OPEN ACCESS Freely available online

Journal of
Aeronautics & Aerospace Engineering

Review Article

A Review on Electromagnetic Propulsion by Stimulated Forces

Patrick Cornille*

C.E.A. Advanced Electromagnetic Systems 7 Rue de la Perdriere, 59320 Ennetieres-en-Weppes, France

ABSTRACT

There are in the literature many reports concerning experiments showing that conductors submitted to high voltage or with high currents passing through them are moving without the help of an external observer. By using Newtonian mechanics and the application of Newton's third law, we are able to explain this motion or propulsion effect either as resulting from a spontaneous force if we use the Ampére force law or as a stimulated force if we use the Lorentz force law. In this paper, we will examine both the theoretical and experimental aspects concerning this effect.

Keywords: Electromagnetic; Ampere force; Newton's third law

INTRODUCTION

Sometimes, it is useful to do an historical review on a given subject as done hereafter to discover a thread between different experiments done by physicists around the world on a long period of time namely 149 years. This thread was discovered for the first time in 1999 in our review paper [1] concerning experiments showing that conductors submitted to high voltage or with high currents passing through them are moving without the help of an external observer. This paper will address this subject by giving a common explanation to the effect, namely the motion results from the violation of the Newton's third law due the magnetic force if we assume that the capacitor has an absolute motion defined with respect to vacuum. This paper has important implications concerning the interpretation of physics and applications to electric propulsion.

PREVIOUS EXPERIMENTAL WORK

A recent paper published in Nature by Xu et al. [2] presented an aeroplane with a solid state propulsion system. However, important references concerning previous work on the subject are not cited both on the experimental and theoretical aspects concerning this kind of propulsion. Indeed, there is an abundant literature concerning the rectilinear and rotational motion of discs, metallic pendulum, asymmetrical capacitors (lifters) and symmetrical capacitors when they are charged with a high voltage.

The first experiment concerning discs charged with a high voltage was done in Faraday time around 1870 where a mica disc moving on a point takes a rapid rotation when connected with a Wimshurst machine. This fact is reported in a communication presented by Ducretet to The Academy of Sciences around 1898 concerning a similar experiment. The test concerning these experiments can be found in Pagés's book [3]. Pag´es reproduced such an experiment with similar results in 1921. He also quotes an experiment with a capacitor [3] which shows a 5 *g* weight decrease for an applied voltage 200 *kV*.

From this date up to 1960, Pagés's did many experiments with disks charged with high voltages which led him to the theory of the electromagnetic Magnus effect.

The mica disk experiment was also done by Ruhmkorff as quoted above in the French text and described in 1876 by Mascart [4]. This experiment was also studied in Jefimenko's book [5]. Below the disk, there are two vertical corona-producing needles mounted on a hard rubber base. One of the needles is connected to Earth while the other is connected to a long, stiff, horizontal wire terminating in a sharp point. To set the disk in rotation, a high voltage terminal is brought in the proximity of the sharp point of the horizontal wire. It is correct to state that, by a corona discharge, one needle sprays charges onto the disk while the other one discharges them to the ground. However, these corona discharges are perpendicular to the disk; therefore the rotation cannot be attributed to the electrostatic forces which are also perpendicular to the disk.

We will demonstrate that the stimulated force is proportional to the current flowing through the conductor. Therefore, the

Correspondence to: Patrick Cornille, Retired Physicist from the C.E.A. Advanced Electromagnetic Systems 7 Rue de la Perdriere, 59320 Ennetieres-en-Weppes, France, Tel: +0033687015487 E-mail: patrick.cornille@libertysurf.fr

Received: April 11, 2020, **Accepted:** May 25, 2020, **Published:** June 01, 2020

Citation: Cornille P (2020) A Review on Electromagnetic Propulsion by Stimulated Forces. J Aeronaut Aerospace Eng. 9:221. doi: 10.35248/ 2168-9792.20.9.221

corona discharge in air is necessary to produce the current and the polarization of matter inside the conducting metal for getting a rotational motion. The corona effect cannot be the direct cause of any stimulated motion. We replicated the disc experiment with modern equipment with impressive results where we use a compact disc which reaches a 4000 rpm rotational speed.

In 1923, Dr. P. A. Biefeld discovered at the same time as Pagès that a heavily charged electrical capacitor moved towards its positive pole. He assigned T. T. Brown [6] to study the effect as a research project. Brown carefully conducted experiments for thirty years with charged bodies in air, oil and in a high vacuum. Brown experimental achievement has been cited in the books by Schaffranke et al. [7-9] in the reports made for the Air Force by Cravens DL [10] and Talley [11]. Most of the experimental work of Brown TT was known from his patents since none of his work was published in scientific magazines.

The results have usually been discounted because they were attributed to ion wind and corona discharge. The critics formulated concerning the results of these experiments can be easily refuted because the ion wind effect is too small. Moreover, Brown performed experiments in a high vacuum and observed that the effect remained as explained in LaViolette's book [8]. The maximum effect was observed in 1928 for a body weighing approximately 10 *kg* charged at 150 *kV* which results in a 1 *N* thrust. Several experiments during many years were done by Brown at different laboratories throughout the world. There are also more impressing reports [12] about this effect when a capacitor built by alternating layers of metal plates and wax paper or some dielectric material is submitted to a high voltage, a 5.5 *kg* measured lift is reported for a capacitor weighing 1 *kg*. However, this experiment has not been replicated for confirming the claim. A retrospective discussion concerning the experiments done during many years by Brown at different laboratories throughout the world can be found in the book by Szames A [6].

We can also cite Dr. E. Saxl [13,14] who made thousands of careful observations for more than ten years with electrically charged torque pendulum. Saxl shows that the voltage versus the pendulum period follows a square law.

Until the year 2001, except the two reports by Cravens and Talley, the effect was totally ignored by the scientific community with no peer review publications explaining the effect except our two papers [15]. Naudin JL worked on the concept of stimulated force applied to scientific projects among them electromagnetic propulsion which is referenced in the literature as the lifter project [16-18]. Lifters build by Naudin JL in 2001 are asymmetrical capacitors joined so as to form a triangle assembly capable of lifting their own weight. The lifter weighting 2.3*g* has a measured acceleration which increases from 0.8 *g* to 1.3 *g*. Face to the evidence concerning these strange experimental results, the scientific community started to examine the subject with a growing interest as proved by the numerous publications done in the scientific magazines as shown in the references [19-32].

Finally, the present author replicated the Trouton Noble experiment from 1998 to 2010 where the rotational motion of a plane plate capacitor was observed [33-42]. This research culminated in a last paper where the experiment was done at the University of LILLE [43]. It was proved that the theory and experimental results match perfectly.

NEWTON'S THIRD LAW IN CLASSICAL MECHANICS

It is fundamental to recall definitions in classical mechanics which are reviewed in several papers [44-52] and book [53], namely we must distinguish between the internal forces and the external forces acting on the particles due to sources outside the system. We can speak of mutual interaction between two particles only if the internal forces follow Newton's third law. Therefore, an external force is by definition a force that does not follow Newton's third law. When the external forces are zero, we say that the system is isolated.

The center of mass of the system is a point $\mathbf{r}$ where the entire mass $m=m_1+m_2$ of the system can be thought to be concentrated. It is defined by the relation $m\mathbf{r}=m_1\mathbf{r}_1+m_2\mathbf{r}_2$. The motion of this point is only determined by the effect of external forces since we have:

$$\frac{d}{dt}mU=\frac{dP_1}{dt}+\frac{dP_2}{dt}=F_e=F_{11}+F_{22} \tag{1}$$

We can now study the motion of a second particle called the relative particle with a reduced mass $M=m_1m_2/(m_1+m_2)$. This single particle is located at the place occupied by either the first or the second particle depending on the choice of the rest position. The distance $\mathbf{R}$ is therefore $\mathbf{R}_{12}=\mathbf{r}_1-\mathbf{r}_2$ if the particle 2 is located at the origin of a reference frame or $\mathbf{R}_{21}=\mathbf{r}_2-\mathbf{r}_1$ if the particle 1 is now the origin of our reference frame. For each choice, we have an equation of motion:

$$\frac{d}{dt}MV_{12}=F_i=F_{12}+\frac{1}{m}\left(m_2F_{11}-m_1F_{22}\right) \tag{2}$$

$$\frac{d}{dt}MV_{21}=-F_i=F_{21}-\frac{1}{m}\left(m_2F_{11}-m_1F_{22}\right) \tag{3}$$

where the relative velocity $\mathbf{V}=d\mathbf{R}/dt$ between the two reference frames is reciprocal since we have $\mathbf{V}_{12}=-\mathbf{V}_{21}$. It follows that the reciprocity $\mathbf{V}_{12}=-\mathbf{V}_{21}$ of the rest reference frame is indeed linked to the existence of Newton's third law as shown in Figure 1 for the three possibilities. The reciprocity concept and Newton's third law are two faces of the same coin.

Therefore, we cannot use the reciprocity of the reference frames in special relativity and at the same time state that Newton's third law does not apply in special relativity.

When the external force is zero $\mathbf{F}_e=0$, the system is isolated and the velocity of the center of mass is zero in the laboratory frame or it is a rectilinear uniform motion in another reference frame as stated by Newton's first law:

$$\frac{d}{dt}mU=\frac{dP_1}{dt}+\frac{dP_2}{dt}=F_e=0 \tag{4}$$

It follows that the velocity $\mathbf{U}=d\mathbf{r}/dt$ and the kinetic energy $E_K=mU^2/2$ of the center of mass are constant or zero. Hence a failure of the third law would be a failure of momentum and energy conservation. If the external forces are zero and the

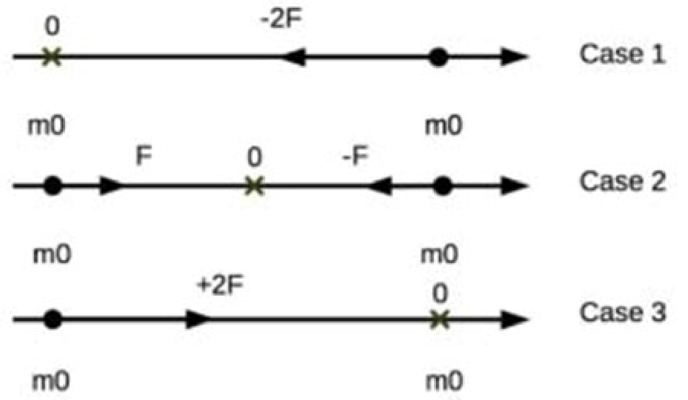

Figure 1: The mutual force between two identical particles of mass m_0 can depend on the choice of an origin for an isolated system.

internal force $\mathbf{F}_i$=$\mathbf{F}_{12}$ is derivable from a potential function E_P (**R**), the equation of motion for the reduced mass becomes:

$$M\frac{dV}{dt} = -\nabla_R E_P \tag{5}$$

One can multiply both sides of the above equation by **V**, it follows

$$\frac{d}{dt}\left(\frac{1}{2}MV^2 + E_P\right) = 0 \tag{6}$$

Therefore, we have conservation of the mechanical energy of an isolated system only when the internal forces are central and satisfy Newton's third law for translation. The splitting between internal and external forces is independent of the nature of the force, and therefore, this partition must apply in all branches of Physics as shown in our review paper [15].

The existence of stimulated forces which do not satisfy Newton's third law deserves special attention since it results from the above calculation that these forces induced inside matter can be used to do space propulsion. To propel a craft with an external force has also a great advantage for the human beings who will not be submitted to stress since this force is only applied to the center of mass of the whole space transportation system. The only question to be answered is how do we generate an external force?. Since the Lorentz force does not follow Newton's third law, this force can be used for building a new advanced propulsion system.

NEWTON'S THIRD LAW IN ELECTROMAGNETISM

The Lorentz force law and the stimulated force

As stated in the introduction, there are two force laws of motion in electromagnetism. The most well-known is the Lorentz force law which leads to the Lorentz-Maxwell's equation of motion

$$\frac{dP_i}{dt} = F_{Lij} \tag{7}$$

where the Lorentz force $\mathbf{F}_{Lij}$ applied to the particle i is given by the formula:

$$\mathbf{F}_{Lij}=q_i(\mathbf{E}_j+1/c\,\mathbf{U}_i\wedge\mathbf{B}_j) \tag{8}$$

The electromagnetic field $\mathbf{E}_j$, $\mathbf{B}_j$ is an external field produced by another charged particle j. We can make several remarks concerning the Lorentz force law above:

- The first remark concerns the fact we use the C. G. S. system of units which is still largely in use within the international scientific community and in universities, in particular by physicists dealing with plasma physics. Moreover, this system of units underlines the role played by the speed of light and allows a direct connection with the special relativity theory.
- The second one is to question the meaning of the velocity $\mathbf{U}_i$ of the charge q_i that appears in Eq. 8. As pointed out by Assis [54], most textbooks do not state explicitly what the velocity $\mathbf{U}_i$ is relative to. Of course, according to the special theory of relativity, the velocity of the charge q_i is the velocity defined with respect to an inertial reference frame. Therefore, this velocity will have different values in different inertial reference frames.
- The third remark concerns the well-known fact that the Lorentz forces do not satisfy Newton's third law since we have $\mathbf{F}_{Lij} \neq -\mathbf{F}_{Lji}$. We will demonstrate again that this fact implies the existence of external forces that can perform work whose energy is provided by the medium. Therefore, to show the existence of external forces, we must consider the interaction between two moving charges with forces that violate Newton's third law. Since the Lorentz forces exerted by freely moving charges upon one another are not equal and opposite in principle, it follows that a system consisting of pair of charged particles in relative motion can change the state of motion of their center of mass without external help.

Consider now two charged particles q_1 and q_2 moving with velocities $\mathbf{U}_1$ and $\mathbf{U}_2$ relative to a given reference frame. We stress that all the following calculations are done in this reference frame; therefore, no change of reference frame is implied in the discussion.

The charge q_1 exerts on q_2 a force $\mathbf{F}_{21}$=q_2($\mathbf{E}_1$+$\mathbf{U}_2 \wedge \mathbf{B}_1$/c) where $\mathbf{E}_1$ and $\mathbf{B}_1$ are the electric and magnetic fields produced by q_1 at the position occupied by q_2. Conversely, the charge q_2 produces on q_1 a force $\mathbf{F}_{12}$=q_1($\mathbf{E}_2$ + $\mathbf{U}_1 \wedge \mathbf{B}_2$/c). In general these two forces have different directions and magnitudes:

$$\frac{dP_i}{dt} + \frac{dP_2}{dt} = F_{12} + F_{21} \neq 0 \tag{9}$$

The above equation can be written in a form often encountered in the literature, namely:

$$\frac{d}{dt}\left(m_1\gamma_1 U_1 + \frac{q_1}{c}A_2\right) + \frac{d}{dt}\left(m_2\gamma_2 U_2 + \frac{q_2}{c}A_1\right) = 0 \tag{10}$$

From this equation, one can deduce that field theory attributes momentum to the electromagnetic to allow a particle to interact only with fields at the position of the particle. It precludes the possibility of instantaneous particle interactions except as an approximation. Therefore, the interaction between the particles proceeds by a transfer of momentum from one particle to the field, then the field transports the momentum at light speed to the position of the second particle where it can be transferred from field to the other particle. However, this transfer cannot be symmetric since the above equation can be rewritten as follows:

$$\frac{dP_i}{dt}+\frac{dP_2}{dt}=F_{12}+F_{21}=-\frac{d}{dt}\left(\frac{q_1}{c}A_2\right)-\frac{d}{dt}\left(\frac{q_2}{c}A_1\right)\neq 0 \qquad (11)$$

Fluid approach of the stimulated force

We will now give a fluid approach of the calculation of the stimulated force by taking into account the motion of positive and negative ions in motion with velocities $\mathbf{U}_i$ and $\mathbf{U}_e$ with respect to a reference frame located in the center of mass of the Milky Way, the potential solutions are given by the integrals:

$$\phi_k(r,t)=\int_{Vk}\frac{1}{R}\rho_k(r_{k,}\ t)\delta\,\mathrm{r}_k^3 \qquad A_k(r,t)=\frac{1}{c}\int_{Vk}\frac{1}{R}J_k(r_{k,}\ t)\delta\,\mathrm{r}_k^3 \qquad (12)$$

for k=e, i with the definition $\mathbf{R}_k$=$\mathbf{r}$−$\mathbf{r}_k$. We can neglect the retardation effect for charge distributions strongly localized in V_k. The two Lorentz forces between the fluids are calculated from the relations:

$$F_1(\mathrm{t})=\int_{Vi}\rho_i(-\nabla\phi_e-\frac{1}{c}\frac{\partial A_e}{\partial t}+\frac{1}{c}U_i\wedge\nabla\wedge A_e)\delta r_i^3 \qquad (13)$$

$$F_2(\mathrm{t})=\int_{Ve}\rho_e(-\nabla\phi_i-\frac{1}{c}\frac{\partial A_i}{\partial t}+\frac{1}{c}U_e\wedge\nabla\wedge A_i)\delta r_e^3 \qquad (14)$$

The equation of motion of the center of mass of the two fluids of mass m is given by the relation:

$$\frac{d}{dt}mU=\frac{dP_1}{dt}+\frac{dP_2}{dt}=F_1+F_2 \qquad (15)$$

Since the electrostatic forces between the two fluids derive from potential functions, we have the identity:

$$\int_{Vi}\rho_e\nabla\phi_i\delta r_e^3+\int_{Vi}\rho_i\nabla\phi_e\delta r_i^3=-\int_{Ve}\int_{Vi}\rho_e\rho_i\left(\frac{R_e}{R_e^3}+\frac{R_i}{R_i^3}\right)\delta r_e^3\delta r_i^3=0$$

(16)

The above equation describes the mutual interaction between the positive and negative particles due tu the electrostatic forces which satisfy the Newton's third law. Therefore, the reciprocity condition $\mathbf{R}_e$=−$\mathbf{R}_i$ implies that the total force applied to the center of mass is zero. Indeed each quantity $\mathbf{R}_k$=$\mathbf{r}$−$\mathbf{r}_k$ in the double integration is calculated for $\mathbf{r}_k$ fixed for $\mathbf{r}_k$ fixed for $\mathbf{r}$=$\mathbf{r}_n$ with $n\neq k$

There is no general agreement on the mechanism responsible for the force produced in the electrostatic pendulum that would be examined hereafter. Therefore, the above equation is fundamental to understand why ion wind or EHD propulsion cannot explain the motion of the pendulum when a high voltage is applied. As explained later, the ionization of air by thin nude wires produces plasma between the wires which prompted some authors to invoke the electrostatic forces and Newton's third law to explain the rectilinear motion of the capacitor or the lifter.

On the contrary, the equations 16 where the charged particles of both the plasma and the copper wires are taken into account in the calculation forbid such a possibility. In fact, it is the magnetic force which produces the motion as shown above.

Indeed, the experiments described in the literature concerning ion and plasma propulsion has nothing to do with the pendulum or the lifter experiments discussed in this paper because the ion and plasma exhaust is quasi neutral in both cases. A special mechanism of neutralization is used to avoid a back motion due to space charge. Therefore, ion and plasma propulsion engines work as rocket engines obtaining thrust in accordance with Newton's third law but for neutral bodies only.

Using the continuity equation and the definition of the total derivative, the stimulated force $\mathbf{F}_e$=$\mathbf{F}_1$+$\mathbf{F}_2$, after a few calculations, is given by the expression:

$$F_e=\frac{1}{c^2}\int_{Ve}\rho_e\rho_i\left[\frac{R_e}{R_e^3}.(U_e-U_i)(U_e+U_i)-\frac{1}{R_e}\left(\frac{dU_e}{dt}+\frac{dU_i}{dt}\right)\right]\delta r_e^3\delta r_i^3 \qquad (17)$$

We can simplify the above expression by writing $\mathbf{V}(\mathbf{r}_e-\mathbf{r}_i, t)$ = $\mathbf{U}_e(\mathbf{r}_e, t)-\mathbf{U}_i(\mathbf{r}_i, t)$ and $2\mathbf{U}(t)\approx\mathbf{U}_e+\mathbf{U}_i$, it follows:

$$F_e\approx 2\frac{U}{c^2}\int_{Ve}\int_{Vi}\frac{\rho_e\rho_i}{\mathrm{R}_e^3}(\mathrm{R}_e.V)\delta r_e^3\delta r_i^3-\frac{2}{c^2}\frac{dU}{dt}\int_{Ve}\int_{Vi}\frac{\rho_e\rho_i}{\mathrm{R}_e^3}\delta r_e^3\delta r_i^3 \qquad (18)$$

The stimulated force is a function of an absolute velocity **U** and its derivative which depend on the choice of a reference frame and a relative velocity **V** which is independent of this choice. We note that the magnitude of the stimulated force depends on the electron current density $\mathbf{J}$=$\rho_e\mathbf{V}$ flowing in the reference frame where the positive ion fluid is at rest.

In the special relativity theory, we consider that Earth is an inertial reference frame where the velocity **U** and its derivative are zero. Consequently, no stimulated motion can be expected in this theory for a body at rest in this reference frame. Since Earth is moving through space, then the existence of rectilinear and rotational motions as discussed in several papers [15,33-53] is expected to be observed in the Earth's reference frame.

For a point particle theory, the charge densities have for expression:

$$\rho_e(\mathbf{r}_e,t)=Q_e\delta[\mathbf{r}_e-\mathbf{r}_1(t)] \quad \rho_i(\mathbf{r}_i,t)=Q_i\delta[\mathbf{r}_i-\mathbf{r}_2(t)] \qquad (19)$$

If we substitute the above relations in Equation 18, we get

$$F_e(t)\approx 2\frac{Q_eQ_i}{\mathrm{C}^2\,\mathrm{R}^3}U(R.V)-2\frac{Q_eQ_i}{\mathrm{C}^2\,\mathrm{R}}\frac{dU}{dt} \qquad (20)$$

where $\mathbf{R}$=$\mathbf{r}_1$−$\mathbf{r}_2$ is the distance between the space charges Q_e and Q_i. From a different point of view as demonstrated in our book [53], we get another expression for the stimulated force in a capacitor simulation:

$$F_e\approx\frac{Q^2}{c^2R^3}\left[(U.V)R+(U.R)V-(V.R)U-\frac{3}{R^2}(U.R)(V.R)R\right] \qquad (21)$$

With the definitions Q=Q_i=−Q_e. In the above relation $\mathbf{V}$=$\mathbf{U}_2$−$\mathbf{U}_1$ and $\mathbf{U}$=$\mathbf{U}_2$ are respectively the relative and absolute velocities where we have assumed the condition $V \ll U$.

Whatever the correct expression for the force, what we need is an estimation of the magnitude of the force, neglecting the acceleration term in Eq.20, then the force has for maximum magnitude:

$$F_e\approx\sim -2\frac{Q_1Q_2}{R^2}\frac{UV}{c^2} \qquad (22)$$

We can always write the definitions $Q_1=-C_1V_b$ and $Q_2=C_2V_b$ where C_1 and C_2 are real or virtual capacities related to the experimental setup and V_b is the voltage of an external battery. Taking into account these definitions in the preceding equation, we have:

$$F_e \approx\sim -2\frac{C_1C_2}{R^2}\frac{UV}{c^2}V_b^2 \quad (23)$$

Therefore, the stimulated force depends on the square of the applied voltage as shown by several experiments [10,30,31].

We can also write formula 22 in another form. If n_k is the density of the free charges present in the volume $Vol=S_kl_k$, then the current is given by the expression $I_k=n_k\,qS_kU_k$ where U_k is either the relative or the absolute speed of the charge $Q_k=N_k\,q$ and q is now the charge of the electron. We can rewrite the above formula in a simple form:

$$F_e \approx -2\frac{I_rI_a}{c^2}\frac{l_rl_a}{R^2} \quad (24)$$

The charges Q_1 and Q_2 have opposite sign; therefore, the force is negative. The currents I_a and I_r are respectively the absolute and relative currents. The above equation demonstrates that the presence of two currents is a necessary condition to observe the motion of a capacitor charged with a high voltage. The conduction current I_r can be provided by the ionization of a plasma between the plates of the capacitor or by the presence of a leakage current in a dielectric. In the vacuum or in an insulating medium such as oil, the conduction current is almost zero but this is not the case of the convection current inside the material as we shall see hereafter. By comparison, the magnetic force between two parallel wires of length l is given by the expression:

$$F_b = -2\frac{I_1I_2}{c^2}\frac{l}{d} \quad (25)$$

The preceding formula can be applied to the two parallel wires of the pendulum where a repulsive force exists since $I_1=-I_2$ but this force is compensated by the presence of the insulating rod between the two balls.

If the ion current I is due to the applied electric field E then we can calculate the electrostatic force as given in the literature to explain the motion of the capacitor:

$$F_e = \int_{Vp}\rho_p(r)E(r)\delta r_p^3 = \frac{Id}{\mu} \quad (26)$$

Where μ is the ionic mobility. We must point out that all the authors made this calculation as if there is only one kind of charged particles which defines the current I while the formula 24 takes into account two currents. We recall that the conduction current definition is $I=nqSV_d$ where V_d is the drift velocity of one kind of charged particles given by the formula $V_d=\mu E$, this is the case in a conductor but not in a plasma. The formula 26 cannot be used to explain the stimulated motion of capacitors as we shall see hereafter. However, the formula 26 explains why the presence of plasma between the plates of a capacitor increases the magnitude of the force for two reasons: the magnitude of the current I in plasma is far greater than the leakage current in a dielectric. The second reason, the ion mobility in the plasma $\mu_p=2.1\ 10^{-4}\times m^2/(Vs)$ is about 18 times smaller than the copper mobility $\mu_c=4.4\ 10^{-3}\ m^2/(Vs)$.

Definition of the current density in a material

As stated in this paper, the stimulated force results from the violation of the Newton's third law by the magnetic force $\mathbf{F}_m=\mathbf{J}\wedge\mathbf{B}/c$. To evaluate the stimulated force produced by the motion of a plasma or a metal in vacuum necessitates to take into account a full set of transport equations as done in our book [54] but applied this time to a three fluids, namely: the positive and negative ions and the neutral molecules in the plasma or to the positive atom lattice, the negative electron fluid and a new negative fluid which results from the injection of new electrons in the metal or the motion of electrons due to the absolute motion of these electrons in vacuum.

Seaver [55] developed a charge flux equation for any charged species in a general material (solid, liquid or gas). In the derivation, he assumed that magnetic field effects could be ignored which is not totally correct if we have to take into account the magnetic force. The density current given by Seaver for the"ith" species is:

$$\mathbf{J}_i=\rho_i\mathbf{V}_i+\sigma_i\mathbf{E}-D_i\nabla\rho_i-\rho_i\mathrm{G}_i\nabla T_i \quad (27)$$

The current density $\mathbf{J}_i$ at any point in the material depends on the charge density ρ_i, the electrical conductivity σ_i, the electric field $\mathbf{E}$ and the diffusion D_i and the temperature T_i at that point. For liquids and gases the material might have a bulk material drift velocity $\mathbf{V}_i$. Seaver considers the case of a stationary metal and assumes that this material drift is zero. To simplify our analysis, we assume that $\nabla T_e=\nabla T_i=0$ and rewrite his equation in a more general form taking into account the conditions $\sigma_i=0$ and $\nabla\rho_i=0$ which are satisfied in a metal.

$$\mathbf{J}_e=\rho_e\mathbf{U}_e-D_e\nabla\rho_e \quad \mathbf{J}_i=\rho_i\mathbf{U}_i \quad \mathbf{J}_n=\rho_n\mathbf{U}_n-D_n\nabla\rho_n \quad (28)$$

The total densities of current and charge become:

$$\mathbf{J}=\rho_e\mathbf{U}_e+\rho_i\mathbf{U}_i+\rho_n\mathbf{U}_n-D_e\nabla\rho-D_n\nabla\rho_n \quad (29)$$

$$\rho=\rho_e+\rho_i+\rho_n \quad (30)$$

Where all the velocities $\mathbf{U}_k$ are now absolute velocities defined with respect to a given reference frame. In this formulation, we take into account a new quantity $\rho_n<0$ which is a density of charges that results from injection of charges in the metal generated by an external source or an unbalanced space charge due to the motion of the metal. Let us write the definitions:

$$\mathbf{U}_e=\mathbf{V}_e+\mathbf{U}_i \qquad \mathbf{U}_n=\mathbf{V}_n+\mathbf{U}_i \quad (31)$$

For the time being, we drop the diffusion terms for the discussion that will follow, and then we have:

$$\mathbf{J}=\rho_e\mathbf{V}_e+\rho_n\mathbf{V}_n+(\rho_e+\rho_i)\mathbf{U}_i+\rho_n\mathbf{U}_i \quad (32)$$

The density of current $\mathbf{J}=\rho_e\mathbf{V}_e=\sigma_e\mathbf{E}$ is the conduction current defines in the Ohm's law with the relation $\sigma_e=-\mu\rho_e$ for $\rho_e<0$. The second term is also conduction current as studied by Seaver. The two last terms are convection currents taken to be zero in the laboratory frame as done in the Seaver's analysis.

The analysis by Seaver [56] concerning the motion of free electrons in an infinite wire far from to any conducting metal is in contradiction with other analysis [57,58] where the magnetic field due to the current itself produces a pinch effect of the electrons which must be taken into account. Therefore, the usual Ohm's law must be replaced by the expression

$\mathbf{J}=\rho_e\mathbf{V}_e=\sigma_e(\mathbf{E}+\mathbf{V}_e\wedge\mathbf{B})$. When the steady state is reached, the electrons are concentrated towards the axis of the wire leaving a layer of positive charges at the surface. This is just the opposite case in the analysis presented by Seaver where the excess of free electrons migrates towards the surface of the wire with no excess of electrons left on the axis of the wire. Taking into account the Hall effect has a consequence concerning the neutrality of the conductor, a fact which is know from a long time [57,58]. For a steady current, wehave:

$$\nabla\cdot\mathbf{J}=\sigma_e\nabla\cdot(\mathbf{E}+\mathbf{V}_e\wedge\mathbf{B})=\sigma_e(\nabla\cdot\mathbf{E}-\mathbf{V}_e\cdot\nabla\wedge\mathbf{B}/c)=0 \quad (33)$$

In the laboratory frame where $\mathbf{U}_i$=0 and assuming ρ_n=0, we have:

$$\nabla.E=4\pi\rho \qquad \nabla\wedge B=\frac{4\pi}{c}J=\frac{4\pi}{c}\rho_e V_e \quad (34)$$

Substituting the preceding equation in Equation 32 gives:

$$\rho=\rho_e+\rho_i=\frac{V_e^2}{c^2}\approx 0 \quad \rho_e=-\gamma^2\rho_i \quad (35)$$

Since the quantity $\mathbf{V}^2/c^2$ has a very small value, we can assume that the metal is neutral. Now if we have U_i=0 and $\rho_n\neq 0$, for the same calculation, we get:

$$\rho=\rho_e+\rho_i+\rho_n=\frac{U_e.J}{c^2} \quad (36)$$

For a conduction current 1.5 *mA* in our pendulum experiment, we get $V_e/c\approx 10^{-19}$ while we have $U_e/c\approx 1.2\ 10^{-3}$ for the convection current.

In an interesting paper, Seaver [56] discuss the conditions that a metal must fulfill to be an Ohmic conductor. We recall that the field form of Ohm's law is defined in a metal by the relation $\mathbf{J}=\sigma\mathbf{E}$ where σ is the electrical conductivity of the metal, $\mathbf{J}$ is the current density flowing through the conductor and $\mathbf{E}$ is the electric field produced by an external battery. The field form of Ohm's law can be used to derive the circuit form $V_b=RI$ of Ohm's law. However, the field form is often used to investigate what happens inside an ohmic conductor. Seaver does a thought experiment which consists to inject instantaneously and in a uniform manner new electrons with a density ρ_n along the metallic wire which is not possible without the presence of a diffusion current. However, Seaver pointed out an argument that has escaped most authors when dealing with the motion of the current in a conductor. Indeed, all the authors state that the intensity I of a current in a conductor is given by the simple formula $I=nqSV$ where n is the number density of the free electrons already present in the conductor and V their uniform speed inside the metallic wire. They assume that all electrons move at the same time as a solid as soon as an external electric field $\mathbf{E}$ has been applied to the two extremities of the wire when a battery has been connected.

In fact in the closed electric circuit, there is is usually a switch and electrodes which are directly connected to the wire in the circuit. When the switch is turn on, two things happen: an electromagnetic wave is produced and propagates at the speed of light around the wire and penetrates the wire radially to induce the slow uniform motion of the electrons and other electrons are injected with a density n_p in the wire by the battery. This input of new electrons modifies the electron number density n_e and therefore the conductivity σ_e of the metal. There is an additional current I_n that must be taken into account in the analysis. It is important to point out that when we measure an ohmic current in a steady state with a current probe, one cannot discriminate between the two conduction currents in Equation 31.

Moreover, if a probe current cannot measure the convection currents, it does not mean that these currents do not exist.

Seaver demonstrates that the Ohm's law is weakly modified if $n_p \ll n$ which implies that the current I_n is small. To verify this condition, the drift speed must be below 1% of the average thermal speed in the conductor. This leads him to evaluate the maximum electron number density in copper to be 3 10^{17} electrons/m^3 and a maximum radial electric field E_r = 2.7 10^6 V/m for a 2 *mm* diameter wire.

The neutrality of a material is an important factor with regards to the production of a stimulated force as shown by equation 32 and equation 36. To understand the difference between the generation of the stimulated force in a plasma or in a conductor when free charges are present or injected by a battery, one have to study the behavior of the free electrons which move with a relative current with respect to the opposite charged particles fixed (conductor) or not (plasma) considered to be at rest in a given reference frame. In a plasma, we used the concept of Debye length $\lambda_d=(k_bT/4\pi nq^2)^{1/2}$ in C.G.S units. This quantity is used to calculate the screening potential function for a charge Q placed at the center of the Debye sphere:

$$\phi(R)=\frac{Q}{R}e^{-\alpha R/\lambda_d} \quad with \quad \alpha=(1+\frac{T_e}{T_i})^{1/2} \quad (37)$$

On the contrary, Arbab [59,60] examines the problem with a wave approach with the set of equations:

$$\frac{\partial\rho}{\partial t}+\nabla.J=0 \quad \frac{1}{c^2}\frac{\partial J}{\partial t}+\nabla\rho=0 \quad \nabla\wedge J=0 \quad (38)$$

form a system of equations which can be uncoupled in two wave equations:

$$\nabla\rho-\frac{1}{c^2}\frac{\partial^2\rho}{\partial t^2}=0 \quad \nabla J-\frac{1}{c^2}\frac{\partial^2 J}{\partial t^2}=0 \quad (39)$$

not knowing that we have introduced these conditions in our book [53]. The solution is well known:

$$\rho(r,t)=\rho_e(r,t)+\rho_i(r,t)=\rho_0 e^{-(r+ct)/\lambda d} \quad (40)$$

with the definitions $\lambda_d=c\tau=cs/\sigma$ where τ is a relaxation time constant. For silver, we get λ_d= 4 10^{-10} *m* and τ = 1.4 10^{-19} *s*.

In a conductor, we are more interested by the time behavior of the charge density $\rho(t)$. Given any initial distribution $\rho(0)$, the time evolution of ρ is given by the equation:

$$\rho(t)=\rho(0)e^{-t/\tau} \quad (41)$$

Once the unpaired charge density has decayed to zero in a conductor, it will remain zero. The above formula explains the reason why no stimulated force is observed in a conductor if no free currents are deliberately sent into it. Indeed, any free charge distribution $\rho=\rho_e+\rho_i\rightarrow 0$ will decay with a decay time $\tau\approx 10^{-19}$ *s* in a good metallic conductor. Thanks to the small τ no metallic object can spontaneously move in our environment. Therefore, the electric field **E** and the relative velocity $\mathbf{V}_e$ are zero in a neutral conductor if there is no DC source connected to the conductor.

Ohanian [61] published an interesting paper with a critical review about the relaxation time constant definition. We can also quote the paper by Seaver [62] who derived an equation for charge decay valid in both conductors and insulators:

$$\rho_n(t) = \frac{\rho_0 e^{-t/\tau m}}{1+(\tau_m/\tau_n)\left[1-e^{-t/\tau m}\right]} \quad (42)$$

where $\tau_m = s/\sigma_m$ is the material time constant and the perturbation time constant $\tau_n = s/\mu\rho_0$ defined by the initial perturbation charge.

ELECTROSTATIC PENDULUM EXPERIMENT

Cornille pendulum experiment

We replicated the electrostatic pendulum experiment first done by Brown in 1929 and reported our results for the first time in 1999 [63,64]. We will review again this experiment in order to bring a new insight in this experiment and compare our results with more recent experiments. The pendulum as shown in Figure 2 consists of two metallic balls $2R=5$ *cm* weighting $m=500\,g$ each suspended by two nude wires $l=2\,m$ and diameter $d=0.5\,mm$ to the ceiling of the laboratory. An insulating rod is used between the balls in order to keep the balls at a fixed distance.

The thin wires create a strong electric field which ionizes air around the wires. This local field is stronger than the average field between the wires. As soon as we turn on the bipolar Glassman HT8 HV power supplies connected to the two nude wires, we can observe a motion towards the positive wire. A reversal of the direction of motion is observed when the polarity of the voltage source is inverted. A stationary state is observed with a measured current of $I=1.5\,mA$ and a displacement of the pendulum $x=8\,mm$. For a pendulum of mass $m=1\,kg$, Equation 44 gives a calculated force 4×10^3 dynes or 4 *g* at 50 *kV*.

The gravitational potential energy of a pendulum of mass m_1 is given by the equation:

$$E_P\left[R(t)\right] = -G\frac{m_1 m_2}{R} \approx\sim -G\frac{m_1 m_2}{R_e}(1-\frac{h}{R_e}) \quad (43)$$

where we have posed $R(t)=R_e+h(t)$ knowing that the Earth's mass verifies the condition $m_2 >> m_1$. The potential and kinetic energies as written in the literature are recovered if we neglect the constant $-m_1 g R_e$. For a classical pendulum, the potential and kinetic energies have for expression:

$$E_K\left[\theta(t)\right] = \frac{1}{2}m_1 l^2(\frac{d\theta}{dt})^2 \quad E_K\left[\theta(t)\right] = m_1 g l(1-\cos\theta) = m_1\, gh(t) \quad (44)$$

The equation of motion and the force for the displacement x of the pendulum are:

$$m_1\frac{d^2\theta}{dt^2} = \frac{g}{l}\sin\theta \quad F = m_1 g\tan\theta = m_1 g\, x/l \quad (45)$$

With the approximation $M \approx m_1$ where m_1 is the mass of the pendulum.

We know that the mechanical energy is conserved during the motion of the pendulum if there is no frictional force and no external force applied to the pendulum.

$$E_T = E_K[\theta(t)] + E_P[\theta(t)] = Ct \quad (46)$$

Once we have given an initial impulse to the pendulum, it will oscillate back and forth forever with a constant magnitude. If an external observer gives an impulse at each period to the pendulum at the right time, then the magnitude of the motion will increase as well as its kinetic energy, therefore, the mechanical energy is no more conserved.

In classical circuit theory, the generator, the wires and the capacitor form an isolated system where the conservation law of energy applies. Therefore, the energy E_G of the generator is converted into energy stored E_C in the charged capacitor and into heat E_R dissipated during the charging process, it follows the conservation law:

$$E_G = E_C + E_R \quad with \quad E_C = \frac{1}{2}CV^2 = E_R = \int_0^\infty RI^2(t)dt \quad (47)$$

If the capacitor is not perfect, there is a leaking current and a corresponding dissipated energy which is provided by the generator.

Once we have given an initial impulse to the pendulum, it will oscillate back and forth forever with a constant magnitude if there is no other force applied to the system. Now If an external force is applied to the center of mass of the pendulum and Earth, there is a motion of this point which is not observable due the important value of the Earth mass. However, the effect on the reduced mass M is observable since we have now to take into account the stimulated force which has for expression:

$$\mathbf{F}_S = 1/m(m_2\mathbf{F}_{11} - m_1\mathbf{F}_{22}) \approx \mathbf{F}_{11} \quad (48)$$

We can now write a law of conservation of power of the pendulum by taking into account the work of the stimulated force $\mathbf{F}_S$:

$$\frac{d}{dt}(\frac{1}{2}MV^2 + E_P) = V.(F_S + F_T) \quad (49)$$

Where $\mathbf{F}_T$ is the tension in the string which does not work $\mathbf{V}.\mathbf{F}_T=0$ and **V** is the velocity of the pendulum in the Earth's reference frame.

When the generator is switched off, a kinetic energy $E_K=MV^2=Mlg(1-cos\theta) \approx Mgx\,/2l$ is recovered. This energy is not given by the generator but is taken from the plasma or vacuum. For two balls charged at 50 *kV*, the kinetic energy of the pendulum is $E_K=1.57\ 10^{-4}\,J$ while the electrostatic potential energy is $E_C=CV^2/2=1.4\ 10^{-2}\,J$. The kinetic energy due to the stimulated force is not taken from the generator since in classical circuit theory no motion of the capacitor is taken into account during the charging process. We also applied the high voltage in a pulsed manner in synchronism with the oscillatory motion of the pendulum. It results in an amplification of the displacement of the pendulum which reaches a magnitude of ± 5 *cm*. The observation of this amplification implies the existence of the stimulated force which increases the preceding kinetic energy by a factor 69. This increase in energy is not given by the power supply since on the contrary, in the pulsed mode; the average power of the power is halved by a factor 2.

To calculate the stimulated force, the problem is not to know whether or not the charge density $\rho=\rho_e+\rho_i$ is zero but to know how we evaluate the quantity ρ_n in the general case. For our electrostatic pendulum, we propose a simple solution since the pendulum is a capacitor moving in vacuum, due to the difference of inertia between the electrons and atoms, we will have a convection current I_n which is given by the relation;

$$I_n = \frac{dQ}{dt} = V_b \frac{dC}{dt} \qquad (50)$$

The capacity expressions for two parallel wires and two metallic balls are given by the formulae:

$$C_w = \epsilon_r \epsilon_0 L_n \left[\frac{2D}{d}\right] \quad C_b = 2\pi \epsilon_r \epsilon_0 \frac{DR}{D-R} \qquad (51)$$

where D is the distance between the center of the balls or the wires and R and d are respectively the radius of the balls and the diameter of the wires. Therefore, the pendulum is equivalent to two capacitors mounted in parallel, one is the capacitor of the wires C_w=8.8 pF and the other is the capacitor of the balls C_b=2.5 pF for $D \approx 4R$.

For the wires, the current is given by the relation:

$$I_w = \epsilon_r \epsilon_0 l V_b \frac{1}{D}\frac{dD}{dt} = \epsilon_r \epsilon_0 V_b U_i \frac{l}{D} \qquad (52)$$

For the balls, the current is given by the relation:

$$I_b = \epsilon_r \epsilon_0 V_b \frac{8\pi}{3}\frac{dR}{dt} = \epsilon_r \epsilon_0 \frac{8\pi}{3} V_b U_i \qquad (53)$$

For $V_b=5\times10^4 V$ and $\epsilon_r=1$, we get I_w=2.3A and I_b=1.3A.

The equation 24 gives clues why a stimulated force is produced and how to increase the magnitude of this force which is validated by experimental results.

- The convection current I_n is calculated for electric charges located on the surface of the two metallic conductors and the dipoles formed by these charges do not decay as the dipoles located inside a good conductor where the neutrality is reached with a time constant 10^{-19} s. This fact can explain the large force in the "gravitator" build by Brown where he put parallel plate capacitors in series. We can also consider special material where some iron dust is embedded in a dielectric placed between metallic plates embedded in a glass material to sustain high voltages and which can be arranged as panels which can be placed on a craft to produce lift and thrust in a given direction. With this approach, we can do propulsion in high altitude where there is no air to ionize. There is a vast field of research to be done about this subject where the material can be tested in an electrostatic pendulum experiment.
- The magnitude of the force increases if we decrease the distance D between the wires. This fact is proved in the Einat [30] experiment where the authors measure the thrust versus the gap between the wire and the large electrode.
- The magnitude of the force increases if we increase the dielectric constant ϵ_r. In air,
- $\epsilon_r \approx 1$, in oil $\epsilon_r \approx 2-3$, for Barium Titanate $\epsilon_r \approx 100-1250$.
- The magnitude of the force increases if we increase the number of the plates which constitutes the larger electrode as proved by the experiment in [30]. This can also explained the reason why Brown obtained good results with his gravitator which is built with many capacitor in series with a dielectric between the plates. Some authors noticed that arcing between the electrodes decreases the effect because arcing kills the charge surface effect.
- Contrary to some assertions given in the literature, the asymmetry of the capacitor is not required to produce the force which moves the capacitor. However, use of an asymmetric capacitor with a large electrode can enhance the generated force by a factor 9 as stated in the reference [24] which can be explained by the higher value of the mutual capacitor between the electrodes. As an example, the capacity for a wire placed at a distance D from a metallic plate is given by the relation:

$$C = \frac{2\epsilon_r \epsilon_0 \pi l}{L_n\left[x+\sqrt{(x^2-1)}\right]} \qquad (54)$$

with $x = D/R$ which gives C ≈ 15, 8 pF for l = 2 m with is about twice the value of the capacity between the wires of our pendulum.

Three experiments by Andersen [24] and Naudin [17] were done in oil where the effect is still observed which refutes the explanation given by several authors that the force results from ion wind or electrostatic force. In oil, the presence of charged particles results from injection of charges by the electrodes to the bulk of the fluid or from the dissociation of neutral molecules which generates free ions in the bulk of the liquid. In oil, the conduction current is quite small $I_c=1.8\times10^{-9}$ A for two reasons: there is a little number of free ions for an insulating medium and the ion mobility is weak $\mu_i \approx 10^{-9}$ m^2/V s. Therefore, the current density in that case becomes:

$$\mathbf{J} \approx \rho_n \mathbf{V}_n + (\rho_e+\rho_i)\mathbf{U}_i + \rho_n \mathbf{U}_i \qquad (55)$$

With now $\rho=\rho e+\rho i \neq 0$ since oil has a low conductivity $\sigma=10^{-13}$ S/m which implies a laps of time 10 s to 50 s to reach a steady state.

In the oil experiment by Andersen, with a conduction current which is 40 times less than the current in air, the authors measured a thrust which is 7 times greater in oil than in air with a 40 times increase in efficiency since the conduction current in oil has decreased. A part of this number can be explained by a dielectric effect $\epsilon_r \approx 2-3$. The authors were unable to provide an explanation of the effect which can be justify by Equation 53.

In a solid body, the positive charge distribution is homogeneous and fixed. Therefore, to induce a stimulated force in a conductor, we must create an inhomogeneous electronic charge distribution on all the electrons present in the conductor or inject new electrons inside the conductor. From solid state physics, we know that there are two kinds of electrons, those that are bound in the valence band and those that are free in the conduction band. The analysis above is essentially done for the free electrons but we have to ask the question whether or not the valence electrons participate to a convection current in the metal.

We can also unbalance the distribution of the free electrons in a conducting body by rotating the body and/or at the same time by applying high inhomogeneous electric field to the conductor to move the free electrons inside the conductor. Let us recall that a current flows inside a conductor if there is a permanent uniform electrical field inside the conductor. The stimulated force is greatly increased if this field is non-uniform. There are several ways to produce this non uniform field especially if we use asymmetric capacitors.

There is one more fact involved in the experiments described in the literature, namely non-uniform electric fields can also set uncharged bodies in motion, a fact which has been recognized in 1960 by H. A. Pohl [63]. The motion of electrically polarized matter in nonuniform fields is called "Dielectrophoresis" where the force depends on the expression $\pm\ Ct\nabla\mathbf{E}^2$.

For the plus sign, the force is done to the strongest part of electric flux. The polarity of the field makes no difference; the only thing that matters is how its strength varies. Thus an alternating voltage applied to the electrodes produces the same result as a direct voltage. This can explain the reason why a force in some experiments was also observed with AC power supply.

Therefore, the polarization of a dielectric can be used to enhance or to decrease the stimulated force produced by the capacitor if there is a non-uniform electric field inside the material (solid or liquid). If the field is made stronger on one side than the other, the forces are no longer in balance, and the body is pulled in the direction of the stronger field or the opposite for the negative sign. If we use a dielectric in a parallel plate capacitor, the presence of a dielectric will increase the charge on the surface of each plate but if we use an asymmetric capacitor with the larger electrode having a strong curvature then all the polarized atoms can participate to the magnitude of the force. However, since this force derives from a potential function, we may rise doubts concerning the fact that this force can move the center of mass of the system.

Calculation of the force in the plasma

Both the pendulum and the plasma between the wires move with the Earth's velocity $\mathbf{U}=\mathbf{U}_i$ where $\mathbf{U}_i$ is the velocity of the positive atoms in the metal or the positive ions in the plasma which is defined with respect to a reference frame at rest with vacuum. If the capacitor moves through vacuum, the free electrons in the metal or the negative ions in the plasma will be accelerated differently, lagging behind with a relative drift velocity $\mathbf{V}=\mathbf{U}_e-\mathbf{U}_i$. At all times, there is an electron or a negative ion drift motion trying to follow the motion of the positive atoms and ion in both the metal and the plasma. Therefore, the stimulated force will exist if there is a drift velocity, that is to say a current, circulating in the plasma and the conductor. This drift velocity in the plasma is evaluated from the definition $\mathbf{V}=\mu\mathbf{E}$ where $E=V_b/D$ is the average electric field between the wires, where $\mu=2.1\times10^{-4}\ m^2/V\ s$ is the mobility in the plasma we get $V=75\ m/s$ for $V_b=50\ kV$ and $D=14\ cm$.

We know that the solar system is moving at $U=368$ km/s relative to the cosmic microwave background in the direction towards the constellation Leo which gives $V\,U/c^2=3\times10^{-10}$. The number of charged particles present in the plasma between the wires can be obtained from the formula $N=ID/qV=1.75\times10^{13}$. Knowing that $q=4.8\times10^{-10}\ Stc$, we have $F=4.2\times10^{-2}/R^2$ dynes.

This force depends on the distance R which is an unknown quantity in our approach since the calculation is done for a point particle theory. We can estimate the value of R by taking the condition $R\approx\lambda_d$ where λ_d is the Debye length which defines a screen distance between a clouds of one kind of charges enclosed by an opposite kind of charge. The Debye length is the maximum distance over which a significant charge separation can occur. Outside the sphere of influence, the charges are all screened as if the plasma is neutral. Its value in plasma is about $\lambda_d\approx3\times10^{-5}\ m$. By using the formula $F=2VU\,(qN/cR)^2$, we can calculate the force which has for value $F=4.6\times10^{-2}\ N$ or $m=4.7\ g$, a number which is quite close to the $m=4\ g$ thrust measured in spite of our crude model.

Calculation of the force in the wires

We can estimate the part of the stimulated force that is produced by the metallic wires alone with two different approaches. By using the formula $F=Id/\mu$ where now d is the radius of the wires since the current is flowing radially through the wires where $\mu=4.42\times10^{-3}$ m^2/V s is the copper mobility, we get $F=8.45\times10^{-5}N$ or $8.6\times10^{-3}\ g$ a very small value in comparison with the 100 g calculated with the same formula in the plasma.

If we use instead Equation 24 to calculate the force $F=2I_rI_a\,l_rl_d/(cR)^2$ we have $l_r=d/4l_a=U\tau$ and $R=\lambda_d=c\tau$, knowing that $Icgs=Imksa{*}c/10$, we get $F=0.354$ dynes or $F=3.54\ \mu N$. The formulation in Equation 24 proves that a stimulated force can be observed if there are two currents circulating in the metal. One is the absolute current due to the convection of the surface charges in vacuum and the other current is due to the conduction current circulating in the metal.

When a metal is placed in a vacuum, the conduction current inside the metal is almost zero but the others currents as defined in Equation 55 are not zero. This is the case in the experiment conducted by Talley [10] which is the first official vacuum tests since the claims made by Brown. Talley performed many experiments on double symmetric or asymmetric capacitors mounted as a rotor which are suspended to a torsion fiber measurement system which was placed in a vacuum chamber up to 10^{-6} Torr. This allowed for extremely small movements to be detected since their minimum detectable force in their experiment is about $2\times10^{-3}\ \mu N$. Slight movement was observed in the vacuum chamber which has been explained by Talley as movement due to electrostatic interaction between the capacitors and the chamber walls.

Contrary to statements made in the literature and even by the authors, a propulsive force was indeed observed. From their table, we can write the following Table 1.

As expected from the above analysis, the force is greater for an asymmetric capacitor and also with the presence of a dielectric. The thrust is not linear since it increases by the square of the voltage as proved by Equation 23 in perfect agreement with the ratios F_2/F_1 calculated in the above table. We can also compare

Table 1: Force is greater for an asymmetric capacitor and also with the presence of a dielectric.

Voltage	F sym	Fasym	(V2/V1)2
V1=10 kV	F1=0.0542 μN	F1=0.0905 μN	
V2=19 kV	F2=0.1992 μN	F2=0.3516 μN	
F2/F 1	3.67	3.66	3.61

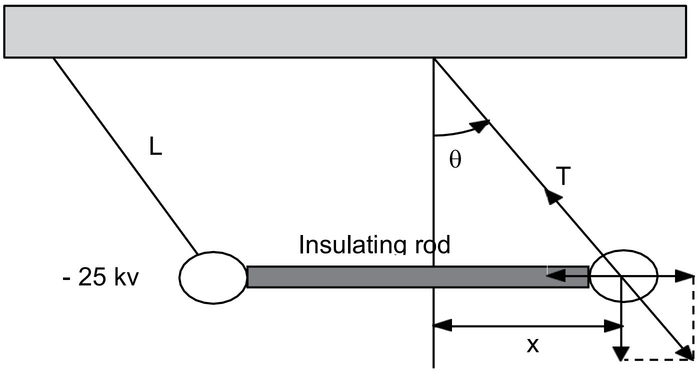

Figure 2: Various forces acting on a double solid pendulum.

theirs results with the above force in the wires for a lower voltage $(19/50)^2=0.144$, therefore we have $0.144\ F_w=0.51\ \mu N$. Knowing that the capacitor of the two wires is about 8.8 pF certainly greater than the capacitors in Talley's experiment, the calculated force in Talley's experiment is in good agreement with our mathematical model.

Calculation of the force in the balls

Using the same approach as for the wires, we can calculate the force for the aluminium balls alone. Knowing that $l_a=d/6$ where $d=5\ cm$ is the diameter of the ball, $\tau_a=2\times 10^{-19}\ s$, $l_a=U_i\ \tau_a$ and $R=\lambda_d=c\tau_a$, we get $F=68.8\ \mu N$, a value which is certainly overestimated since most of the conduction current 1.5 mA circulates through the plasma.

Dr. M. Rambaut, a scientist who worked for the French Atomic Energy Commission as the author of this paper participated to the pendulum experiment described above. After witnessing the translation motion of the bi-filar pendulum, Dr. Rambaut suggested to use instead a one ball pendulum connected to a low voltage battery $V_b=12\ V$ in order to get a higher current $I_r=4$ A crossing the metallic ball since we have $I_r=\sigma$**ES**. Doing a similar calculation as above with $C=4\pi s_0\ R$, we get $F=67\ \mu N$.

It suffices to connect a car battery with thin wires to the metallic ball in order to provide the necessary resistance to avoid short-circuit the battery. Moreover, the fineness and the flexibility of the wires which must be hung from the ceiling prevent any mechanical coupling through an heating process between the wires and the ball $m=0.5\ kg$. As soon as the current is turn on, one can see, if the experiment is properly done, a rotation and a small translation of the ball. These effects can certainly not result from any wind effect or induction effects. To increase the translation effect, one can oscillate the D. C. voltage in phase with the oscillatory motion of the pendulum. The fact that the amplitude of the oscillatory motion increases is a proof that the stimulated force is an external force whose work increases the kinetic energy of the pendulum as anybody who has played with a swing in his youth knows very well. To increase the sensitivity and the accuracy of the measurements, one can stick a laser pencil to the wire to measure the displacement of the pendulum on the wall of the laboratory.

In 2003, Bahder [19] get the same idea to test a simplest capacitor configuration which consists of a suspended thin wire from the hot electrode of the high-voltage power supply. To observe the wire movement, a small piece of transparent tape was attached at the lower end of the thin wire. The suspended thin wire also showed force with 35 kV and 1 mA current. From a vertical position, the wire lifted by as much as 30°, once the high voltage is turn on. Actually, the wire did not remain suspended, but oscillated back and forth approximately 60° from vertical. Without the piece of tape at the end, the wire did not lift as much. The piece of tape seems to increase the capacitance and the air ionization. This suspended wire configuration can be viewed also as a capacitor surrounded by the ground system located several feet away.

Naudin pendulum experiment

Naudin [65] replicated our pendulum experiment in 2002 to clarify the physics involved in the generation of motion when a high voltage is applied to the capacitor formed by the wires and the balls. Naudin made an interesting change to the experimental set up by replacing the insulating rod by a spark gap which was electrically connected to the two balls and inserted in a plastic cylinder to avoid ionization of air. The analysis of the experiment proves as expected that the main contribution to the pendulum motion results from the nude wires when a voltage below 40 kV is applied since the threshold voltage for arcing the spark gap is above 40 kV.

More interesting is the test 3 done by Naudin where the spark gap is turn on with a voltage 50 kV when the two HV power supplies are now connected with insulating wires to the two external sides of the balls to oblige the current to cross the metallic balls. Surprisingly, no motion of the pendulum was observed in spite of the fact that the current crossing the balls and the spark gap was $I=3\ mA$, two times greater than the current $I=1.5\ mA$ of our previous experiment. Therefore, the force for the balls alone must be two times greater than our previous calculation, namely $F=137,\ 6\ \mu N$ which is a small quantity. The absence of motion proves one more time that ion wind and EHD propulsion cannot be the cause of the pendulum motion. Unfortunately, we do not know the nature of the gas and the pressure inside the spark gap since the ion mobility can increase significantly which results in a diminution of the magnitude of the force. We note also that the spherical symmetry of the two balls is not favorable to the generation of a unidirectional force since the ball capacitor value is small 2.5 pF.

The formula of Equation 22 suggests another explanation, namely the magnitude of the stimulated force depends on the square of the number of particles present in the plasma. For the cylinder spark gap, we can calculate the volume $Vol_g=\pi r^2 d$=7.85 cm^3 while the plasma volume between the wires is about $Vol_p=dle$=1291 cm^3. Therefore, we have Vol_p/Vol_g=164, the magnitude of the force due to the spark gap is about 1.46 μN. The difference between these numbers can be greater if the particle density is lower in the spark gap. Several authors have also noted that arcing can decrease the effect.

We may give one more proof that ion wind and EHD propulsion cannot explain the thrust observed in the pendulum experiment. One can build easily a parallel plate's capacitor by sticking two aluminium foils on a plexiglas plate. This capacitor is suspended to the ceiling of the laboratory to obtain a classical pendulum but this time, the capacitor is connected to the HV power supplies with insulated wires. Therefore, no ion wind or ionization of air is possible, as soon as the HV power supplies are turn on, one can observe a small rectilinear displacement of the capacitor which can be amplified by oscillating the voltage the power supply. The same experiment was done in a more sophisticated manner at the French University of LILLE to observe the rotational motion of the capacitor as predicted by Trouton Noble which was published in 2010 [43].

DIFFERENT CRAFTS USING THE PAGES-BROWN EFFECT

The case of the B-2 bomber

LaViolette, in his book, [8] speculates that secretly developed electrogravitic technology has been put to use in the B-2 Stealth Bomber to provide an auxiliary mode of propulsion. His view is based on the disclosure that the B-2 electrostatically charges both the leading edge of its wing-like body and its jet exhaust stream to a high voltage. Positive ions emitted from its wing leading edge would produce a positively charged parabolic ion sheath ahead of the craft while negative ions injected into its exhaust stream would set up a trailing negative space charge with a potential difference in excess of 15 million volts.

Indeed, the B-2 bomber works as a very large asymmetric capacitor where the wings are the larger positive electrode and the exhaust stream the negative electrode which moves the flying craft in the direction of the positive pole. An electrogravitic drive of this sort could allow the B-2 to function with great propulsion efficiency when cruising at supersonic velocities. To jump from our 4 g in our pendulum experiment to 80 T thrust in the bomber necessitates an increase of the force by a factor 2 10^7. We note that the stimulated force is proportional to the square of the number of charged particles that participates to the calculation of the force which implies a large plasma cloud surrounding the bomber. This cloud can be seen in the figures published on the page 159 of LaViolette's book.

We need a high voltage to move the bomber and a lot of energy to create a plasma cloud on a distance 10 m or more since the breaking threshold for the electric field is E=3 MV/m. There is a clue how to produce such a hight voltage by noting that the creation of the plasma is pulsated at a very low frequency as one can see on the movie taken during the flight of the B-2 bomber. Let us consider the problem in two steps:

The exhaust gas is ionized, the capacity C_1 formed by the wings and the ionized gas is charged with a charge $Q=C_1V_1$, then we switch off the ionization of the exhaust gas, the capacitor C_1 decreases to a value C_2, since the charge Q is conserved, the preceding relation:

becomes $Q = C_2V_2$, we get the ratio: $\beta=\frac{C_1}{C_2}=\frac{V_2}{V_1}\rangle\rangle 1$ *(56)*

by using such a process, we can multiply the initial voltage by a factor 5−25. We tested the principle with a plasma tube with success but the factor β was never greater than 5.

The electrostatic energies stored in the capacitors C_1 and C_2 are given by the relations:

$$E_1=\frac{1}{2}C_1V_1^2=\frac{1}{2}Q^2/C_1 \quad E_2=\frac{1}{2}C_2V_2^2=\frac{1}{2}Q^2/C_2 \qquad (57)$$

The result is a multiplication of the initial electrostatic energy:

$$E_2=\beta E_1 \qquad (58)$$

We know that the energy used $E_c=Q^2/C_1$ by the HV source to charge the capacitor C_1 is the double of the energy present in C_1, Cornille [66], therefore the efficiency is reduced by a factor 2. The above process is interesting since the efficiency of the system is above 100%.

We can estimate the stimulated force produced by the plane alone knowing that the absolute current I_a for a plane capacitor has for expression:

$$I_a=-\frac{C_1}{D}UV_2 \qquad (59)$$

For $C_1=10^{-9}$ F, $V_2=5\times10^6$ V and D=5 m, we obtain I_a=370 A. Knowing that the ejection speed has for value V=700 m/s, the relative current is given by the relation $I_a=n_eqSV$ where S=1 m^2 is the surface of the outlet and $n_e=10^{18}$ $electrons/m^3$ is the density of electrons, we get I_r=112A. The force is obtained from the relation $F=2I_rI_al_rl_d/(cR)^2$ with $l_r=D$=5 m, $l_a=U\tau_a$ and $R=\lambda_d=c\tau_a$, knowing that $Icgs=Imksa*c/10$, we get $F=8.3\times10^{10}$ dynes or $F=8.3\times10^5 N$ or 85 T, a very large force.

Other technologies found on Internet

Another detailed description of a possible craft able to fly in upper atmosphere referred to as the Fluxliner ARV is available in multiple documentaries available with a quick internet search, particularly in Valone paper [31]. This craft certainly use the effect discovered by Pagès and Brown.

Another controversial technology was developed by J. R. R. Searl who was living in England working for an electrical company. The first generator was built by Searl in 1952; it consists of a series of three stationary magnetic rings and magnetic rollers that go around the rings. The first ring contains twelve rollers, the number of rollers increases by approximately 10 rollers for each ring. Each roller rotates in itself while rotating freely around the rings. Each ring's set of rollers runs at two and half times the speed of the preceding set starting from the center. Therefore, each magnetic roller is a self-sustaining homopolar generator which produces a negative voltage at the surface of the cylindrical roller. While the rollers revolve freely between the rings, they induce charges in the plates that form the rings. The rings form a set of capacitors mounted in series. It is said that this generator produced an unexpected high potential about

100 kV at relatively low speeds. May be this generator works as a kind of Van de Graaf generator where the number of electrons is multiplied during the motion of the rollers. This technology has been replicated by a Russian team [67].

It is clear from the preceding theory that the Searl disks are propelled by the stimulated forces generated inside its generator. Therefore, the device produces its own energy along with the levity phenomenon. We have shown that the stimulated force occurs at a very high potential, it seems that Searl's device is able to generate this huge potential. In ordinary generators, the maximum potential is limited by the ionized breakdown of the air. The geometry and the arrangement of the Searl generator are such that flashover is eliminated until the generator is in vacuum and is then impossible.

Certainly, there are also several other features in the Searl technology that are not well understood at the present time. However, the basic principles used in the Searl technology can now be understood, once we recognize the existence of the stimulated force for translation and rotation. It is essential to realize that the stimulated force only applied to the center of mass of the craft. Therefore, this explain the reason why a passenger aboard the craft will not fell the acceleration inside the craft, how strong the acceleration can be. Searl did specific experiments in order to demonstrate the absence of any measured acceleration effect inside the disk.

There was certainly a need to apply a great deal of caution during the examination of these claims. However, it is interesting to report theirs findings and let the reader makes his own opinion since the description given in the web sites is particularly clear concerning the levitation effect.

REVIEW OF THE DIFFERENT EXPLANATIONS FOR THE THRUST

Let us review some explanations given in the literature:

Explanation by Earth's magnetic field

The force produced by the Earth's magnetic field can be easily calculated knowing that the Earth's magnetic field is about B = 0.5 gauss, the magnitude of this force is $\sqrt{1.5 \times 10^{-2}}$ dynes. Therefore, the thrust observed cannot result from the Earth's magnetic field since the magnetic force is smaller than the observed force force by several orders of magnitude and moreover is not applied in the good direction.

Explanation by interaction with the surroundings

Some authors invoke the interaction forces resulting from the induced charges produced in the surroundings by the high electric field to explain the observed. Four tests with the pendulum were done to reject the hypothesis that the force is induced by the surroundings. We can conclude safely that no induced forces in the surrounding environment can explain the existence of the observed force. As soon as the voltage is increased, one can see a thrust of the two balls in the direction of the positive ball.

Explanation by ion wind

We can think that ions and neutral molecules in air transfer momentum to the wires by collision. But by reason of symmetry, the transfer for the two wires must average to zero. We can also take into account the difference of mass between the positive and negative ions which amounts to a momentum transfer of electrons.

Since the negative and positive ions are attracted by the wires of opposite polarity. The transfer of momentum in the positive direction can be explained by a collision process due to the difference of mass between the two kinds of ions. If the motion results from a direct collision of both kinds of ions with the nude wires, then the transfer of momentum must be attributed to the difference of masses between the two kinds of ion, namely the masses of the electrons. The estimation done by several authors' leads to a force that is smaller by 3 orders of magnitude compared to what is measured.

Another approach is given In A. D. Moore's book [68] where it is stated that 6 10^{12} electrons per second leave the negative electrode for a corona amounting to 10^{-6} A. For a 1.5 mA leakage current, we obtain 9 10^{15} electrons/s which amounts to a mass transfer 8×10^{-12} g/s which is several orders smaller than the 4 g observed force. Moreover, this explanation can rejected definitively because the effect remains when the capacitor moves in Vacuum or oil as shown by several authors.

Explanation by electrostatic force

We have proved with the identity of Equation 15 that an explanation of the effect based of the electrostatic force and the application of Newton's third law is physically not correct since there is no mechanism to neutralize the space charge as in the ion thruster. However, let us calculate the force with the formula of Equation 26 for a current I=1.5 mA, knowing that the distance between the wires is d=14 cm, we get F=10^5 dynes or 100 g which is greater than the observed force 4 g. The formula 25 overestimates the calculation of the force since the magnetic force is U/c smaller than the electrostatic force.

To prove the existence of the stimulated force violating Newton's third law, we applied the high voltage to the electrostatic pendulum in an oscillatory manner in synchronism with the oscillatory motion of the pendulum. This is easily done with professional HV power supply since the magnitude of the voltage is controlled by a potentiometer that an observer can turn on and off since the period of the oscillatory motion is great and can be calculated from the formula T=2π (l/g)=2.8 s

It results in an amplification of the displacement of the pendulum which reaches a mag- nitude of x= ±5 cm. From the theory explained above, the existence of the stimulated force is proved because the magnitude of the force increases with each oscillation implying that an external force is doing work. This work is neither done by an observer as any parent has done when pushing the swing with their child on it nor by the power supplies. On the contrary, the average power P=VI given by the power source decreases almost by a factor 2 and at the same time, the kinetic energy increases by a factor 69.

DEPENDENCE OF THE FORCE ON THE EARTH MOTION IN SPACE

The formulation of Equation 20 or Equation 21 indicates that the force depends on the direction of the Earth motion through space. Therefore, a change of the force must be observed if measurements are performed over a long period of time which is the case as shown by several authors.

Brown experimental work

T.T. Brown was the first author to speak of the effect ignoring the work of Trouton- Noble in 1903 when he wrote:"In subsequent years, from 1930 to 1955, critical experiments were performed at the Naval Research Laboratory, Washington, DC.; the Randall-Morgan Laboratory of Physics, University of Penna., Philadelphia; at a field station in Zanesvill, Ohio, and two field stations in Southern California, of the torque was measured continuously day and night for many years. Large magnitude variations were consistently observed under carefully controlled conditions of constant voltage, temperature, under oil, in magnetic and electrostatic shields, not only underground but at various elevations.

These variations, recorded automatically on tape, were statistically processed and several significant facts were revealed. There were pronounced correlations with mean solar time, sideral time and lunar hour angle. This seemed to prove beyond a doubt that the thrust of "gravitors" varied with time in a way that related to solar and lunar tides and sideral correlation of unknown origin. These automatic records, acquired in so many different locations over such a long period of time, appear to indicate that the electrogravitic coupling is subject to an extraterrestrial factor, possibly related to the universal gravitational potential or some other unidentified cosmic variable."

Saxl experimental work

Saxl and Allen [12,13] worked with an electrically charged torque pendulum. Saxl used high voltage in the range of 5 kV on his very massive torque pendulum. The changes in period of oscillation measurements with solar or lunar eclipses, showed great sensitivity to the shielding effects of gravity during an alignment of astronomical bodies, helping to corroborate Brown's observation. The pendulum Saxl used was over 100 kg in mass. Most interesting were the "unexpected phenomena" which Saxl reported in his Nature paper. The positively charge pendulum had the longest period of oscillation compared to the negatively charged or grounded pendulum. Diurnal and seasonal variations were found in the effect of voltage on the pendulum, with the most pronounced occurring during a solar or lunar eclipse.

Cornille-Naudin experimental work

This effect can be tested more easily in the case of rotational motion of parallel-plate capacitor such as in the Trouton-Noble experiment. The experiments were performed in a laboratory located nearby Paris. These experiments were repeated dozens of time with similar test devices and different types of power supplies over a three-year period. The same types of results invariably came out. We shall only present here the exploratory side of this research so as to encourage the replication of the TN experiment by academia and other members of the scientific community.

Our basic experimental set up was built along the following lines: a parallel-plate capaci- tor 500 pF was manufactured by fixing together two conducting aluminum foils 190*150 mm 0, 33 mm thick on either side of a transparent, non-shielded insulating plate of Plexiglas $250 * 210$ mm, 2 mm thick, ϵ_r=4. This capacitor was suspended from the ceiling of by a thin nylon thread l=1.5 m. A hole, diameter 0.5 mm lined up with the center of mass of the capacitor, perforated the plate of Plexiglas 10 mm away from the top edge. The thread was attached to the capacitor by means of a node, and fixed to the ceiling so as to reduce frictional forces. The suspended capacitor could rotate freely either side on its vertical axis, without being significantly affected in its rotational motion by the mechanical counter torque originating from the suspending fibber. The wires feeding the capacitor with high voltage were coated. Two variants of this basic device were used, thus enabling us to obtain three different manifestations of what seems to be the same underlying effect.

Test 1: The wires feeding the capacitor were connected to the center of the plates. Our first qualitative experimental results were obtained back in 1996 and 1997 with a Wimshurst generator. This type of generator is known to produce high voltage 70 kV and very low currents ≈ μA. Any time the experiment was repeated, our capacitors sought a position of stable equilibrium in the East-West direction, where they remained "locked" until discharged. The total torque was subsequently demonstrated to be negligible for a symmetric and homogeneous distribution of charges over the plates, provided that the voltage used in the experiment were low. The observed effect was also demonstrated to be extremely weak if the charges distributed over the plates were the only charges involved in the calculation of the effect. Indeed, it appears that the structure of space charges inside the plates and the polarization of the dielectric material can significantly affect the generation of the observable torque when the two following criteria are met: the applied voltage must be higher than 25kV and a small leakage current must exist inside the dielectric material.

Test 2: We employed a Wimshurst generator. The phenomenon of electrical influence was chosen as the primary mechanism for feeding the capacitor. A coated electrical wire, top bare, neighbored a rotating distributor, these two elements being distant from each other. The distributor was a flat, disc-shaped device attached to the suspending fibber, enabling us to benefit from the inertia effect. The capacitor would gain momentum whence charged, and discharged when it reached its calculated, stable position of equilibrium. We thus observed a continuous rotation of ≈ 10 rpm.

Test 3: Quantitative experimental results were obtained with a shielded, grounded bipo- lar power supply, two Glassman HT8 HV generators. With such generators, voltage and potential differences were controlled, monitored and reached a maximum value of 50kV. Currents could be monitored with an accuracy of 1%. Test 3 consisted in a slightly modified version of test 2, where the segmented distributor was replaced by a continuous distributor. A continuous rotation was observed as soon as the HV power is turn on. When the experiment was started, the plates of the capacitor were lined up with the $NNW - SSE$ direction $\theta = -45^{\circ}$. The West-hand plate was negatively charged while the East-hand plate was positively charged. A "trigger effect" was observed when the potential difference reached a critical value of ≈ 25 kV. The capacitor was then set into motion clockwise. The first half-turn was completed in 13 s or 2, 3 rpm

while the second half turn in 9 *s* or 3, 3 *rpm*. During the cruise regime, i.e., before the rotation of the capacitor was curbed and inhibited by the mechanical counter torque originating from the torsion fibber, the capacitor was found to rotate at 6 *rpm*.

We discovered that the direction of rotation of the suspended, parallel-plate capacitor had changed between April-June and early September 1998. To our extreme puzzlement, a new change in the direction of rotation was observed "live" on September 23, 1998, i.e., the day of the autumnal equinox. The "ecliptic crossover" is physically impossible to perform since the Earth never crosses the plan its defines with the Sun. However, we did observe that the direction of the rotational motion of the suspended parallel-plate capacitor would change when the Earth crossed its equinoctial positions. However surprising, this experimental result must be compared to Allais' statistical analysis of Miller's chronological series. Among others, Allais demonstrated that Miller's optical an ether drift observations would reach their climax when the Earth crosses its equinoctial positions [69] in particular. All these experimental results were published in an international conference STAIF 2000[41].

DISCUSSION AND CONCLUSION

We reviewed in this paper, over a 149 years period of time, many experiments done throughout the world showing the rectilinear and rotational motion of material objects when they are submitted to external voltages. These experiments have been totally ignored by the scientific community except for the last 20 years where the lifters experiments and theirs publications on web sites finally raise the interest of some physicists. May be, we can explain this lack of interest by the fact that no credible explanation was given to justify these motions.

Finally, we explain the reasons why these motions are possible within classical physics by noting that the Lorentz's force violates Newton's third law due to the magnetic force. All the experiments done with capacitors supplied with high-voltage and low-current or high-current and low-voltage prove the existence of stimulated forces violating Newton's third law. The rectilinear and rotational motion has been observed for capacitors moving in vacuum or oil and also for plate capacitors with a dielectric where no ionization is possible. Therefore, the experimental evidence concerning these forces cannot anymore be denied and should lead to important technical applications concerning space propulsion in the near future and also a better comprehension of physics.

ACKNOWLEDGMENTS

The author wishes to thank Dr. Loic Lamballais for a financial support for the publication of this paper.

REFERENCES

1. Cornille P. Review of the application of Newton's third law in physics. Prog. Energy Combust. Sci. 1999;25:161-206.
2. Xu H, He Y, Strobel KL, Gilmore CK, Kelley SP, Hennick CC, et al. Flight of an aeroplane with solid-state propulsion. Nature. 2018;563:532-535.
3. Pages MJJ. Le défi de l'antigravitation, Editions Chiron. Paris. 1974.
4. Mascart ME. Traité d'électricité statique, Vol. 1. G. Masson. Paris. 1876.
5. Jefimenko OD. Electrostatic Motors, Electret Scientific Company, P. O. Box No. 4132, Star City, West Virginia 26505, U. S. A, 1973.
6. Szames AD, L'Effet Biefeld-Brown: la plus grande découverte scientifique du XXe siècle, Coll. Histoire secrète de l'antigravit´e (Vol.1), A. Szames Ed., 451, Rue d'Aguesseau, 92100 Boulogne, France, 1998.
7. Sigma R. Ether Technology: A rational approach to gravity-control. Cadake Indus- tries, Clayton, GA 30525, USA, 1977.
8. LaViolette PA. Secrets of Antigravity Propulsion. Bear & Company, One Park Street, Rochester Vermont, USA, 2008.
9. Valone T. Electrogravitics Systems, Integrity Research Institute, Washington DC, USA, 1994.
10. Cravens DJ. Electric propulsion study, AD-A227 121, AFSC, Edwards AFB, CA 93523-5000, August, 1990.
11. Talley RL. Twenty first century propulsion concept, May, by Veritay Technology Inc, New York, 1991.
12. http://www.amasci.com/caps/capwarp.html.
13. Saxl EJ. An electrically charged torque pendulum. Nature. 1964;203:136.
14. Saxl EJ, Allen M. 1970 solar eclipse as seen by a torsion pendulum. Phys Rev D. 1971;3:823.
15. Cornille P. The Lorentz force and the Newton's third principle. Can J Phys. 1995:73:619-625.
16. J.L. Nausin, http://jnaudin.free.fr/lifters/main.html, 2001.
17. J.L. Naudin, http://jnaudin.free.fr/html/ttbekp.html, 2002.
18. J.L. Naudin, http://lifters.online.fr/lifters/ascvacuum/index.html, 2007.
19. Bahder TB, Fazi C. Force on an Asymmetric Capacitor. Army Research Laboratory, Adelphi, MD, 2003.
20. Canning FX. Asymmetrical capacitors for propulsion, Institute for scientific research, IEEE Upper Monongalia Subsection of Pittsburgh, Section of IEEE, February 23, 2004.
21. Canning FX, Melcher C, Winet E. Asymmetrical capacitors for propulsion, Institute for scientific research. NASA/CR—2004-213312, October. 2004.
22. Buehler DR. Exploratory Research on the Phenomenon of the Movement of High Voltage Capacitors, J Space Mixing. 2004;1-22.
23. Musha T. Explanation of dynmical Biefeld-Brown effect from the standpoint of ZPF Field. JBIS. 2008;61:379-384.
24. Andersen NP, Larsen KF. The Electrostatic Levitation Unit. Technical University of Denmark: FYS Special Project, 10064, June 23, 2008.
25. Wilson J, Perkins HD, Thompson WK. An Investigation of Ionic Wind Propulsion, NASA-TM-2009-215822, December, 2009.
26. Koziell L, Zhao L, Liaw J, Adamiak K. Experimental Studies of EHD lifters, Proc. ESA Annual Meeting on Electrostatics. Electrical and Computer Engineering Dept. Gannon University, Erie, USA, 2011.
27. Zadeh MS. Measurement of ion mobility in dielectric liquids, Master of Science Thesis in Electric Power Engineering, Department of Materials and Manufacturing Technol- ogy, Division of High Voltage Engineering, Chalmers University of Technology, Go¨teborg, Sweden, Report No. 66/2011, 2011.
28. Ieta A, Schrecengost Z, Chirita M, Mills J. Corona wind visualization in an asymmetric capacitor using liquid nitrogen. Proc Joint Electrostatics Conference, 2012.

29. Chen M, Rong-de L, Bang-jiao Y. Surface aerodynamic model of the lifter. J Electrostat. 2013;71:134-139.

30. Einat M, Kalderon R. High efficiency Lifter based on the Biefeld-Brown effect. AIP Advances. 2014;85.

31. Valone TF, Review of Electrogravitics and Electrokinetics Propulsion. International Journal of Geosciences. 2015;6.

32. Monrolin N, Plourabou ́e F, Praud O. Electrohydrodynamic thrust for in atmosphere propulsion. AIAA Journal. 2017;1-10.

33. Cornille P. Making a Trouton-Noble experiment succeed. Gal Electrodynamics. 1998;9:33.

34. Cornille P. Jean-Louis Naudin and Alexandre Szames, Way Back to the Future: Why Did the Trouton-Noble Experiment Fail and How to Make it Succeed, Paper presented at the Sixth Conference on the Physical Interpretations of the Relativity Theory PIRT., London, UK, September 11–14, Forthcoming. 1998.

35. Cornille P. A linear Trouton-Noble experiment which shows the violation of Newton's third law". Hadronic J. Supplement. 1998;13:191-202.

36. Cornille P, Naudin JL, Szames AD. Way back to the future: why did the Trouton-Noble experiment fail and how to make it succeed, 81, Physical Interpretations of Relativity Theory VI Eds. M. C. Duffy, Imperial College, London: 11-14 September, British Society for the Philosophy of Science, 1998.

37. Cornille P, Naudin JL, Szames AD. Stimulated forces demonstrated: why the Trouton-Noble experiment failed and how to make it succeed, Space Technology & Applica- tions International Forum, Albuquerque NM, 1999.

38. Cornille P, Naudin JL, Szames AD. Stimulated forces demonstrated: Why the Trouton-Noble experiment failed and how to make it succeed. Electric Space Craft. 1999;28:14.

39. Cornille P, Naudin JL, Szames AD. Stimulated Forces Demon- strated: Why the Trouton-Noble Experiment Failed and How to Make it Succeed, Paper presented at the Space Technology and Applications International Forum STAIF., Albu- querque, NM, USA, January 31–February 4, Forthcoming, 1999.

40. Cornille P, Naudin JL, Szames AD. Report on a replication of the Trouton-Noble experiment which successfully shows a stimulated torque, 180, Galileo back in Italy II: The return of rationality in modern science Bologna, 26-28 May, Andromeda, Via S Allende 1, 40139 Bologna, 1999.

41. Szames AD, Cornille P, Naudin JL, Bizouard C. Simple Electrostatic Aether Drift Sensors (SEADS): New Dimensions in Space Weather and Their Possible Consequences on Passive Field Propulsion Systems. University of New Mexico Conference, Enabling tech- nology and required scientific developments for interstellar missions; Space technology and applications international forum, Albuquerque, NM in AIP Conference Proceedings. American Institute of Physics, 2000;504:1004-1017.

42. Semet C, Cornille P, Gabillard R. Capteur de d ́eplacement pour l'exp ́erience de Trouton-Noble, 4e, Colloque interdisciplinaire en instrumentation, C2I 2007, 255, 17-19 Oc- tobre, Nancy Universit ́e, Lavoisier. 2007.

43. Gabillard R, Semet C, Cornille P, Bizouard C. Replication of the Trouton-Noble Experiment. Chin J Phys. 2010;48:427-438.

44. Cornille P. On the difference between the Lorentz and Amp ̀ere force law in magne- tostatic. J of Physics A: Math. and Gen. 1989;22:4075.

45. Cornille P. On the meaning of special relativity in the Earth frame. Phys Essays. 1992;5:262.

46. Cornille P. Derivation of the ether from anomalies in Newton's third law, p.103, New Frontiers in Physics, Vol I (Eds. T.L. Gill), Hadronic Press, Palm Harbor, FL 34682-1577, USA, 1996.

47. Cornille P. Why Newton's third principle is the most important principle in physics, p.264, International Conference: Descartes and Scientific Thought 1596-1996, Eds. U. Barto- cci, Perugia, Edizioni Scientifiche Italiane, 1996.

48. Cornille P. Newton's third principle in Physics, Physics as a Science (Eds. G. Galeczki, P. Marquardt and J.P. Wesley), Hadronics Press, Inc., Palm Harbor, 1998;p:300.

49. Cornille P. Why free energy is mathematically and physically possible. Infinite Energy. 1998;4:50.

50. Cornille P. Newton's third principle in post-Newtonian physics-part I: Theory. Galli- lean Electrodynamics. 1999;10:43.

51. Cornille P. Newton's third principle in post-Newtonian physics-part-II: Interpretation and experiment. Gal. Electrodynamics. 2000;11:69.

52. Cornille P. Why Galilean mechanics is not equivalent to Newtonian mechanics. Special Issue of Infinite Energy on Einstein. 2001;39:73.

53. Cornille P. Advanced Electromagnetism and Vacuum Physics. World Scientific, 21, New Jersey, USA, 2003.

54. Assis AKT, Peixoto FM. On the velocity in the Lorentz force law, The Physics Teacher. 1992;30:480.

55. Seaver AE. Effect of a time varying electric field on the charge transport equation. Journal of Electrostatics. 2004;61:231-244.

56. Seaver AE. Some comments on the charge decay paradox in metals. Proc. ESA Annual Meeting on Electrostatics. Paper D4, 2008.

57. Redzic DV. Charges and Fields in a current carrying wire, Faculty of Physics, University of Belgrade, PO Box 368, 11001 Beograd, Serbia, Yugoslavia.

58. McDonald KT. Charge density in a current-carrying wire. Joseph Henry Laboratories, Princeton University, Princeton. 2019.

59. Arbab AI, Widatallah HM. On the generalized continuity equation, Department of Physics, Faculty of Science, University of Khartoum, P.O. Box 321, Khartoum 11115, Sudan, Department of Physics, College of Science, Sultan Qaboos University, P.O. Box 36 Al-Khod, Muscat, 123, Oman, February, 2010.

60. Arbab AI. On the electric and magnetic properties of conductors, Department of Physics, Faculty of Science, University of Khartoum, Sudan, 2010.

61. Ohanian HC. On the approach to electro- and magneto-static equilibrium, American. J of Physics. 1983;51:1020.

62. Seaver AE. An Equation for Charge Decay Valid in Both Conductors and Insulators, presented at Northwestern U., June 26-28 and published in Proceedings ESA-IEJ, Laplacian Press: Morgan Hill, CA. 2002;349-360.

63. Pohl HA. Non-uniform electric fields. Sc American. 1960;12:107.

64. Naudin JL, http://jnaudin.online.fr/elecpexp/elecpexp.html, 1997.

65. Naudin JL http://jnaudin.free.fr/pcnpend/html/pcespend.html, 2002.

66. Cornille P. How to minimize energy loss during an energy transfer between a source and a receiver. Boson Journal of Modern Physics 2018;4:299-312.

67. Roschin VV, Godin SM. An experimental investigation of the physical effects in a dynamic magnetic system, Tech Phys Lett. 2000;26:1105-1107.

68. Moore AD. Electrostatics, Doubleday & Company. Gaden city, New York, USA. 1968.

69. Allais M. L'Anisotropie de l'Espace. Clément Juglar Ed., Paris, France. 1997.