Possibility of the Space Propulsion System Utilizing the ZPF Field

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Abstract. According to the gravity theory proposed by H. E. Puthoff, gravity is a form of long-range van der Waals force associated with the Zitterbewegung of elementary particles in response to zero-point fluctuations (ZPF) of the vacuum and the inertia mass is arisen from the interaction with the vacuum electromagnetic zero-point field. From the standpoint of the ZPF field theory, the author studied the possibility of the space propulsion system, which is based on interactions between the zero-point field of the quantum vacuum and high potential electric field. By the theoretical analysis, it is considered that impulsive high potential electric field can produce a sufficient momentum for the spacecraft, which would permit interstellar travel instead of conventional chemical rockets.

Keywords: Zero-Point Field, Space Propulsion, Mass Shift, Field Propulsion, Plasma Propulsion
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INTRODUCTION

In recent years, the concept of field propulsion was presented by many researchers utilizing point energy field, negative mass, warp drive and etc. Minami (2003) discussed the fundamental principles and some candidates of field propulsion systems in his paper. There have been various attempts at developing ideas, which one might base a spacecraft that would permit interstellar travel. Among these ideas, there is a field propulsion system utilizing electromagnetic fluctuations of zero point field in the vacuum (Haisch and Rueda, 1997; Puthoff, 1998; Haisch, Rueda and Puthoff, 1999). The idea that gravity is a form of long-range van der Waals force associated with the Zitterbewegung of elementary particles in response to zero-point fluctuations (ZPF) of the vacuum was introduced by Puthoff (1989) in his article. According to his theory, the inertia mass is arisen from the interaction of elementary particles with the quantum ZPF field. From this theory, the author tries to consider another possibility of propulsion system by alternating its inertial mass due to the zero-point fluctuations of the vacuum.

MASS SHIFT INDUCED BY THE EXTERNAL ELECTROMAGNETIC FIELD

According to the quantum electrodynamics, the quantum vacuum is filled with the zero-point electromagnetic field as shown in Figure 1. However this electromagnetic field is in the state of non-radiating mode and we can not recognize the influence of zero point fluctuation of quantum electromagnetic field. Haisch, Rueda and Puthoff (1999) suggested that if one could somehow modify the vacuum medium then the mass of a particle or object in it would change according to the zero-point field theory.

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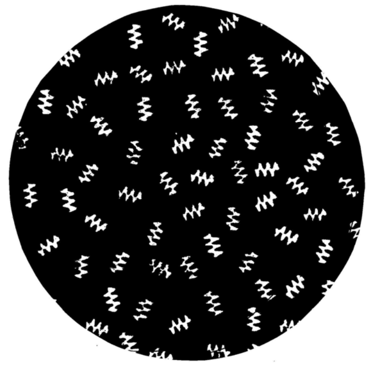

FIGURE 1. ZPF field in the Vacuum

Under an intense electromagnetic field, it has been theoretically predicted that electron experiences an increase of its rest mass.

Let H_A be the electrodynamic Hamiltonian of the particle under high electromagnetic field, it has the form shown as

$$H_A = \frac{e^2}{2m_0 c^2} < A^2 >, \tag{1}$$

which was analogically discovered by Milonni shown in the paper by Haish, Rueda and Puthoff (1994), where m_0 is the rest mass of the particle, e is its charge and A is the vector potential.

The similar equation by using terms of the ZPF field was also proposed by Haisch, Rueda and Puthoff (1994) shown as

$$H'_A = \frac{e^2 \hbar}{2\pi m_0 c^3} \omega_c^2, \tag{2}$$

where $\hbar$ is a Plank constant divided by 2π and ω_c is a cutoff frequency of ZPF spectrum in the vacuum. Assuming that electrodynamic Hamiltonians, shown in equations (1) and (2), are identical with each other, therefore we have $\Delta H_A = \Delta H'_A$ for the dielectric material under impressed electric field as shown in Figure 2. We suppose that the cutoff frequency of the vacuum is shifted as $\omega_c = \omega_0 + \Delta\omega$ when the electromagnetic field is impressed to the dielectric material, $\Delta H'_A$ becomes

$$\Delta H'_A = \frac{e^2 \hbar}{2\pi m_0 c^3} \{(\omega_0 + \Delta\omega)^2 - \omega_0^2\} \approx \frac{e^2 \hbar}{\pi m_0 c^3} \omega_0 \Delta\omega, \tag{3}$$

where ω_0 is the Plank frequency given by $\omega_0 = \sqrt{c^5 / \hbar G} \approx 3 \times 10^{43}$ Hz.

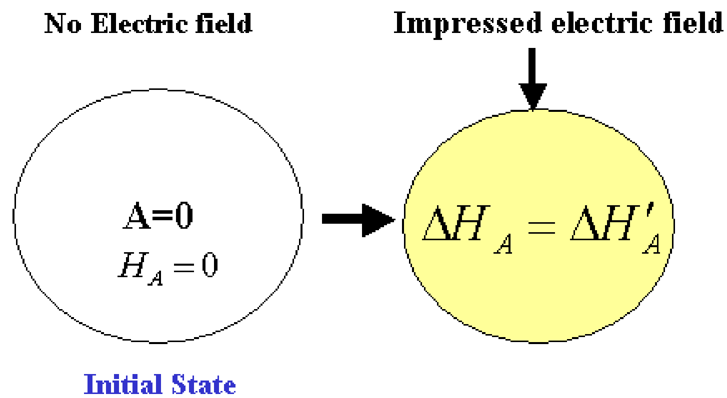

FIGURE 2. Electro-dynamic Hamiltonian with and without electric field

As shown in Figure 2, $H_A = 0$ at the initial state, then we obtain the formula given by

$$\Delta\omega \approx \frac{\pi c}{2\hbar\omega_0} < A^2 > . \tag{4}$$

According to the gravitational theory proposed by Haisch, Rueda and Puthoff (1994), we can suppose that the inertial mass of elementary particles induced by ZPF field can be given by

$$m = \frac{\Gamma\hbar\omega_c^2}{2\pi c^2}, \tag{5}$$

where Γ is the radiation reaction damping constant defining the interaction of charged elementary particles with electromagnetic radiation field.

From which, we have

$$\Delta m / m = \frac{2\Delta\omega_c}{\omega_c} = \frac{\pi c}{\hbar\omega_0^2} < A^2 > . \tag{6}$$

For the dipole field generated by the variance of electric charge as shown in Figure 3, the vector potential of the electromagnetic field becomes

$$A = \frac{1}{4\pi\varepsilon_0 c^2}\frac{\dot{p}(t - r/c)}{r} \approx \frac{1}{4\pi\varepsilon_0 c^2}\frac{\dot{p}(t)}{r}, \tag{7}$$

(Feynman, Leighton and Sands, 1964), where p is a dipole momentum given by $p = qd$ (q : charge of particles, d : displacement of the charge) and ε_0 is a permittivity of free space.

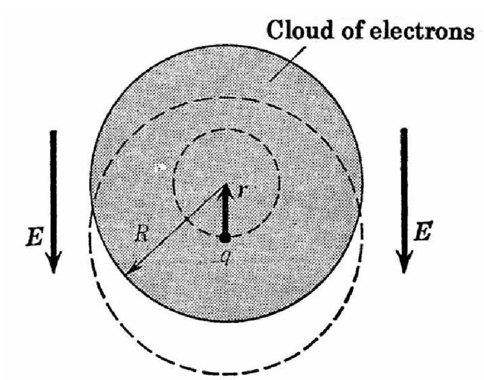

FIGURE 3. Dipole field generated by the electric field

If we let $p(t) = p_0 \sin\omega t$ ($p_0 = Ned$), then we have

$$A = \frac{1}{4\pi\varepsilon_0 c^2}\frac{\omega\ p_0 \cos\omega t}{r} = \frac{1}{4\pi\varepsilon_0 c^2}\frac{\omega Ned \cos\omega t}{r}. \tag{8}$$

In this equation, N is a number of charges per unit volume and d is given by

$$d = \frac{e}{m}\frac{E}{\omega_e^2 - \omega^2}, \tag{9}$$

where E is an amplitude of the impressed electric field and ω_e is a resonant angular frequency given by $\omega_e = \sqrt{Ze^2/\alpha_e m}$ (α_e : electron polarizability), which yields about $10^{15} \sim 10^{16}$ Hz.

As the energy dissipation can be incorporated into the analysis by replacing the angular frequency with the complex one given by $\omega' = \omega(1+i\eta/2)$, where η is a damping factor which can be given by $\eta \approx \tau_e \cdot \omega$ (τ_e : relaxation time of the electro-dynamical system), we obtain the following equation from above equations for the charged sphere with a radius of R ;

$$\begin{aligned}\Delta M(\omega)/M &= \frac{\pi\ G}{c^4}\int <A^2> dv \\ &= \frac{1}{16\pi}\frac{N^2 e^4 G}{\varepsilon_0^2 c^4 m^2}E^2 \left.\frac{\omega^2}{(\omega_e^2 - \omega^2)^2}\right|_{\omega\to\omega'} \int_0^{\pi}\sin\theta d\theta \int_0^R dr \int_0^{2\pi} d\varphi \ \cdot \\ &\approx \frac{N^2 e^4 G}{4\varepsilon_0^2 m^2 c^8}\frac{\omega^2}{(\omega_e^2 - \omega^2)^2 + \eta^2\omega^4}E^2 R\end{aligned} \tag{10}$$

GENERATED FORCE BY THE HIGH POTENTIAL ELECTRIC FIELD

From equation (10), the mass shift of the dielectrics under high potential electric field can be obtained for the cases to impress the alternating electric field and the impulsive electric field, respectively.

Case for the Alternating Electric Field

By impressing alternating electric field to the capacitor composed of dielectric material, equation (10) can be approximated from

$$\frac{\omega^2}{(\omega_e^2 - \omega^2)^2 + \eta\omega^4} \approx \frac{\omega^2}{\omega_e^4}, \tag{11}$$

when satisfying $\omega << \omega_e$.

Then we have

$$\Delta M(\omega) \approx \frac{N^2 e^4 GR}{4\varepsilon_0^2 m^2 c^8}\frac{\omega^2}{\omega_e^4}E^2 M. \tag{12}$$

If the high potential electric field shown as $\psi(t) = V_0 \sin\omega t$ is impressed to the dielectrics of the capacitor moving with the displacement given by $x = \delta\sin(\omega_o t)$, where δ is its displacement and ω_o is the oscillating frequency, the new force generated due to the mass shift is given by

$$\hat{F} \approx \dot{x}\frac{d}{dt}M(t) = \gamma\cdot\dot{x}N^2 R\frac{\omega^2}{\omega_e^4}\frac{M}{d^2}\frac{d}{dt}\psi(t)^2, \tag{13}$$

where $\gamma = e^4 G/(4\varepsilon_0^2 m^2 c^8)$.

From which, the amplitude of the generated force becomes

$$\hat{F}_0 = 2\gamma\omega_o \delta N^2 R \frac{\omega^3}{\omega_e^4} M \frac{V_0^2}{d^2} . \tag{14}$$

As the electric power P delivered to the capacitor is proportional to the square of the impressed voltage, the force generated for the capacitor satisfies the relation given by $\hat{F}_0 \propto \delta\omega^3 P$, which is similar to the equation by Mahood (1999) on the experiments conducted by Woodward (see; Woodward, Mahood and March, 2001).

Case for the Impulsive Electric Field

For the impulsive electric field, which has a wide frequency range of spectrum, the bandwidth of the spectrum ($\omega_2 - \omega_1$) is large compared to the width of the resonance, then the following integration over frequencies across the resonance becomes

$$\int_{\omega_1}^{\omega_2} \frac{\omega^2 d\omega}{(\omega_e^2 - \omega^2)^2 + \eta^2 \omega^4} \approx \frac{\pi}{2\eta\omega_e} . \tag{15}$$

From which, we obtain the ratio of the mass shift vs. its rest mass under the impulsive electromagnetic field shown as

$$\Delta M / M = \int_{\omega_1}^{\omega_2} \Delta M(\omega)/M \cdot d\omega = \frac{\pi}{8} \frac{e^4 G}{\varepsilon_0^2 m^2 c^8} \frac{N^2 R}{\eta\omega_e} E^2 . \tag{16}$$

Assuming that the damping factor η is on the order of the Abraham-Lorenz damping constant given by $\Gamma_e = 2e^2/3mc^2$ (Haishi, Rueda and Puthoff, 1994), we have

$$\Delta M \approx \frac{\pi}{8} \frac{e^4 G}{\varepsilon_0^2 m^2 c^8} \frac{N^2 R}{\Gamma_e \omega_e} E^2 M , \tag{17}$$

where N is a number of electrons per unit volume in a space including the dielectric material, R is a radius of the electron cloud and E is a magnitude of the impulsive electric field.

Comparing equations (12) and (17), the ratio of them becomes

$$\Delta M / \Delta M(\omega) \approx 10^{70} / \omega^2 , \tag{18}$$

when satisfying $\omega < \omega_e$. From which, it can be seen that the mass shift by the impulsive electric field to the dielectrics is much greater than the case for impressing alternate electric field. Hence it is considered that the impulsive electric field could generate force for applying the space propulsion system.

POSSIBLE PROPULSION SYSTEM BY THE IMPULSIVE ELECTRIC FIELD

From the electrogravitic formula given by $E_g \approx -Z\sqrt{4\pi\varepsilon_r\varepsilon_0 G} \cdot E$ (which was independently obtained by the author (Musha, 2007 and 2008) and Ivanov (2004)), where Z is an atomic number of the dielectric material, ε_r is a specific inductive capacity of the dielectrics and E_g is a gravitational field induced by the external electric field, the force produced by electrogravitic field becomes

$$F = -(M + \Delta M) E_g \approx Z\sqrt{4\pi\varepsilon\ G} \left(1 + \frac{\pi}{8} \frac{e^4 G}{\varepsilon_0^2 m^2 c^8} \frac{N^2 R}{\Gamma_e \omega_e} E^2 \right) EM . \tag{19}$$

From the equation for the momentum given by $F = dP/dt$, the momentum generated by the gravitational field becomes

$$P_{field} = \int F dt = \int m \cdot E_g dt \approx m E_g \Delta t \, . \tag{20}$$

When the electric charge moves between electrodes with a distance l, the time it takes to move that distance becomes $\Delta t = l / v_d$, where v_d is a drift velocity of electrons, the momentum produced by the impulse of charges between electrodes can be given by

$$P_{field} = \int (M + \Delta M) \cdot E_g dt \approx Z \sqrt{4\pi\varepsilon \; G} M \left(1 + \frac{\pi}{8} \frac{e^4 G}{\varepsilon_0^2 m^2 c^8} \frac{N^2 R}{\Gamma_e \omega_e} E^2 \right) \frac{El}{v_d} \, . \tag{21}$$

From this equation, new factors to induce a momentum for the dielectric material are presented as follows:

- Increase the voltage impressed to the dielectric material, nonlinear increase of the momentum is produced.
- Increase the charge density of electrons in the dielectric material, the greater momentum is produced.
- Increase the separation between the electrodes, the greater momentum is produced.
- Increase the radius of electron clouds, the greater momentum is produced.

This equation suggests that high impulsive electric field impressed to the dielectric material may affect the inertia of the mass and it would produce a rapid acceleration without strain or stress inside it. Originally plasma propulsion system is designed for the deep space propulsion system, which utilized electromagnetic field to accelerate ionized propellant to drive the spaceship. The pulsed plasma propulsion system is under developed, which utilizes self-induced magnetic field for accelerating the plasma to high exhaust velocities to produce thrust (Lerner, 2000).

From which, the space propulsion system for the spacecraft as shown in Fig. 4 can be proposed:

> If we suppose that plasma cloud surrounding the spacecraft can influence its mass, the propulsion system can attain the higher capability of acceleration by the plasma cloud generated by the ion source contained inside the spacecraft according to equation (21).

This system produces high charged plasma cloud surrounding the spacecraft and generates a greater speed to drive it by applying impulsive high potential electric field along its body.

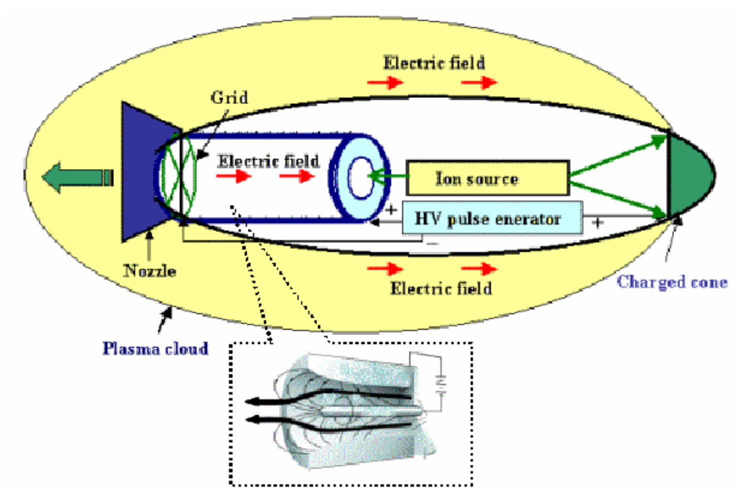

FIGURE 4. Proposed propulsion system for the spacecraft

From equation (21), the velocity of the spacecraft can be estimated from $v = P_{field} / M'$ (M' : total mass of the spacecraft) as shown in Figure 5.

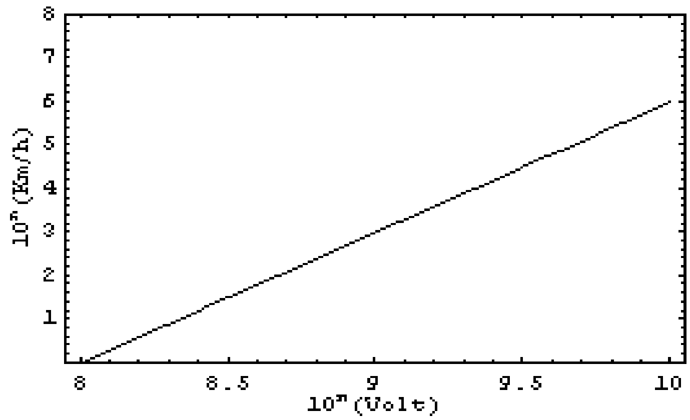

FIGURE 5. Velocity of the spacecraft by the ZPF propulsion.

For Figure 5, the calculation was conducted by assuming that $l = 10$ m, $R = 5$ m, $\omega_e = 10^{15}$ rad/s, $m = 9.11 \times 10^{-31}$ kg (electron's mass), $N = 10^{26}$, $v_d = 10^8$ m/s for the value of the vacuum arc (Boxman, Martin and Sanders, 1996), and $M \approx M'$. Assuming that the electro-dynamical damping factor has the value on the order of the Abraham-Lorenz damping constant, it can be seen from the calculation result that this spacecraft has the possibility to attain the velocity, 9.5×10^5 km/h, when applied 10GV impulsive voltage to electrodes, which is over 30 times the speed of the conventional chemical rocket, that enables us to reach the stars far beyond the rim of our solar system.

CONCLUSION

From the theoretical analysis by the zero-point field theory, it is considered that the interaction of zero-point vacuum fluctuations with pulsed high potential electric field can induce a higher acceleration to the moving body. This result suggests that the impulsive electric field applied to the spacecraft may produce artificial gravity sufficient for practical application to the space propulsion technology that would permit interstellar travel.

NOMENCLATURE

H_A	=	electrodynamic Hamiltonian of the particle under high electromagnetic field
m_0	=	rest mass of the particle (kg)
c	=	speed of the light (m/s)
e	=	charge of the particle (C)
A	=	vector potential of the electromagnetic field (Wb/m)
$\hbar$	=	Plank constant divided by 2π (J・s)
ω_0	=	Plank frequency (rad/s)
ω_c	=	cutoff frequency of ZPF spectrum in the vacuum (rad/s)
Γ	=	radiation reaction damping constant defining the interaction of charged elementary particles with electromagnetic radiation field
G	=	gravitational constant (N・m^2/kg^2)
p	=	dipole momentum (C・m)
d	=	displacement of the charge (m)
ε_0	=	permittivity of free space (F/m)
N	=	number of charges per unit volume (m^{-3})
E	=	amplitude of the impressed electric field (V/m)

ω_e	=	resonant angular frequency (rad/s)
η	=	damping factor of the electro-dynamical resonant system ($\approx \tau_e \cdot \omega$)
τ_e	=	relaxation time of the electro-dynamical system (s)
R	=	radius of a charged sphere (m)
ΔM	=	mass shift of the dielectric material (kg)
Γ_e	=	Abraham-Lorenz damping constant ($\approx 2\times 10^{-25}$ for the electron)
Z	=	atomic number of the dielectric material
ε_r	=	specific inductive capacity of the dielectrics
E_g	=	gravitational field induced by the external electric field (N/kg)
l	=	distance between electrodes (m)
v_d	=	drift velocity of electrons (m/s)
F	=	force produced by electrogravitic field (N)
P_{field}	=	momentum produced by the impulse of charges between electrodes (kg・m)

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