminum as a transmitting antenna because, mathematically, perfect spheres, pulsating with radial symmetry about a fixed centroid, can only generate and transmit scalar waves. (See Fig. 1.) That is, the surface charge on an oscillating sphere is divergenceless, meaning the divergence and curl of its scalar potential are zero, so it is incapable of producing any transverse electrodynamic waves. The receiver was a replica of the transmitter so it would only be able to detect waves normal to its surface; that is, longitudinal waves.

In the experiments, a 433.59 MHz signal generated with a 12-V car battery was delivered to the transmitting antenna. Transmissions were triggered by a 1-second oscillator, which was also used for calibration purposes. A 12-V car battery also powered the receiving antenna, where the intercepted signal was to be processed with a low-noise, gallium-arsenide, field-effect transistor amplifier and a logarithmic RF detector. The power level was then read by a digital voltmeter and sent, with GPS coordinates, to a PC. To simplify calculations, a street running due south was chosen as the test site.

The key piece of equipment was the polarizer-analyzer, a cubical array of nine parallel brass wires on a rotatable platform. (See Fig. 2.) Each wire was cut to a length of 34.6 cm, corresponding to half of the wavelength being generated. The array served to disclose the orientation of the electric field. Theoretically, only the component of an electric field running along the axis of a given wire can cause ohmic losses in that wire, and the losses will be proportional to the square of the field component. Therefore, classical transverse electromagnetic waves should be filtered if the polarizer is oriented orthogonally to the path between antennas.

The first experiment involved the rotation of the array through 180° with the wires oriented horizontally. Stray transverse waves generated by the electrical equipment, though determined to be negligible, were to be filtered with a cross-polarizer consisting of two of these arrays. The data collected in this test clearly showed that signal reception was essentially unimpeded when the wires were orthogonal to the path between the transmitter and receiver, and blocked when they were parallel. (See Fig. 3.)

Undeniably, an electric field was emitted radially from the transmitter, so the next step was to demonstrate that this field behaved as a wave. The authors reasoned that if the signal was travelling as a wave, it would (1) obey the inverse square law, (2) reflect off the conducting earth surface, and (3) arrive at the receiver as the composition of the directly transmitted and reflected waves. (See Fig. 4.) The theoretical power level at the receiver, which assumed the effective reflecting surface of the earth to be half a wavelength below the physical surface and dropped negligible terms, was a sinusoidal function of increasing period riding an inverse-square carrier signal. (See Fig. 5.)

In the experiment, the transmitter was positioned 4 m above ground, and the receiver, 4.4 m above ground, was wheeled, with the entire receiving system, down the street in a hand cart. Copious data was taken in each of six trials. In the data set shown, two minima occurred at the predicted antenna separations, but the other two were not manifest at all. Monstein and Wesley proposed that RF noise and a GPS error of ±5 m may have obscured the absent minima, and felt the agreement of the other two with theory satisfactorily supported their wave hypothesis.

Continuing the analysis, they found the signal to obey an inverse-square law for antenna separations up to 100 m. The accelerated decrease at greater distances was attributed to earth currents induced by the longitudinal transmission waves. Since the electric fields of transverse waves could not produce such currents, this deviation from theory only reinforced the hypothesis.

Back in 1958, one of the authors, Wesley, was not able to explain the enormous electrical signal accompanying nuclear explosions with transverse electrodynamic wave theory alone. However, the existence of longitudinal waves, which capture ejected electrons in radial oscillating patterns, could account for the deficit. This prospect should be verifiable if signals from novae and supernovae can be intercepted with appropriate antennas.

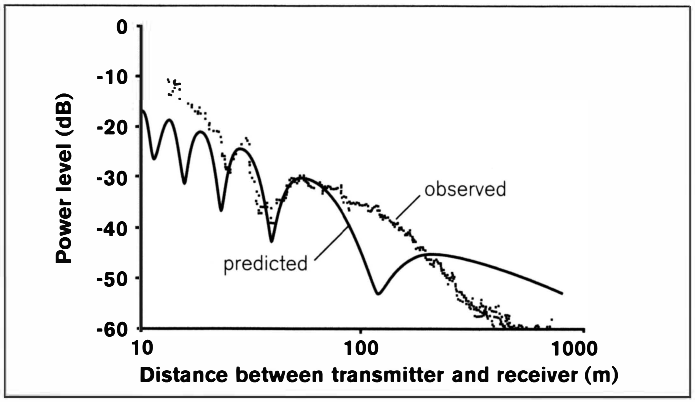

FIGURE 5 Graph from one of the six experiments showing that the signal diminished according to an inverse-square law and evidenced two minima coinciding with theoretical zones of destructive interference.

Notes

1 C. Monstein and J. P. Wesley, "Observation of Scalar Longitudinal Electrodynamic Waves," *Europhysics Letters* 59, no. 4 (2002): 514-520.

2 Stanley J. Farlow, *Partial Differential Equations for Scientists and Engineers* (New York: Dover Publications, Inc., 1993), 245-47.

3 J. D. Jackson, *Classical Electrodynamics* (New York: John Wiley & Sons, Inc., 1967), 179-80.

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The Speed of Gravity

An experiment claiming to have measured the speed of gravity brings public attention to an ongoing debate.

At an Astronomical Society meeting in Seattle on January 7, 2003, astronomers Sergei Kopeikin, of the University of Missouri in Columbia, and Edward B. Fomalont, of the National Radio Astronomy Observatory in Charlottesville, VA, announced that Einstein's general theory of relativity was correct in predicting that gravity traveled at the speed of light (*c*). The announcement was based on findings from an experiment first proposed by Kopeikin in 2000.[1] Accepting the infeasibility of measuring the rate of propagation of gravity waves directly, Kopeikin reworked some of Einstein's equations to express the gravitational field in terms of the mass and velocity of a test object and the speed of gravity. He believed an upcoming near-eclipse, in which Jupiter would pass within 3.7 arc minutes of Quasar J0842+1835, would present an opportunity to measure the three key variables at once.

Kopeikin had assumed that the bending of the quasar's light by Jupiter's gravitational field would delay the arrival time of the light on earth by a quantity that, substituted in his equations, would reveal the speed of propagation of gravity away from Jupiter. To execute the experiment, Kopeikin and Fomalont took observations from the National Science Foundation's Very Long Baseline Array, ten 25-m radio telescopes spaced between Hawaii and the U.S. Virgin Islands, and a 100-m telescope in Germany, and timed the light with atomic clocks. They found that Jupiter bent the light 5.7×10^{-6} arc seconds, from which they determined the speed of gravity to be $(0.95 \pm 0.25)c$.

Criticism of this experiment had been running rampant before any of the measurements were ever taken. Among the first to object, Hideki Asada[2] stated that the experiment would measure a quantity that propagates at the speed of light, but definitely not the speed of gravity. This objection was published in the journal that rejected Kopeikin and Fomalont's first submitted paper, and received another paper from Kopeikin[3] after the data had been collected, which employed a revised mathematical approach. Normally, it is considered scientifically improper to change the predictions of a theory after the experiment has been conducted and present them as *a priori* assumptions. However, Steve Carlip of the University of California - Davis justified Kopeikin's modifications, saying he only changed the method of approximation required, and the fact that both approximations gave the same result strengthened his argument. On the other hand, Tom Van Flandern,[4] president and head research scientist at Meta Research, argues that the change was serious because it introduced a new time term which not only precluded near-instantaneous speeds of gravity, but caused calculations to conflict with results obtained in other experiments.

With the passage of time, it appears that most scientists are convinced that Kopeikin's experiment did not measure the speed of gravity. Clifford M. Will, an astrophysicist at Washington University in St. Louis, said that meticulous calculations revealed that the delay in the light caused by Jupiter's gravitational field was totally independent of the speed of gravity. Instead, Will argues that the experiment could only test for another prediction of the general theory of relativity, gravitomagnetism, but only with more sensitive instrumentation than is currently available. Gravitomagnetism is described as an effect analogous to the magnetic field of a current, wherein a planet would be the electron; its gravitational field would be the electric field; and its orbit, the electric circuit. Will chairs the NASA Science Advisory Committee for the Gravity Probe B that will test for evidence of this effect in 2003.

Another shortcoming in the calculations was Kopeikin's failure to apply retardation effects consistently. The equations apparently defined Jupiter's position, at the time when the light was supposed to be interacting with its gravitational field, to be its location when the light reached the earth. When Stuart Samuel[5] of the Lawrence Berkeley National Laboratory reframed the equations, the predicted time-delay was two to three orders of magnitude smaller than anything the telescope array could have detected. The calculations are complex; the position of Jupiter at the critical time cannot be found by a simple time-dependent interpolation along its orbit, but must be represented as a function of possible retardation rates induced by gravitational effects.

A piece of evidence Van Flandern[6] cites in favor of a superluminal speed of gravity is the fact that the earth accelerates toward a position in space 20 arc seconds ahead of the apparent solar position. This number is computed from optical data acquired from eclipses and the gravitational data derived directly from geometric ephemerides compiled from eclipse data. Because light from the sun takes 8.3 minutes to reach the earth, whereas light from the moon takes only 1.3 seconds, eclipses are viewed when the moon blocks eight-minute-old light radiated from the sun's eight-minute-old position. (See Fig. 1.) The three celestial bodies don't actually align until later. The maximum gravitational interaction between the sun and the moon is detected on earth 40 seconds after the visual alignment. Whether or not the gravitational effect is retarded, it is, at least, verifiably unequal to the visible effect.

Another persuasive argument Van Flandern gives in support of gravity traveling faster than light is that astronomers have to assume gravitational interactions to be instantaneous in order to conserve angular momentum. The effects can be observed by introducing a delay in the propagation speed of gravity in computer programs modeling celestial mechanics. As Arthur Eddington[7] explained, if each of two celestial bodies were to be attracted to the other's retarded position, the resulting force couple would increase the system's angular momentum. This would cause a continuous increase in a planet's angular velocity and/or orbital radius. According to Van Flandern's calculations, if gravity propagated at light speed, the distance between the earth and sun would double in 1200 years.

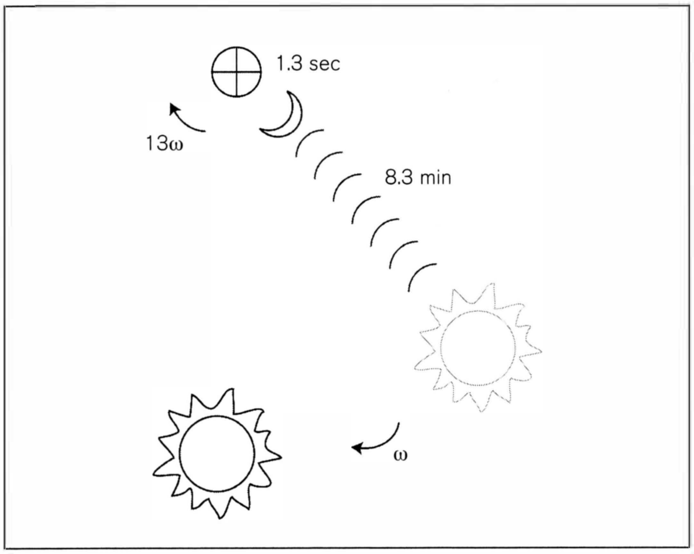

FIGURE 1 Solar eclipses appear to occur before alignment as the moon occludes light radiated from the sun's position 8.3 minutes ago.

Michael Ibison, Harold Puthoff, and Scott Little[8] do not dispute that gravity acts in alignment with the unretarded positions of bodies, but see no need to invoke superluminal velocities to explain why. They presented a mathematical electrodynamic analogy to demonstrate that the force exerted on a test object by a uniformly-accelerating source is the composition of a delayed force and a correction term that exactly cancels the deviation of the retarded effects from the instantaneous effects in magnitude and direction. The argument didn't convince Van Flandern, who reasoned that the cancellation would not work in the case of orbiting binary pulsars. However, Ibison, Puthoff, and Little esteemed Van Flandern's published responses to their paper to be too tenuous to justify reconsideration of their rigorous theoretical developments. After several respectful attempts at conciliation, it appears that a resolution of the debate will depend upon refinement of the underlying assumptions each side has taken from modern physics.

Notes

1 S. Kopeikin, "Testing the Relativistic Effect of the Propagation of Gravity by Very Long Baseline Interferometry," *Astrophysics Journal* 556, no. 1 (2001): L1-L5, part 2.

2 H. Asada, "The Light Cone Effect on the Shapiro Time Delay," *Astrophysics Journal* 574 (2002): L69-L70.

3 S. Kopeikin, "The Post-Newtonian Treatment of the VLBI Experiment on September 8, 2002," (2003), <http://xxx.lanl.gov/abs/gr-qc/0212121>.

4 T. Van Flandern, "Kopeikin and the Speed of Gravity," Meta Research Press Release (2003), <http://metaresearch.org/media%20and%20links/press/SOG-Kopeikin.asp>.

5 S. Samuel, "On the Speed of Gravity and the *v/c* Corrections to the Shapiro Time Delay," *Physical Review Letters*, (2003), <http://xxx.lanl.gov/abs/astro-ph/0304006>.

6 T. Van Flandern, "The Speed of Gravity – What the Experiments Say," *Physics Letters A* 250: 1-11 (1998), <http:/www.metaresearch.org/cosmology/speed_of_gravity.asp>.

7 E. A. Eddington, *Space, Time and Gravitation* (1920; reprint, Cambridge: Cambridge University Press, 1987).

8 M. Ibison, H. Puthoff, and S. Little, "The Speed of Gravity Revisited," (1999), <http://xxx.lanl.gov/abs/physics/9910050>.