Quantum Electromagnetics – A Local-Ether Wave Equation Unifying Quantum Mechanics, Electromagnetics, and Gravitation

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Abstract – The theory of *Quantum Electromagnetics* presents a wave equation for electromagnetic and matter waves. A fundamental feature entirely different from the principle of relativity is that the position vector and the time derivative in the wave equation are referred uniquely to the proposed local-ether frame. For electromagnetic wave, the local-ether wave equation accounts for a wide variety of propagation phenomena, including those commonly ascribed to the general relativity. For matter wave, the wave equation leads to modifications of Schrödinger's equation which in turn leads to a unified quantum theory of electromagnetic and gravitational forces in conjunction with the identity of inertial and gravitational mass. Moreover, it leads to modifications of the Lorentz force law and of Maxwell's equations. Furthermore, the wave equation leads to dispersion of matter wave, from which the speed-dependences in mass of particle and in wavelength, angular frequency, and quantum energy of matter wave are derived. These are in accord with the postulates of de Broglie, the Lorentz mass-variation law, and with various experiments, except the reference frame of particle speed. Thereby, the local-ether wave equation unifies quantum mechanics, electromagnetics, and gravitation.

1. Introduction

The theory of *Quantum Electromagnetics* is constructed by proposing a wave equation for electromagnetic and matter waves [1]. A fundamental feature different from the principle of relativity is that all the physical quantities of position vectors, time derivatives, velocities, and current density involved in this brand-new theory are referred specifically to their respective reference frames. No particular space-time transformations are adopted in this theory, except Galilean transformations. As a consequence, all the relevant physical quantities or phenomena remain unchanged when observed in different reference frames, as expected intuitively. In spite of the restriction on reference frame, the wave equation leads to a wide variety of consequences which are in accord with experiments. In some cases, the physical quantities or relations derived from the wave equation can be independent of the velocity of the laboratory frame, particularly for quasi-static case. Thus the quantum electromagnetics can be in accord with the principle of relativity in conjunction with Galilean transformations.

In Chapter 1, the local-ether model of wave propagation is proposed, from which the unique reference frame of the presented wave equation is determined. Then, in order to comply with the local-ether model and Galilean transformations, we present a new classical force law which leads to modifications of the Lorentz force law and of Maxwell's equations, as discussed in Chapters 2 and 3. In Chapters 4 and 5 it is shown that the local-ether wave equation leads to a unified quantum theory of the electromagnetic and the gravitational forces along with the identity of inertial and gravitational mass. Furthermore, it is shown in Chapters 6–8 that the local-ether wave equation leads to the speed-dependent mass of particle, the speed-dependent angular frequency and wavelength of matter wave, and to the speed-dependent quantum energy of the matter wave bounded in atom. The consequences of these speed-dependences are in accord with various experiments.

2. Local-Ether Model of Wave Propagation

In Chapter 1, it is proposed that electromagnetic wave can be viewed as to propagate via a medium like the ether. However, the ether is not universal. Specifically, it is proposed that in the region under sufficient influence of the gravity due to the Earth, the Sun, or another celestial body, there forms a local ether which in turn is stationary with respect to the gravitational potential of the respective body [2]. Thus each local ether together with the gravitational potential moves with the associated celestial body. Each individual local ether is finite in extent and may be wholly immersed in another local ether of larger extent. Thus the local ethers may form a multiple-level hierarchy. For earthbound wave, the medium is the earth local ether which is stationary in an ECI (earth-centered inertial) frame, while the sun local ether for interplanetary wave is stationary in a heliocentric inertial frame. Consequently, for a geostationary observer, an earthbound wave depends on earth's rotation but is entirely independent of earth's orbital motion around the Sun or whatever, while an interplanetary wave depends on the orbital motion around the Sun as well as on the rotation.

This local-ether model has been adopted to account for the effects of earth's motions in a wide variety of propagation phenomena, particularly the Sagnac pseudorange correction in GPS (global positioning system), the time comparison by intercontinental microwave link, and the echo time in interplanetary radar. As examined within the present accuracy, the local-ether model is still in accord with the Michelson-Morley experiment which is known to make the classical ether notion obsolete. Moreover, this local-ether model is in accord with the Sagnac effect in loop interferometer, the constancy of speed of light from binary stars, synchrotron electrons, and from semistable particles, the spatial isotropy in the one-way fiber-link experiment, the Kennedy-Thorndike experiment, and in the cavity heterodyne experiment, the Doppler effect in GPS, stellar frequency shift, Roemer's observations, and in earthbound radar, and with the dipole anisotropy in CMBR (cosmic microwave background radiation). Meanwhile, the one-way-link rotor experiment is proposed to test the local-ether propagation model [2, 3].

Further, the matter wave associated with a particle is supposed to follow the local-ether propagation model and then be governed by a wave equation. Quantitatively, it is postulated that the matter wave Ψ of a particle is governed by the nonhomogeneous wave equation proposed to be

$$\left\{\nabla^2 - \frac{\partial^2}{\partial t^2}\right\}\Psi(\mathbf{r},t) = \frac{\omega_0^2}{c^2}\Psi(\mathbf{r},t), \tag{1}$$

where the position vector $\mathbf{r}$ and the time derivative are referred uniquely to the associated local-ether frame, c is the speed of light, and the natural angular frequency ω_0 is supposed to be an inherent constant of the particle represented by wavefunction

Ψ. This wave equation looks like the Klein-Gordan equation, except the reference frame. If the natural frequency is zero, the equation reduces to the homogeneous electromagnetic wave equation in free space. As a consequence, it implies that the propagation of electromagnetic wave is referred to this specific reference frame.

3. Classical Theory of Local-Ether Electromagnetics

In Chapter 2, we present the electromagnetic force law based on the augmented potentials, which are derived from the electric scalar potential by incorporating a velocity difference between the effector and the source particles. Under the common low-speed condition, where the source particles forming the current drift very slowly in a neutralizing matrix, the local-ether model reduces to a modified form of the Lorentz force law in terms of the potentials. That is [4],

$$\mathbf{F}(\mathbf{r},t) = q\left\{-\nabla\Phi(\mathbf{r},t) - \left(\frac{\partial}{\partial t}\mathbf{A}(\mathbf{r},t)\right)_m + \mathbf{v}_{em}\times\nabla\times\mathbf{A}(\mathbf{r},t)\right\}, \qquad (2)$$

where the electric scalar potential Φ and the magnetic vector potential $\mathbf{A}$ are associated with the net charge density ρ_n and the neutralized current density $\mathbf{J}_n$, respectively. The fundamental modifications are that the current density generating the vector potential, the time derivative applied to this potential in the electric force, and the effector velocity connecting to the curl of this potential in the magnetic force are all referred specifically to the matrix frame and that the propagation velocity of the potentials is referred to the local-ether frame. It is pointed out that this local-ether model is identical to the Lorentz force law, if the latter is observed in the matrix frame as done tacitly in common practice.

Based on the local-ether model of wave propagation and the corresponding electromagnetic force law, the wave equations of potentials, the continuity equation, and the Lorentz gauge are reexamined in Chapter 3. Then the divergence and the curl relations of electric and magnetic fields are derived. These relations present modifications of Maxwell's equations. That is [5],

$$\left\{\begin{array}{rcll}
\nabla\cdot\mathbf{E}(\mathbf{r},t) &=& \dfrac{1}{\epsilon_0}\rho_n(\mathbf{r},t) & (3a)\\
\nabla\times\mathbf{E}(\mathbf{r},t) &=& -\left(\dfrac{\partial}{\partial t}\mathbf{B}(\mathbf{r},t)\right)_m & (3b)\\
\nabla\cdot\mathbf{B}(\mathbf{r},t) &=& 0 & (3c)\\
\nabla\times\mathbf{B}(\mathbf{r},t) &=& \mu_0\mathbf{J}_n(\mathbf{r},t) + \dfrac{1}{c^2}\left(\dfrac{\partial}{\partial t}\mathbf{E}(\mathbf{r},t)\right)_m . & (3d)
\end{array}\right.$$

The fundamental modifications are that the time derivatives in the two curl relations and the neutralized current density are all referred to the matrix frame. Ordinarily, the consequences due to the modifications are negligibly small. Further, from the wave equations of potentials, the local-ether wave equations of fields are derived. It is found that the wave equation of electric field is in accord with some precision interference experiments, including the one-way-link experiment with a geostationary fiber, the Sagnac rotating-loop experiment with a comoving or geostationary dielectric medium, and Fizeau's experiment with a moving dielectric medium in a geostationary interferometer.

4. Quantum Theory of Electromagnetic and Gravitational Forces

In Chapter 4, the local-ether wave equation is proposed to incorporate the electric scalar potential which in turn connects to the augmentation operator. Quantitatively, it is postulated that the matter wave Ψ of a particle of natural frequency ω_0 and charge q is governed by the nonhomogeneous wave equation proposed to be [6, 7]

$$\left\{\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right\}\Psi(\mathbf{r},t) = \frac{\omega_0^2}{c^2}\left\{1 + 2\frac{q\Phi}{\hbar\omega_0}(1+U)\right\}\Psi(\mathbf{r},t), \quad (4)$$

where the augmentation operator is given by $U = \{(-ic/\omega_0)\nabla - \mathbf{v}_s/c\}^2/2$. This operator is derived from the Laplacian operator by incorporating the source velocity $\mathbf{v}_s$ in the local-ether frame and tends to enhance the effect of the electric scalar potential. For a harmonic-like wavefunction, a first-order time evolution equation can be derived from the wave equation. For an effector moving slowly with respect to the local-ether frame, the evolution equation becomes

$$i\hbar\frac{\partial}{\partial t}\psi(\mathbf{r},t) = \frac{1}{2m_0}\mathbf{p}^2\psi(\mathbf{r},t) + q\Phi(\mathbf{r},t)\left\{1 + \frac{(\mathbf{p}-m_0\mathbf{v}_s)^2}{2m_0^2c^2}\right\}\psi(\mathbf{r},t), \quad (5)$$

where $\mathbf{p}$ $(= -i\hbar\nabla)$ is the momentum operator and the rest mass is related to the natural frequency as $m_0 = \hbar\omega_0/c^2$. This evolution equation presents modifications of Schrödinger's equation. The fundamental modification is that the time derivative is referred specifically to the local-ether frame. Furthermore, the vector potential in Schrödinger's equation does not appear in the evolution equation and its effect is implied in the augmentation operator connected to the electric scalar potential. By following the procedure in deriving Ehrenfest's theorem in quantum mechanics, this modified equation leads to the local-ether electromagnetic force law based on the augmented potentials proposed in Chapter 2. Furthermore, it is found that the inertial mass of a charged particle under the influence of the electromagnetic force originates from the natural frequency and hence from the temporal variation of the associated matter wave.

Under the influence of the gravitational potential due to a celestial body, it is supposed that the d'Alembertian operator of the wave equation is modified. Quantitatively, it is postulated in Chapter 5 that under the influence of the gravitational potential Φ_g and the electric scalar potential Φ, the local-ether wave equation becomes

$$\left\{\frac{1}{n_g}\nabla^2 - \frac{n_g}{c^2}\frac{\partial^2}{\partial t^2}\right\}\Psi(\mathbf{r},t) = \frac{\omega_0^2}{c^2}\left\{1 + 2\frac{q\Phi}{\hbar\omega_0}\right\}\Psi(\mathbf{r},t), \quad (6)$$

where the augmentation operator is neglected for simplicity and the gravitational index n_g is given in terms of the gravitational potential as $n_g(\mathbf{r}) = 1 + 2\Phi_g(\mathbf{r})/c^2$. Again, the position vectors, time derivative, and the potentials involved in the wave equation are referred to their respective reference frames. From this wave equation, a time evolution equation similar to Schrödinger's equation is also derived. Then the electrostatic and the gravitational forces can be derived. That is [7],

$$\mathbf{F} = -q\nabla\Phi + m_0\nabla\Phi_g. \quad (7)$$

Another important consequence is that the gravitational mass associated with the gravitational force as well as the inertial mass is identical to the natural frequency, aside from a common scaling factor. Thereby, the local-ether wave equation leads to a unified quantum theory of electromagnetic and gravitational forces in conjunction with the identity of inertial and gravitational mass.

Furthermore, for electromagnetic wave with a zero natural frequency, the wave equation leads to the deflection of light by the Sun and the increment of echo time in interplanetary radar [8]. For a particle bounded in atom, the gravitational potential is found to cause a decrease in the energy of each quantum state of the matter wave. The corresponding gravitation-dependence of the transition frequency is in accord with the gravitational redshift demonstrated in the Pound-Rebka experiment. Thereby, alternative interpretations of the evidences supporting the general theory of relativity are provided. However, the derived gravitational redshift origins from a quantum nature of matter wave bounded in the involved atom.

5. Quantum Theory of Speed-Dependent Mass and Wave Properties

In Chapters 6–8, the speed-dependent properties of matter wave of free or bounded particles are explored, with the restriction on the particle speed being removed. By using the dispersion of matter wave and by evaluating the particle velocity from the first-order time evolution equation derived from the wave equation, the speed-dependent angular frequency ω and propagation constant k of matter wave are derived in Chapter 6. That is, $\hbar\omega = mc^2$ and $\hbar k = mv$, where the speed-dependent mass is given by

$$m = m_0 \frac{1}{\sqrt{1 - v^2/c^2}}, \tag{8}$$

where the particles speed v is referred specifically to the local-ether frame. These formulas look like the postulates of de Broglie and the Lorentz mass-variation law, except the reference frame. By using this mass and Galilean transformations, the time evolution equation becomes a form similar to Schrödinger's equation with the time derivative being multiplied by the mass-variation factor. That is [9],

$$i\hbar \frac{m}{m_0} \frac{\partial}{\partial t} \psi(\mathbf{r}, t) = -\frac{\hbar^2}{2m_0} \nabla^2 \psi(\mathbf{r}, t) + q\Phi(\mathbf{r})\psi(\mathbf{r}, t), \tag{9}$$

where the position vector $\mathbf{r}$ and hence the time derivative are referred to the atom frame, instead of the local-ether frame. Thereby, the energy of each quantum state in a moving atom is lowered by this factor. When the gravitational redshift is also taken into account, the transition frequency between two quantum states decreases as

$$f = f_0 \sqrt{1 - v^2/c^2} (1 - \Phi_g/c^2), \tag{10}$$

where v is the speed of atom with respect to the local-ether frame and f_0 is the rest transition frequency of the atom when it is stationary and at a zero gravitational potential. The speed- and the gravitation-dependent frequency shifts derived from the local-ether wave equation are identical to those based on the special and the general relativity, respectively, except the reference frame of atom velocity. The atomic clock rate is linearly proportional to the transition frequency. It is shown that the local-ether model is in accord with the east-west directional anisotropy and the clock-rate difference observed in the Hafele-Keating experiment with circumnavigation atomic clocks, the synchronism and the clock-rate adjustment in GPS, and with the spatial isotropy associated with frequency stability in the Hughes-Drever experiment. The frequency shift in earthbound and interplanetary spacecraft microwave links is also discussed. Meanwhile, the local-ether wave equation predicts a constant deviation in frequency shift from the calculated result reported in an interplanetary spacecraft link, which provides a means to test its validity [9].

In Chapter 7, we present the resonant absorption between moving atoms by taking the frequency shift due to the Doppler effect of electromagnetic wave and that due to the quantum effect of matter wave into accounted. A variety of phenomena associated both with electromagnetic and matter waves are accounted for, including the Ives-Stilwell experiment, the TPA (two-photon absorption) heterodyne experiment, the output frequency from ammonia maser, and the Mössbauer rotor experiment, which are commonly ascribed to consequences of the special relativity.

Finally, based on the speed-dependent matter wavelength, the interference between matter waves of two coherent particle beams is explored in Chapter 8. It is shown that the local-ether propagation model is in accord with the electron-wave interference experiments of the Bragg reflection in the Davisson-Germer experiment, of the double-slit diffraction, and of the Sagnac effect, as examined within the present precision. Moreover, it accounts for the neutron-wave interference due to earth's rotation and gravity. Meanwhile, the local-ether wave equation predicts a directional anisotropy in the Bragg angle in neutron diffraction due to earth's rotation, which provides a means to test its validity.

6. Summary

The theory of *Quantum Electromagnetics* is based on a local-ether wave equation which unifies quantum mechanics, electromagnetics, and gravitation and accounts for a wide variety of experiments. This wave equation incorporates a natural frequency and the electric scalar potential and leads to the speed-dependences in mass of particle, in wavelength and frequency of matter wave of free particle, and in energy of quantum state of matter wave of particle bounded in atom. By connecting the electric scalar potential to the augmentation operator derived from the Laplacian operator by incorporating the velocity of the source particle, a first-order time evolution equation is derived, which presents modifications of Schrödinger's equation. From this modified equation, electromagnetic force law is derived, which presents modifications of the Lorentz force law. From the modified force law, relations between electric and magnetic fields are derived, which present modifications of Maxwell's equations. Furthermore, by modifying the d'Alembertian operator of the wave equation with a gravitational potential, the gravity is derived. Thereby, the wave equation presents a unified quantum theory of gravitational and electromagnetic forces in conjunction with the identity of gravitational and inertial mass. The ground work of this wave equation is that both electromagnetic and matter waves are proposed to propagate according to the local-ether model. That is, wave propagates in a medium like the ether. However, the ether is not universal. It is supposed that in the region under sufficient influence of the gravity due to the Earth, the Sun, or another celestial body, there forms a local ether which in turn moves with the gravitational potential of the respective body.

Consequently, in this local-ether wave equation all the involved physical quantities of position vectors, time derivatives, propagation velocity, particle velocities, and current density are referred specifically to their respective reference frames and hence remain unchanged in different frames. In spite of such a restriction on reference frame, the consequences of this new-classical theory are in accord with a wide variety of experiments, including the Sagnac effect in GPS, in the intercontinental microwave link, and in interferometry, the round-trip Sagnac effect in the interplanetary radar, the apparently null effect in the Michelson-Morley experiment, the constancy of speed of light radiated from a moving source, the spatial isotropy with phase stability in the Kennedy-Thorndike experiment and the one-way fiber-link experiment, the Doppler shift in Roemer's observations and CMBR, the effects of a moving medium in Fizeau's experiment and the Sagnac loop experiment, the light deflection by the Sun, the gravitational effect on the interplanetary radar echo time, the gravitational redshift in the Pound-Rebka experiment, the speed- and gravitation-dependent atomic clock rate in GPS, in the Hafele-Keating experiment, and in spacecraft microwave links, the spatial isotropy with frequency stability in the Hughes-Drever experiment, the resonance-absorption in the Ives-Stilwell experiment, in the TPA heterodyne experiment, in the output frequency from ammonia maser, and in the Mössbauer rotor experiment, the matter wavelength in the Davisson-Germer experiment and the double-slit diffraction, the matter-wave Sagnac effect, and the effects of earth's rotation and gravity in the neutron-wave interference. Meanwhile, this theory leads to some predictions, particularly associated with earth's motion, which can provide different approaches to test the validity of the local-ether wave equation.

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