

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

Ching-Chuan Su  
Department of Electrical Engineering  
National Tsinghua University  
Hsinchu, Taiwan

**Abstract** – The theory of *Quantum Electromagnetics* presents a wave equation which is constructed, in compliance with Galilean transformations, for electromagnetic and matter waves. A fundamental feature entirely different from the principle of relativity is that the wave equation is referred specifically to the proposed local-ether frame. For electromagnetic wave, the local-ether wave equation accounts for a wide variety of experiments on propagation and interference. For matter wave, the wave equation leads to modifications of Schrödinger’s equation which in turn lead to a unified quantum theory of electromagnetic and gravitational forces in conjunction with the origin and the identity of inertial and gravitational mass. Further, it leads to modifications of the Lorentz force law and of Maxwell’s equations. Moreover, the wave equation leads to the dispersion of matter wave, from which the speed-dependence in the mass of a particle and in the wavelength, angular frequency, and quantum energy of a matter wave can be derived. The consequences of the wave equation are in accord with a wide variety of experiments that are commonly ascribed to the special relativity, the general relativity, the Lorentz mass-variation law, or to the de Broglie matter wave. Thereby, the local-ether wave equation unifies quantum mechanics, electromagnetics, and gravitation.

## 1. Introduction

It is known that Maxwell’s equations and the Lorentz force law can be shown to be in accord with the principle of relativity by resorting to the Lorentz transformation. Meanwhile, it is noticed that the magnetic force observed in ordinary experiments is actually due to the conduction current rather than the convection current. Unlike the convection current, the conduction current is electrically neutralized, such as the familiar one formed by the mobile electrons embedded in the positive ions in a metal wire. For such a neutralized current, it is the drift speed of the mobile charged particles with respect to the neutralizing matrix that determines the current. Consequently, the current density in Ampère’s law complies with the principle of relativity simply based on Galilean transformations. Further, the drift speed is quite low ordinarily. If the magnetic force is associated with the squared velocity difference between the involved particles, then, as well as the drift speed, the particle velocity in the Lorentz force law can be referred specifically to the neutralizing matrix. Thus at least some of the major motivations for introducing the Lorentz transformation can be accounted for from an entirely different approach.

The theory of *Quantum Electromagnetics* presents a wave equation which is constructed, in compliance with Galilean transformations, for electromagnetic and matter waves [1]. A feature different from the principle of relativity is that all the physical

quantities of the position vectors, time derivatives, propagation velocity, particle velocities, and current density involved in this brand-new theory are referred specifically to their respective frames. 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 frames, the wave equation leads to a spate of consequences which are in accord with a wide variety of 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 cases. Thus the presented theory can be in accord with the principle of relativity in conjunction with Galilean transformations.

First of all, the local-ether model of wave propagation is proposed in Chapter 1, from which the unique reference frame of the presented wave equation is determined. Then, in order to comply with Galilean transformations and the local-ether model, 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. Further, it is shown in Chapters 4 and 5 that the local-ether wave equation leads to a unified quantum theory of electromagnetic and gravitational forces along with the identity of inertial and gravitational mass. Moreover, it is shown in Chapters 6–8 that the local-ether wave equation leads to the speed-dependences in the mass of a particle, in the angular frequency and wavelength of a matter wave, and in the quantum energy of the matter wave bound in an atom.

## 2. Local-Ether Model of Wave Propagation

In Chapter 1 it is proposed that electromagnetic wave can be viewed as propagating 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 gravitation 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 waves, the medium is the earth local ether which is stationary in an earth-centered inertial frame, while the sun local ether for interplanetary waves is stationary in a heliocentric inertial frame. Consequently, the propagation of earthbound waves can depend on earth's rotation but is entirely independent of earth's orbital motion around the Sun or whatever, while the propagation of interplanetary waves 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 the global positioning system (GPS), the time comparison via the intercontinental microwave link, and the echo time in the interplanetary radar. As examined within the present precision, 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 interferometers; the constancy of the speed of light with binary stars, synchrotron electrons, and with semistable particles; the spatial isotropy in the Kennedy-Thorndike experiment, the cavity heterodyne experiment, and in the one-way fiber-link experiment; the Doppler effect in GPS, the stellar frequency shift, Roemer's observations,

and in the earthbound radar; and with the dipole anisotropy in the cosmic microwave background radiation. Meanwhile, the one-way-link rotor experiment is proposed to test the local-ether propagation model [2, 3].

Further, matter wave associated with particles is supposed to follow the local-ether propagation model and then be governed by a wave equation. Quantitatively, it is postulated that a particle is represented by a matter wave  $\Psi$ , which in turn is governed by the nonhomogeneous wave equation proposed to be

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

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 frequency  $\omega_0$  is supposed to be an inherent constant of the particle represented by the wavefunction  $\Psi$ . This wave equation looks like the Klein-Gordan equation for free particles, except the reference frame. If the natural frequency is zero, the equation reduces to the homogeneous wave equation for electromagnetic wave in free space. As a consequence, it implies that the propagation speed of electromagnetic wave is  $c$  when referred to the specific frame.

### 3. Classical Theory of Local-Ether Electromagnetics

Under the influence of the electric scalar potential, the local-ether wave equation presented in the following section leads to an electromagnetic force law in terms of the augmented potentials  $\check{\Phi}$  and  $\check{\mathbf{A}}$ , which in turn are derived from the electric scalar potential by incorporating a velocity difference between the effector and the source particles. That is, the electromagnetic force exerted on an effector particle of charge  $q$  is given by  $\mathbf{F} = q\{-\nabla\check{\Phi} - (\partial\check{\mathbf{A}}/\partial t)_e\}$ , where the time derivative is referred specifically to the effector frame in which the effector is stationary. In Chapter 2 this force law is taken as a postulate. Then it can be shown that under the common low-speed condition, where the source particles forming the conduction current drift very slowly in a neutralizing matrix (such as electrons in a metal wire), the force law reduces to [4]

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

where the electric scalar potential  $\Phi$  is due to the net charge density  $\rho_n$  and the magnetic vector potential  $\mathbf{A}$  is due to the neutralized current density  $\mathbf{J}_n$  which in turn is related to the source charge density by  $\mathbf{J}_n = \mathbf{v}_{sm}\rho_v$ . This equation represents modifications of the Lorentz force law. The fundamental modifications are that the source velocity  $\mathbf{v}_{sm}$  associated with the current density  $\mathbf{J}_n$  generating the vector potential, the time derivative of this potential in the electric induction force, and the effector velocity  $\mathbf{v}_{em}$  connecting to the curl of this potential in the magnetic force are all referred specifically to the matrix frame in which the matrix is stationary, and that the propagation velocity of the potentials is referred specifically to the local-ether frame. Thus the electromagnetic force remains unchanged in different frames in uniform motion of translation, as expected intuitively. It is pointed out that this new classical 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 for the potentials, the continuity equation, and the Lorenz gauge are reexamined in Chapter 3. Then the divergence and curl relations for the electric and magnetic fields are derived. These relations read [5]

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

apart from some deviation terms which are relatively small. This set of relations represent modifications of Maxwell's equations, which comply with Galilean transformations and the local-ether propagation model. The fundamental modifications are that the time derivatives in the two curl relations and the neutralized current density are all referred specifically to the matrix frame. Further, from the wave equations for the potentials, the local-ether wave equations for the fields are derived. Then the phase speed of electromagnetic wave in a moving medium is derived. Thereby, it is found that the wave equation for the electric field is in accord with several precision interference experiments, including the one-way-link experiment with a geostationary fiber, the Sagnac rotating-loop experiments with a comoving or a geostationary dielectric medium, and Fizeau's experiment with a moving dielectric medium in a geostationary interferometer [6].

## 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 with the augmentation operator. Quantitatively, it is postulated that the matter wave  $\Psi$  of a particle of natural frequency  $\omega_0$  and charge  $q$  is governed by the nonhomogeneous wave equation proposed to be [7, 8]

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

where the augmentation operator is given by  $U = \{(-ic/\omega_0)\nabla - \mathbf{v}_s/c\}^2/2$ . This operator is derived from the Laplace operator by incorporating the source velocity  $\mathbf{v}_s$  in the local-ether frame, and tends to enhance the effects of the electric scalar potential and the Laplace operator. 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

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

where the reduced wavefunction  $\psi$  is related to the wavefunction  $\Psi$  by  $\Psi(\mathbf{r}, t) = \psi(\mathbf{r}, t)e^{-i\omega_0 t}$ , the momentum operator  $\mathbf{p} = -i\hbar\nabla$ , and the rest mass is related to the natural frequency by  $m_0 = \hbar\omega_0/c^2$ . This evolution equation represents 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 effects are implied in the augmentation operator connected with 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 earlier. 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 wavefunction  $\Psi$ .

In the presence of the gravitational potential due to a celestial body, it is supposed that the d'Alembert operator in the wave equation needs a refinement. Quantitatively, it is postulated in Chapter 5 that under the influence of the gravitational potential  $\Phi_g$  and the electric scalar potential  $\Phi$ , the local-ether wave equation takes the form

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

where the gravitational index  $n_g$  is given in terms of the gravitational potential by  $n_g(\mathbf{r}) = 1 + 2\Phi_g(\mathbf{r})/c^2$ . Again, from this wave equation, a time evolution equation similar to Schrödinger's equation can be derived. Then the electrostatic and the gravitational force can be derived in a quantum-mechanical way [9]. That is,

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

where the effects of the augmentation operator are omitted for simplicity. 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 origin and the identity of inertial and gravitational mass.

For an electron bound in an atom, it is found that the gravitational potential causes a proportional decrease in the energy of each quantum state of the matter wave. The corresponding gravitation-dependence of the transition frequency between two quantum states (to be given in the following section) is in accord with the gravitational redshift demonstrated in the Pound-Rebka experiment. Moreover, 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 the interplanetary radar [10]. Thereby, alternative interpretations of the evidence supporting the general theory of relativity are provided. However, a discrepancy is that the derived gravitational redshift originates from a quantum nature of the matter wave bound 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 and bound 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  $\omega$  and propagation vector  $\mathbf{k}$  of a matter wave are derived in Chapter 6. That is,  $\hbar\omega = mc^2$  and  $\hbar\mathbf{k} = m\mathbf{v}$ , where the speed-dependent mass is given by

$$m = m_0 \frac{1}{\sqrt{1 - v^2/c^2}} \quad (8)$$

and the particle velocity  $\mathbf{v}$  is referred specifically to the local-ether frame. These formulas are identical to 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 for an electron bound in a moving atom becomes a form similar to Schrödinger's equation with the time derivative being multiplied by the mass-variation factor [11]. That is,

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

where the position vector  $\mathbf{r}$  and hence the time derivative are referred to the atom frame in which the nucleus of the atom is stationary. 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

$$f = f_0(1 - v^2/2c^2 - \Phi_g/c^2), \quad (10)$$

where  $v$  is the atom speed 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-induced frequency shift 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 the atom velocity. As the atomic clock rate is determined by the transition frequency, it is pointed out that the local-ether model is actually in accord with the east-west directional anisotropy and the clock-rate difference observed in the Hafele-Keating experiment with circumnavigation atomic clocks, with 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 shifts in an earthbound and an interplanetary spacecraft microwave links are also discussed. Meanwhile, by virtue of a discrepancy in the reference frame chosen for the clock at the ground station in an interplanetary microwave link, the local-ether wave equation predicts a constant deviation in frequency shift from the calculated result reported in the literature, which provides a means to test its validity [11].

In Chapter 7 we present the resonant-absorption condition between moving atoms, by taking both the Doppler frequency shift for electromagnetic wave and the quantum energy variation of matter wave into account. Several phenomena associated with both electromagnetic and matter waves are accounted for, including the Ives-Stilwell experiment with fast-moving hydrogen atoms, the output frequency from ammonia masers, and the Mössbauer rotor experiment [12].

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 elucidated that the local-ether wave equation is in accord with the Davisson-Germer

experiment on the Bragg reflection and with other electron-wave interference experiments on the double-slit diffraction and the Sagnac effect, as examined within the present precision. Moreover, it accounts for the effects of earth's rotation and gravity in the neutron-wave loop interferometry [13, 14]. Meanwhile, the local-ether wave equation predicts an anisotropy in the Bragg angle in neutron diffraction due to earth's rotation, which then provides another 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 leads to the speed-dependent frequency and wavelength of the matter wave of a free particle and to its speed-dependent mass. By incorporating the electric scalar potential, the wave equation leads to the speed-dependent quantum energy of the matter wave of a particle bound in an atom. With the electric scalar potential being connected with the augmentation operator, which is derived from the Laplace operator and the velocity of the source particles, a first-order time evolution equation is derived, which represents modifications of Schrödinger's equation. From this modified equation, an electromagnetic force law is derived, which represents modifications of the Lorentz force law. From the modified force law, relationships among the spatial and temporal derivatives of the electric and magnetic fields are derived, which represent modifications of Maxwell's equations. These modified equations are substantially identical to their counterparts observed in the matrix or atom frame as done tacitly in common practice. Furthermore, by refining the d'Alembert operator in the wave equation with a gravitational potential, the gravitational force is also derived. Thereby, the wave equation leads to a unified quantum theory of gravitational and electromagnetic forces in conjunction with the wave-motion origin and the identity of gravitational and inertial mass.

The groundwork of this wave equation is that both electromagnetic and matter waves are proposed to propagate according to the local-ether model. That is, the wave propagates via a medium like the ether. However, the ether is not universal. It is supposed that in the region under a sufficient influence of the gravitation due to the Earth, the Sun, or another celestial body, there forms a local ether which in turn comoves with the gravitational potential of the respective body. In this local-ether theory all the involved physical quantities of the position vectors, time derivatives, propagation velocity, particle velocities, and current density are referred specifically to their respective frames and hence remain unchanged in different frames under Galilean transformations.

In spite of such a restriction on reference frames, the consequences of this brand-new theory account for a spate of experiments associated with the propagation or interference of electromagnetic wave, and are in accord with a wide variety of experiments commonly ascribed to the special relativity, the general relativity, the Lorentz mass-variation law, or to the de Broglie matter wave. These experiments demonstrate various phenomena, including the Sagnac effect in the global positioning system (GPS), the intercontinental microwave link, the rotating-loop interferometer, and in the Michelson-Gale experiment; the round-trip Sagnac effect in the interplanetary radar; the apparently null effect in the Michelson-Morley experiment; the constancy of the speed of light with a moving source; the spatial isotropy with phase stability in the Kennedy-Thorndike experiment and the one-way fiber-link experiment; the Doppler

effects and spatial anisotropy in Roemer's observations and the cosmic microwave background radiation; the effects of the moving medium in Fizeau's experiment and the Sagnac loop interferometry; the gravitational deflection of light by the Sun; the gravitational effect on the interplanetary radar echo time; the gravitational redshift in the Pound-Rebka experiment; the gravitation- and speed-dependent atomic clock rate in GPS, the Hafele-Keating experiment, and in the spacecraft microwave links; the spatial isotropy with frequency stability in the Hughes-Drever experiment and the cavity heterodyne experiment; the resonant absorption in the Ives-Stilwell experiment, the ammonia-maser experiment, and in the Mössbauer rotor experiment; the matter-wave Bragg reflection in the Davisson-Germer experiment; the matter-wave Sagnac effect; and the effects of earth's rotation and gravity in the neutron-wave loop interferometry. Moreover, in spite of the restriction on reference frames, many consequences of the local-ether wave equation can comply with Galilean relativity, including the magnetic force, the electric induction, the propagation and interference of electromagnetic wave, the interference of matter wave, the quantum effect in an atom, and the resonant absorption between atoms.

Meanwhile, this theory leads to some predictions, particularly those with the effects of earth's motions. Based on the round-trip Sagnac effect due to earth's rotation, we predict a quadrupole anisotropy in phase difference in the Michelson-Morley experiment and a like one in beat frequency in the cavity heterodyne experiment. Further, based on the one-way Sagnac effect due to earth's rotation, we propose the one-way-link rotor experiment, in which a strong first-order terrestrial anisotropy in phase variation is predicted. Moreover, in the radar tracking of low-earth-orbit satellites, a transverse Doppler shift is predicted; in the magnetic deflection an effect of the relative motion between the deflection yokes and the accelerating electrodes is predicted; in the Sagnac loop interferometry, various index-dependences among the phase-difference terms associated with the rotation rates of the Earth and the loop are predicted; in the interaction of atoms with electromagnetic radiation, a stronger second-order effect is predicted; in the gravitational redshift the quantum origin and the transition-dependence are predicted; in the stellar spectrum a gravitation-induced downshift depending on the mass of the star is predicted; in the interplanetary spacecraft microwave link, a constant deviation in frequency shift associated with the role of earth's orbital motion for the clock at the ground station is predicted; and in the neutron diffraction a terrestrial anisotropy in matter wavelength and the Bragg angle due to earth's rotation is predicted. These various predictions then provide different approaches to test the validity of the local-ether wave equation.

## References

- [1] C.C. Su, *Quantum Electromagnetics* (<http://qem.ee.nthu.edu.tw>).
- [2] C.C. Su, "A local-ether model of propagation of electromagnetic wave," *Eur. Phys. J. C*, vol. 21, pp. 701–715, July 2001.
- [3] C.C. Su, "Reinterpretation of the Michelson-Morley experiment based on the GPS Sagnac correction," *Europhys. Lett.*, vol. 56, pp. 170–174, Oct. 2001.
- [4] C.C. Su, "Modifications of the Lorentz force law complying with Galilean transformations and the local-ether propagation model," <http://arXiv.org/physics/0211019>.

- [5] C.C. Su, “Modifications of Maxwell’s equations invariant under Galilean transformations,” in *IEEE Antennas Propagat. Soc. Int. Symp. Dig.*, July 2001, vol. 1, pp. 212–215.
- [6] C.C. Su, “Reinterpretation of Fizeau’s experiment with moving medium in accord with the Sagnac effect due to earth’s rotation,” *J. Electromagnetic Waves Applicat.*, vol. 19, pp. 559–567, Apr. 2005.
- [7] C.C. Su, “A local-ether wave equation and the consequent electromagnetic force law,” *J. Electromagnetic Waves Applicat.*, vol. 16, pp. 1275–1290, Sept. 2002.
- [8] C.C. Su, “Modifications of Schrödinger’s equation complying with the effect of earth’s rotation on quantum energy in atoms and with the electromagnetic force,” <http://arXiv.org/physics/0208083>.
- [9] C.C. Su, “A local-ether wave equation unifying gravitational and electromagnetic forces,” *J. Electromagnetic Waves Applicat.*, vol. 16, pp. 403–410, Mar. 2002.
- [10] C.C. Su, “A wave-propagation model for gravitational effects on light deflection and radar echo time,” *J. Electromagnetic Waves Applicat.*, vol. 15, pp. 259–268, Feb. 2001.
- [11] C.C. Su, “A local-ether wave equation and speed-dependent mass and quantum energy,” *Eur. Phys. J. B*, vol. 24, pp. 231–239, Nov. 2001.
- [12] C.C. Su, “Resonant absorption between moving atoms due to Doppler frequency shift and quantum energy variation,” <http://arXiv.org/physics/0208084>.
- [13] C.C. Su, “Reinterpretation of matter-wave interference experiments based on the local-ether wave equation,” <http://arXiv.org/physics/0208085>.
- [14] C.C. Su, “Reinterpretation of the effects of earth’s rotation and gravity on the neutron-interferometry experiment,” *Europhys. Lett.*, vol. 60, pp. 1–6, Oct. 2002.