Gravity between Internally Electrodynamic Particles

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Abstract. We present a first-principles’ prediction that two charged particles of masses $M_1$ and $M_2$ separated $R$ apart in a dielectric vacuum act on each other always an attractive force in addition to other known forces in between. This component attractive force on one charge results as the Lorentz force in the radiation depolarization- and magnetic- fields of the other charge, being an attractive radiation force, and is in addition to the ordinary repulsive radiation force. The exact solution for the attractive radiation force is $F_g = G M_1 M_2 / R^2$, an identical formula to Newton’s law of gravitation. $G = X_0 \epsilon^4 / 4 \pi \epsilon_0^2 \rho l$ is identifiable with Newton’s gravitational constant, $X_0$- being the susceptibility and $\rho l$ the linear mass density of the vacuum, and the remaining fundamental constants of the usual meaning. The $F_g$ force is conveyed by a transverse vacuuonic dipole-moment wave traveling at the velocity of light and can penetrate matter freely. In all of respects, the $F_g$ force represents a viable cause of Newton’s universal gravity.$^\dagger$

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$^\dagger$ This edition mainly contains update of certain terminology in current use. A more comprehensive treatment of the gravity of IED particle is in preparation. JXZJ, Feb, 2010.
Since Sir. Isaac Newton discovered in 1986 gravity described by an inverse square law, the cause of this feeble but ubiquitous fundamental force between all bodies has remained a subject of many studies. The cause of gravity has remained as an open question to date. One of us (JXZJ) recently, based on overall experimental information, developed an internally electrodynamic (IED) particle model (earlier termed a basic-particle formation scheme) along with a model construction of the vacuum. The first-principles’ solutions predict a range of particle properties and their relations, including an attractive radiation force, directly comparable with observations and the established basic laws of physics. In the present paper we elaborate on the solution in detail; we shall show that the solution for the DR force predicts an inverse square formula identical to Newton’s law of gravitation; the proportionality constant is expressed solely by fundamental constants or constants of the medium. As a major extension to the earlier conference paper, in this paper we also present a quantitative determination of the electric susceptibility of vacuum.

Consider two IED model particles, \( i = 1, 2 \) located at \( R_1 = 0 \) and \( R_2 \) along X-axis (FIG. 1); \( R = |R| = |R_2 - R_1| \). The IED particles are each composed of an oscillatory charge \( q_i \) of zero rest-mass and the resulting electromagnetic waves. The charge is at its creation in the vacuum initially endowed with a kinetic energy \( E_{qi} \), and in the potential well due to a dielectric vacuum polarized by the charge’s own field, executes an oscillation. This is about fixed site \( R_i \) assuming \( E_{qi} \) below a threshold value, with an angular frequency \( \Omega_{qi} \) characteristic of \( E_{qi} \) and the charge-vacuum interaction. Given the vacuum has only a single energy level as in observation, \( E_{qi} \) can not be dissipated except in a pair annihilation. The radiation displacement (out of a total that is predominately non-radiative), assuming small, will be effectively sinusoidal, \( u_{qi}(T) = A_{qi} \sin(\Omega_{qi} T) \), with \( A_{qi} \) the amplitude. \( u_{qi}(T) \) has a specified orientation during a finite time, but will vary in a random fashion over long time under the influence of environmental fields. Except in the context of Eq. (7) later, we shall assume \( u_{qi}(T) \) is along the Z-axis for a duration being finite but short compared to the time of measurement of say their interaction forces.

Either charge, say 1, will owing to its oscillation generate electromagnetic waves, being monochromatic for the oscillation about fixed site \( R_1 \). In three dimensions the wave is propagated in radial directions, along radial path \( R(R, \theta, \phi) \) at angles \( \theta \) and \( \phi \) at the Z- and X-axes, see inset (a) of FIG. 1. For the classical radiation in question here, the component radiation electric field \( E_1 \) and magnetic field \( B_1 \) are given by the solutions to Maxwell’s equations, \( E_1(R, \theta, T) = \frac{E_{10}(R, T)}{R} \sin \theta \). Here,

\[
E_{10} = \frac{q_1 \Omega_{1}^2 A_{q1}}{4\pi \varepsilon_0 c^2},
\]

\[
j_1(R, T) = \sin(\Omega_{1} T - K_1 \cdot R + \alpha_1),
\]

\( \varepsilon_0 \) is the permittivity of the vacuum and \( c \) the speed of light; \( \Omega_{1} = \Omega_{qi} \); \( \Omega_{1} \) and \( K_1 = \Omega_{1}/c \) are the normal mode angular frequency and wavevector, and \( \alpha_1 \) is the initial phase. Along the X-axis on which charge 2 lies, \( \theta = \pi/2 \) and \( \phi = 0 \); hence
sin θ = 1, \( \mathbf{K}_1 \cdot \mathbf{R} = K_1 R \), and

\[
\mathbf{E}_1(R, T) = \frac{E_{10} j_1(R, T)}{R} \mathbf{Z}, \quad \mathbf{B}_1(R, T) = -\frac{E_1}{c} \mathbf{Y}.
\]  (3)

In the dielectric vacuum \( E_1(0, T) \equiv E_{q1}(T) \), represents a macroscopic field at \( R = 0 \). This conjures an applied field \( E_{q1^*}(T) \) measured in a space after removal of the vacuum medium, termed our free space. As a generalization [3a,c] of the dielectrics of ordinary materials[4] to a nonpolar dielectric vacuum, relevant to here we can write down these: \( E_{q1^*} \) produces in the vacuum a polarization \( \mathbf{\varphi}_{q1} = \epsilon_0 (E_{q1^*} - E_{q1}) \) with \( E_{q1}(T) = E_{q1^*} / k_0^* \), and thus a depolarization field[3a,c]:

\[
\mathbf{E}_{p,q1}(T) = -\frac{\mathbf{\varphi}_{q1}(T)}{\epsilon_0} = -\chi_0^* \mathbf{E}_{q1}(T).
\]

Here \( \epsilon_0 \) is the permittivity, \( k_0^* \) the dielectric constant and \( \chi_0^* = k_0^* - 1 \) the electric susceptibility of the vacuum, each being measured with respect to the free space. Along the chain of the polarized vacuums, their dipole displacements are mutually coupled as with their center-of-mass motions; so the disturbance \( \mathbf{E}_{p,q1}(T) \) will be propagated as a radiation depolarization field:

\[
\mathbf{E}_{p1}(R, T) = -\chi_0^* \mathbf{E}_1(R, T).
\]  (4)

Assuming \( E_1 \) is relatively small and is real, \( E_{p1}(R, T) \) is therefore linear and is in phase with \( E_1(R, T) \), as shown in FIG. 1. The radiation due to charge 2 can be written down similarly.

The wave variables transform to particle variables as follows. The total electromagnetic wave described by the fields \( E_i, B_i \) above of frequency \( \Omega_i \), has according to M. Planck an energy \( E_i = \hbar \Omega_i \). The wave together with its generating charge, \( i \), makes up our IED particle \( i \). Therefore the wave is here the internal components of particle \( i \). Consequently its energy \( \mathcal{E}_i \) represents the total rest energy of the particle (with its source charge oscillating about fixed site); and this gives in turn the particle’s rest mass \( M_i \) given by \( \mathcal{E}_i = M_i c^2 \) from direct solution for the IED process [3a, g,j]. The two equations of \( \mathcal{E}_i \) give

\[
\Omega_i^2 = M_i^2 c^4 / \hbar^2, \quad i = 1, 2.
\]  (5)

\( \mathcal{E}_i \) is nondissipative as is \( \mathcal{E}_{q_i} \), and it retains with charge \( i \) through wave reflections from surrounding objects. We can describe the electromagnetic waves alternatively as a heuristic technique only here as elastic waves (see a systematic justification and representation given in [3a]), along a chain of coupled vacuonic oscillators of size \( b \) each. The standard solution of classical wave mechanics, [3a,g,h], gives the total wave energy integrated over all directions across a total wave train length \( L_\varphi \), thus \( L_\varphi / b = \frac{c \Delta T}{b} \) oscillators, in time \( \Delta T \), to be

\[
\mathcal{E}_i = \frac{1}{8\pi} c \Delta T \rho_i \Omega_i^2 A_{q_i}^2, \quad i = 1, 2.
\]  (6)
The $E_i$ of (6) and the $E_i = M_i c^2$ earlier together yield

$$\Omega_i^2 A_{qi}^2 = 8 \pi M_i c / \Delta T \rho_1.$$  (7)

Charge 2 is in the $E_{p1}$ field of charge 1 subject to the Coulomb force $F_{p12} = q_2 E_{p1}$. Suppose in time $(T - \Delta T, T + \Delta T)$ particle 2 is driven from at rest into motion of a component velocity $v_{p2}(\Delta T)$. This substituted in Newton’s second law, $F_{p12} = M_2 \frac{\partial v_{p2}}{\partial T}$, gives the equation of motion of particle 2:

$$q_2 E_{p1} = M_2 \frac{\partial v_{p2}}{\partial T},$$

(8)

In the $B_1$ field the moving charge 2 is further acted by a force according to the Lorentz force law:

$$F_{g_{12}}(R, T) = q_2 v_{p2}(R, \Delta T) \times B_1(R, T) = -|q_2 v_{p2} B_1| \hat{X}.$$  (9)

$F_{g_{12}}$ is an attractive radiation force resulting from the radiation depolarization electric field and magnetic field of charge 1, and being antiparallel with the ordinary repulsive radiation force. The direction of $F_{g_{12}}$ is perpendicular to $v_{p2}$ and $B_1$ (the right-hand rule), lying along the $X$-axis. The second expression of (9) holds always valid for $v_{p2} \perp B_1$ here. $v_{p2} \times B_1 < 0$ for $q_2 > 0$; and $v_{p2} \times B_1 > 0$ for $q_2 < 0$ (as in FIG. 1). That is, in either case $F_{g_{12}}$ is pointed toward mass $M_1$, and is an attraction.

Figure 1. Oscillatory charge $q_1$ produces at $R$ a radiation electric and magnetic fields $E_1(R, T)$, $B_1(R, T)$, and in a dielectric vacuum also a radiation depolarization field $E_{p1}(R, T)$. Consequently charge $q_2$ of dynamical mass $M_2(\Omega_2)$ at $R$ is acted the component Coulomb force $q_2 E_{p1}$, driven into motion at a component velocity $v_{p2}$, each along $Z$-axis. $q_2$ is in turn acted by an attractive radiation Lorentz force $F_{g_{12}} = q_2 v_{p2} \times B_1$ in $-X$-direction; $F_{g_{12}}$ points toward $M_1$ and is an attraction always. Similarly (not shown in the plot), charge $q_1$ is acted by an attractive radiation Lorentz force $F_{m_{21}}$ due to the fields of $q_2$. Inset (a) shows a radial wave path $R$ making an angle $\theta$ at the charge oscillation $Z$-axis; (b) shows $E_{p1}$ in relation to the radiation electric field due to $q_1$, $E_1$, measured in free space, and $E_1$ in vacuum.
Gravity between Internally Electrodynamic Particles

Now with (8) for $\mathbf{v}_{\nu 2}$ and (3) for $\mathbf{B}_1$ in (2), we have $F_{g_{12}} = -\frac{(\Delta T) q_1^2 q_2^2 \Omega_{q_1} A_{q_1}^2 j_1^2(R, T)}{(4\pi)^2\epsilon_0 c^3 M_2} \hat{X}$. Further with (3) for $E_1$, this becomes

$$F_{g_{12}}(R, T) = -\frac{(\Delta T) X_0^2 q_1^2 q_2^2 \Omega^2_{q_1} A_{q_1}^2 j_1^2(R, T)}{R^2} \hat{X} \quad (10)$$

As an elementary consideration here we put $q_1, q_2 = \pm e$ or $-e$, with $e$ the elementary charge. With accordingly $e^4$ for $q_1^2 q_2^2$, and in turn (3) for $\Omega_{q_1}^2$, and (7) for $\Omega_{q_1}^4 A_{q_1}^2$ in (a), simplifying algebraically, we have

$$F_{g_{12}}(R, T) = -\frac{2GM_{j_1}^2 j_2^2(R, T)}{M_2 R^2} \hat{X}, \quad (11)$$

where

$$G = \frac{\pi X_0^2 e^4}{\epsilon_0^2 h^2 \rho_1}. \quad (12)$$

Or with $c = 1/\sqrt{\mu_0 \epsilon_0}$, (12) is written as $G = \frac{\pi X_0^2 \mu_0^6 e^4}{h^2 \rho_1}$. We can likewise regard charge 2 as the source and get similarly an always attractive radiation Lorentz force acting on particle 1 due to 2:

$$F_{g_{21}}(R, T) = -F_{g_{12}}(R, T) = \frac{2GM_{j_2}^2 j_1^2(R, T)}{M_1 R^2} \hat{X}, \quad (13)$$

with $j_2(R, T) = \sin(\Omega_2 T + K_2 R + \alpha_2)$ and $\alpha_2$ the initial phase of the EM wave due to charge 2.

As expressed in (9) and (13), for $q_i$ and $q_j (i, j = 1, 2)$ having any signs, and moved to any locations relative to each other, the attractive radiation Lorentz force acting on charge $i$ due to (the radiation fields of) the charge $j$, $F_{g_{ij}}$, is always attractive. An always attractive force $F_{g_{12}}$ follows also from the fact that it has a field $E_{\nu 1}$ always antiparallel with $E_1$ that together with the common $B_1$ produces a repulsive ordinary radiation force.

The dynamical variables $F_{g_{12}}$ and $F_{g_{21}}$ are mutually uncorrelated and statistical, as $\alpha_1$ and $\alpha_2$ are. Their total action as sampled at one time is therefore the geometric mean

$$\tilde{F}_g(R, T) = \sqrt{|F_{g_{12}}(R, T)||F_{g_{21}}(R, T)|} = \frac{2GM_{j_1}^2 j_2^2(R, T)}{R^2} \quad (14)$$

We are furthermore interested in the average of $\tilde{F}_g$ over a macroscopic time comparable with experimental measurement, or practically over the wave periods $\Gamma_1$ and $\Gamma_2$ which suffices for the periodic processes here. This is: $F_g = \langle 1/\Gamma_1 \Gamma_2 \rangle \int_0^{\Gamma_1} dT \int_0^{\Gamma_2} \tilde{F}_g(R, T)dT$; or, $F_g = \frac{2GM_{j_1}^2 j_2^2}{R^2}$ where $I = \langle \frac{1}{\Gamma_1} \int_0^{\Gamma_1} j_1(R, T) dT \rangle^2 = \frac{1}{2}$. Hence

$$F_g = \frac{GM_1 M_2}{R^2}. \quad (15)$$

$F_g$ is always an attractive force given that $F_{g_{12}}, F_{g_{21}}$ and $\tilde{F}_g$ are attractive, and it is described by an inverse square formula (15) identical to Newton’s law of gravitation.
Gravity between Internally Electrodynamic Particles

The precoefficient $G$ is expressed in (12) by solely fundamental constants, $e$, $\epsilon_0$, and $\hbar$, and the constants $X_0^*$ and $\rho_i$ characteristic of the vacuum. $G$ follows therefore to be a constant, in direct resemblance to the universal gravitational constant $G$. Also, it can be readily checked that $G$ given by (12) has a dimension $m^3 \text{kg}^{-1} \text{s}^{-2}$ correctly as required by formula (15), or, it is the same as $G$.

In all, the attractive radiation force $F_g$ given in (15) is a direct analogue of Newton’s gravitational force, in its functional form, its sign, and the constancy of its $G$. It is therefore plausible that the underlying physics presents a viable cause of Newton’s universal gravity. Subsequently $\mathbf{E}_\mu(R, T)$ and $\mathbf{B}_i(R, T)$, making up a dipole wave—a periodic wave motion of the vacuum dipole moments, represents a gravitational wave. Following (3)–(4), this is a transverse wave and has a wave velocity $c_g = \frac{d \Omega_i}{d K_i} = c$, with $c$ the velocity of light as before; $d \Omega_i d K_i = \Omega_i K_i$ in the linear dispersion region of $\Omega_i$. Put $G \equiv G$, with $G$ the gravitational constant; thus (12) writes

$$G = \frac{\pi X_0^* e^4}{\epsilon_0^2 \hbar^2 \rho_i};$$

accordingly

$$F_g = \frac{GM_1 M_2}{R^2}. \quad \text{(15)}'$$

With the known values for $G = (6.673 \times 10^{-11} \text{ m}^3 \text{kg}^{-1} \text{s}^{-2})$, $e$, $\epsilon_0$ and $\hbar$, we get an estimate

$$\rho_i / X_0^* = \pi e^4 / (\epsilon_0^2 \hbar^2 G) = 9.00(8) \times 10^{23} \text{ kg/m}. \quad \text{(16)}$$

Besides the two earlier evaluations, the total wave energy in time $\Delta T = \frac{L \phi}{c}$ is more immediately given by the standard result computed from radiation electromagnetic fields, $E_i = \frac{1}{4 \pi F_i} \int_0^T \int_0^{4\pi} \epsilon_0 E_i^2(R, \theta, T) R^2 d\theta dT = \frac{L \epsilon_0 e^2 \Omega_i^2 A_i^2}{9 \pi^2 \epsilon_0 c^4}$. This combined with (6) yields: $\rho_i = \frac{\pi \mu_0 e^2 c^2 M_i^2}{3 \hbar^2}$. A vacuum region between two masses $M_i$ and $M_j$ is described by the mean value

$$\rho_i = \sqrt{\rho_{ii} \rho_{jj}} = \frac{\pi \mu_0 e^2 c^2 M_i M_j}{3 \hbar^2}, \quad i, j = 1, 2. \quad \text{(17)}$$

(17) and (16) enable us to determine $X_0^*$ directly:

$$X_0^* = \frac{\epsilon_0 GM_i M_j}{3 e^2}, \quad i, j = 1, 2. \quad \text{(18)}$$

$X_0^*$ of (18) and $\rho_i$ of (17) are seen to both increase with $M_i M_j$, while their ratio $\rho_i / X_0^*$ as of (16) is a constant.

Any material body is representable as a matrix of charges of alternating sings in general, of equal quantities in a neutral body. The total attractive radiation force between two such bodies is thus straightforwardly given by the vector sum of those between two charges from the respective bodies, over all charges in each body, provided
Gravity between Internally Electrodynamic Particles

the force penetrates all of material objects on its way. That the DR force has indeed such a superpenetration power is elucidated in [3b].

In addition to the $F_g$, two single charges $1, 2$ are always also repelled by the usual Lorentz force due to their fields $E_1, E_2$: $F_r = \frac{F_g}{X_0}$. For between an electron mass $M_e$ and proton mass $M_p$, for example, (18) gives $X_0(e, p) = 1.17 \times 10^{-41} << 1$. So $F_r \gg F_g$, giving a net repulsion. However, for two macroscopic masses, say $M_a = M_b = 1$ kg, (18) gives $X_0(a, b) = 7.67 \times 10^{15}$.

Therefore

$$F_r = \frac{F_g}{7.67 \times 10^{15}} << F_g. \tag{20}$$

Considering also, for their macroscopic sizes, say of radius $r_a = 0.1$ m, $\alpha = a, b$, $F_r$ due to the enormous number, of order $10^{27}$, of particles in the interim of each body will be effectively shielded off; the surface population is only a fraction $r_a/a \sim 10^{-10}$ of the body (taking $a = 5 \times 10^{-11}$ m). In total, the two forces scale as $\frac{F_g}{F_r} \cdot \frac{a}{r_a} \sim 10^{-26}$. Consequently, two macroscopic sized (neutral) bodies interact with a net attraction.

The gravity theory for IED particle (earlier editions [3f]) is conceived and developed by Dr Zheng-Johansson within a unification project. Began in April 2003 (-2006), Prof R. Lundin kindly agreed to have IRF as a tentative host location for a VR funding application for Dr Zheng-Johansson’s unification project, with also a tentative prospect for an academic position. The research in practice is privately funded by scientist P-I Johansson. We thank Professor VK Dobrev for having the work presented at QTS 4, Vana, 2005, and the discussions of Professors H-D Doebner and G Goldin since our meeting at QTS 4 in connection with the IED model and solutions compared with quantum mechanical properties.

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