The Biefeld-Brown Effect: Misinterpretation of Corona Wind Phenomena

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Abstract

Originating from the early 1920's, the so-called Biefeld-Brown effect claims the generation of thrust in capacitor configurations exposed to high voltage. This thrust was claimed to be not due to corona wind phenomena and also exists in vacuum. These claims, although only published in patents, survived until recent publications for very advanced propulsion concepts. This paper reviews Brown's and similar work, as well as credible theoretical and experimental studies relating to the Biefeld-Brown effect. Moreover, an experiment was carried out to investigate any thrust not related to corona discharges. No thrust was detected within the accuracy of the experimental set-up. This puts new boundaries on any anomalous Biefeld-Brown force. Measurements indicate, that such anomalous force must be at least five orders of magnitude below corona wind phenomena and have at least a two orders of magnitude higher power-to-thrust ration compared to traditional electric propulsion thrusters. Hence, even if the effect exists, it would be not attractive for space propulsion. The obtained results suggest that corona wind effects were misinterpreted as a connection between gravity and electromagnetism.

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INTRODUCTION

Because the propellant onboard a spacecraft contributes to a large extend to the overall mass, propellentless propulsion with thrust levels at least comparable with existing electric propulsion thrusters could reduce current costs for space exploration dramatically. Conventional concepts along this goal use either electromagnetic tethers (utilizing the Earth's magnetic field) or photons (solar sails or laser propulsion). NASA launched the Breakthrough Propulsion Physics Project[1] in 1996 to investigate more speculative and exotic concepts, for instance possible connections between gravitation and electromagnetism, that could be utilized for propulsion. Appearing especially in the popular literature and internet homepages, one quickly finds the so-called Biefeld-Brown effect[2], which is claimed to show just such connection and promises a breakthrough in propulsion. Although the description of this effect is solely based on patent claims, and even the claims have been shown to be from a different origin that a connection to gravity, recent papers and patents (even by NASA) revive the Biefeld-Brown topic repeating the original claims[3-6].

This paper will review the literature including claims, theoretical and experimental studies related to the Biefeld-Brown effect. Moreover, an experiment has been carried out hoping to definitely settle the matter. The results, as well as all previous credible studies suggest, that the Biefeld-Brown effect, within the accuracy of the used instrumentation, is not a connection between gravitation and electromagnetism but a misinterpretation of corona wind phenomena. The phenomena is indeed used for new propulsion concepts, such as drag reduction systems for supersonic aircraft and future launchers.

The Biefeld-Brown Effect

Reviewing unconventional propulsion approaches[7] one finds the so-called Biefeld-Brown effect, discovered by Dr. Paul Biefeld and Thomas Townsend Brown in the early 1920's. They claim that if a capacitor was charged up to high DC potentials, it generates a thrust from the negative towards the positive terminal. The effect is enhanced by using an asymmetrical electrode configuration (see **Fig. 1**), causing an additional thrust in the direction from the low-flux to the high-flux region (in this case from the plate/disc to the wire) with respect to the ambient dielectric medium (usually air). In such configurations, also AC currents might be used to generate the effect. Brown claimed[8], that this effect remained even if the ambient medium was vacuum (up to 10^{-6} Torr). Hence, the thrust must be independent of electric wind effects usually created by corona discharges which are proportional to the air pressure[9]. Brown thought that this effect may show a possible connection between gravitation and electromagnetism. Unfortunately, nearly all his work is only summarized in patents and a popular magazine article[8,10-14] and not in scientific publications. Hence, these studies lack from detailed information about the behavior of this effect with respect to voltage, current or ambient pressure. No data is given at all about thrust amplitudes. Brown studied the effect by putting the electrode configuration on pendulums. Based on his empirical finding, the effect depends on:

1. The separation of the plates of the capacitor: the closer the plates, the greater the effect.
2. The dielectric strength of the material between the electrodes: the higher the strength, the greater the effect.
3. The area of the conductors: the greater the area, the greater effect.

4. The voltage difference between the plates: the greater the voltage, the greater effect.
5. The mass of the dielectric material; the greater the mass, the greater the effect.

Especially the last claim triggered Brown to think of a possible connection of gravitation with electromagnetism. At the time of his last patents, several other people filed patents with practically identical electrode configurations and propulsion claims[15,16]. In one of these, at least data is given about thrust levels and the electric power used. De Seversky reports[16], that an electrode configuration with an area of 0.1 m^2, a electrode separation distance of 5 cm using 20 kV at 0.5 mA produced a force of 50 mN. Contrary to Brown, he also stated that the thrust efficiency varied with humidity and air pressure. This is exactly what one would expect from a corona wind phenomena.

Christensen and Møller[17] built a similar electrode setup and published measurements of the obtained thrust in ambient air and compared with theoretical predictions due to the electric wind. The agreement was very good tending to explain the Biefeld-Brown effect as a purely electric wind phenomena. Similar theoretical studies have been performed by Cheng[18]. However, Brown claimed that the effect remained in vacuum and therefore is not due to ionization of the ambient air. This was left unconfirmed.

Two decades later, Talley studied Brown's electrode configurations in vacuum chambers up to 10^{-6} Torr in great detail[19,20]. He found no thrust in the case of a static DC potential applied to the electrodes. However he noticed an anomalous force during electrical breakdowns when a current was flowing.

This force due to currents in divergent electric fields (due to the asymmetrical electrode configuration) finds further support in 5-dimensional theories coupling the gravitational and electromagnetic field. Williams integrated a mass dependent 5th dimension into the relativistic Maxwell theory predicting a coupling between both fields[7,21]. In this theory, a divergent current flow results in an induced mass flow if the coupling constant is non-zero[22].

If we consider an asymmetrical electrode configuration similar to **Fig. 1**, and if we apply a sufficient high electric potential to initiate a corona discharge, a divergent current flows between both the wire and the plate/disc electrode. According to Williams's 5D coupling theory, such configuration would then cause an additional mass flow, which would additionally accelerate the ions in the discharge proportional to the divergence of the current. This results in a force that would accelerate the whole configuration with respect to its surroundings being a possible explanation for the claimed Biefeld-Brown effect.

If a corona discharge is ignited inside a sealed Faraday cage box, the known side effects of a discharge like the corona wind would only contribute to oscillations of the box. However, a successful 5D coupling would result in a movement of the whole box with respect to its surroundings. This measurement can clarify, if a Biefeld-Brown type of effect exists under electric breakdown conditions as indicated by Talley's report without using expensive vacuum facilities.

EXPERIMENT

The design of the used electrode configuration is shown in **Fig. 2** and the box configuration in **Fig. 3** respectively. Contrary to the Biefeld-Brown plate/disc and wire shaped design, a cylinder and a ring shaped electrode have been used similar to Christensen and Møller[17] to limit possible ion propulsion effects (electrons leaving the end of the wire electrode) and only concentrate on the corona discharge. Both cylinder and ring electrodes are made out of aluminum and are separated by four dielectric rods. The separation distance of 6 cm in air corresponds to the maximum applied potential of 40 kV to prevent sparks which would disturb the corona discharge.

The box is made out of wood and has the dimensions 50cm x 50cm x 50cm with a thickness of 5 mm at each wall. The walls are covered outside with an aluminum foil which is grounded and therefore acts as a Faraday cage. The electrode configuration is fixed to a bar made out of wood which is located in the middle of the box. The cables to connect the electrodes to the terminals outside are high voltage insulated. Both the cables as well as the box (through strings) are connected to two rings which are fixed through steel rods to a plate. This steel rods are finally connected to the terminals of a high voltage power supply (HEINZINGER HNCs 40 000-3ump). Therefore, the whole box including the cables can swing around the fixed rings.

This movement is measured using a laser displacement meter (KEYENCE LC-2400 W) as shown in **Fig. 4**. The laser was operated 105 cm away from the middle of the box to prevent possible electrostatic influence. The positioning data can be used to calculate, if the

corona discharge inside the box produces a mass flow which causes the whole box to move with respect to its surroundings. The force of the box can be derived from

$$F = m.g.\sin\alpha = m.g.\frac{\Delta x}{d} \tag{8}$$

where *m* is the mass of the box including the experiment and cables, *g* the acceleration in the Earth's gravitational field, *l* the length from the rings to the bottom of the box from where *Δx,* the difference from the box's position from it's zero position, is measured. The parameters during the measurement were **m=7.499 kg**, **l=70 cm** and **g=9.81 m/s^2**. With a sensitivity of the laser unit giving positions of ± 0.1 μm, the achieved accuracy of the force measurement was 10.5 μN. This is within the range of low thrust electric propulsion devices and is therefore representative to investigate, if an observed Biefeld-Brown effect could be utilized for space propulsion purposes. The potential on the HV power supply was manually increased from zero to approximately 38 kV and the positioning data as well as the potential and current information was transferred to a computer via a IEEE interface. The results are shown in **Fig. 5**.

DISCUSSION

The biggest difficulty during the experiment was to keep the oscillations from the box initially as small as possible. At the beginning of the measurement in **Fig. 5**, the oscillations where limited to approx. 50 μN which corresponds to 0.95 μm. When the potential was increased from 0 to 20 kV, the corona discharge ignited and a small current of approximately 0.01 mA started to flow. However, the oscillations remained constant.

During the next increase of the potential to its maximum at 38 kV, the discharge current was increased accordingly resulting in a maximum current of 0.6 mA. At this maximum, the box oscillations were increasing from 50 μN to 100 μN. The corona discharge created a corona wind which resulted in an air flow[9] circulating inside the box. This seems to explain the increase of the oscillations. After reducing the potential back to zero, the discharge current felt down very quickly and the oscillations were slowly reduced due to the conservation of energy. The most important result is, that the box always oscillated around the same mean position during the corona discharge with a maximum amplitude of 100 μN. This means, that no noticeable linear thrust was observed within the accuracy of the used instrumentation. If a linear thrust exists in the presented configuration, the data suggests that it must be below 10 μN. Considering the maximum power used (38 kV x 0.6 mA = 22.8 W) we can express the specific power to thrust ratio as

$$\frac{P}{F} \geq 2280 \text{ W/mN}. \tag{9}$$

Comparing this value to other highly efficient electric propulsion devices[23] like Hall, Ion or FEEP thrusters with power-to-thrust ratios ranging from 20-70 W/mN, we note that

this ratio is at least 2 orders of magnitude above current existing technologies. Therefore, even considering that such a linear thrust exists in the presented configuration and taking the advantage of a propellantless propulsion system into account, existing electric propulsion devices would be far superior. Calculating the maximum thrust due to corona winds, we use the measured expression by Christensen et al,

$$F = P \cdot \frac{l}{U} \cdot \frac{1}{b \cdot (1+\phi)} \tag{10}$$

where F is the thrust, l the electrode separation distance, U the applied potential difference, b the ion mobility (b_{air}=2.15x10^{-4} m^{2}V^{-1}s^{-1}) and ϕ the fluid performance parameter (ϕ_{air}=2x10^{-2}). This equation also explains quite well the behavior of the effect described by Brown.

Using again the maximum input power during the measurement, the calculated maximum thrust due to corona winds in dry air is 163 mN. This value is similar to the claim of de Severski in a Brown-type electrode configuration[16]. Comparing this value to our obtained upper limit for an additional effect of 10 μN, a possible gravitation-electromagnetism interaction must be at least 5 orders of magnitude below the electric wind effects. Vacuum tests by Talley[19,20] did not confirm the effect. Therefore, any thrust in vacuum chambers claimed by Brown was most likely a corona wind triggered by not sufficient outgassing of the electrode assembly in the vacuum chamber. Hence, the Biefeld-Brown effect in the claimed order of magnitude (movement of similar electrode configurations in vacuum and air) can not be confirmed. The results suggest that corona wind effects were misinterpreted as a connection between gravitation and electromagnetism.

However, corona winds are indeed used for advanced propulsion concepts such as drag reduction. There is a rich literature[24-27] reporting wind tunnel tests with active components, such as corona discharges, which may be utilized for supersonic aeroplanes or future launchers. Hence, the "Biefeld-Brown Topic" did not slip through mainstream research but is a well understood phenomena which might be indeed utilized for propulsion purposes – but not along its original claims.

CONCLUSION

Theory and experiments regarding the so-called Biefeld-Brown effect were reviewed and discussed. An experiment was carried out to investigate any linear thrust excluding corona wind effects. No linear thrust was observed within the accuracy of the used instrumentation. A possible connection between gravitation and electromagnetism which leads to a force due to the divergent currents used must be at least 5 orders of magnitude below the corona wind forces. A propulsion device based on this 5-dimensional concept would be at least 2 orders of magnitude less efficient than existing electric propulsion thrusters.

The results suggest, that corona wind effects were misinterpreted as a possible connection between gravitation and electromagnetism. The author hopes that the paper will help to put an end at a story that lasted some 80 years and still survived within the very recent literature.

ACKNOWLEDGMENT

The author would like to thank Prof. Becker from the International Space University for his support and the equipment to built a first setup. Many thanks go to M. Fehringer, who helped throughout the measurements in 1999 carried out at ARC Seibersdorf research. Many stimulating discussions with C. Belleval and C. de Matos were greatly appreciated.

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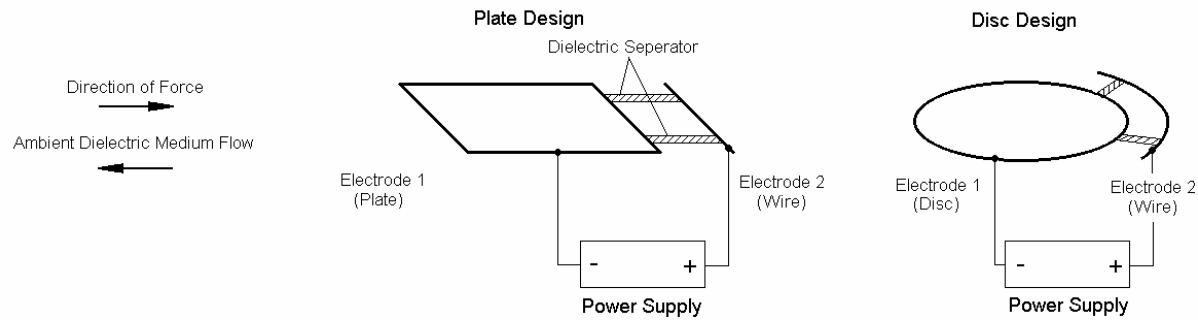

FIGURE 1. Brown's asymmetrical plate/disc-wire electrode configuration.

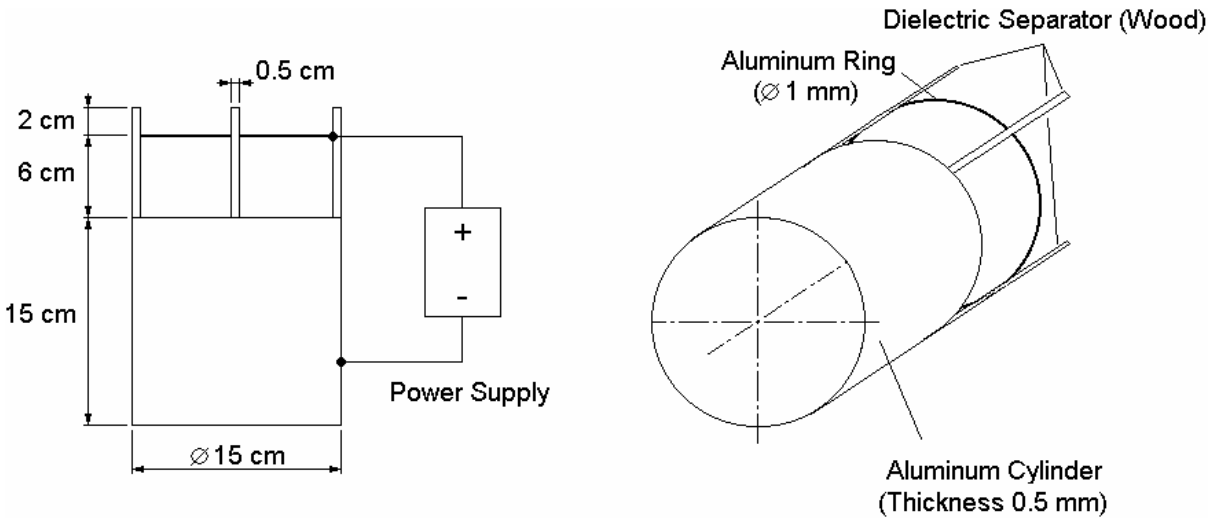

FIGURE 2. Electrode Configuration.

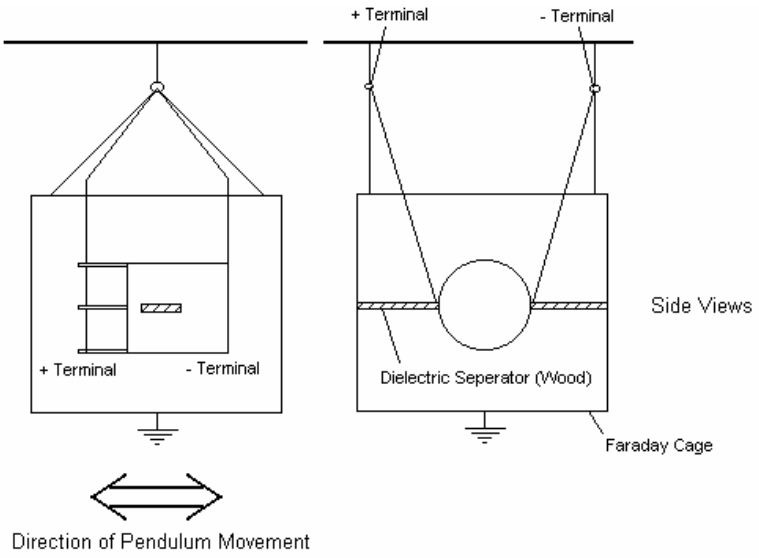

FIGURE 3. Box Configuration.

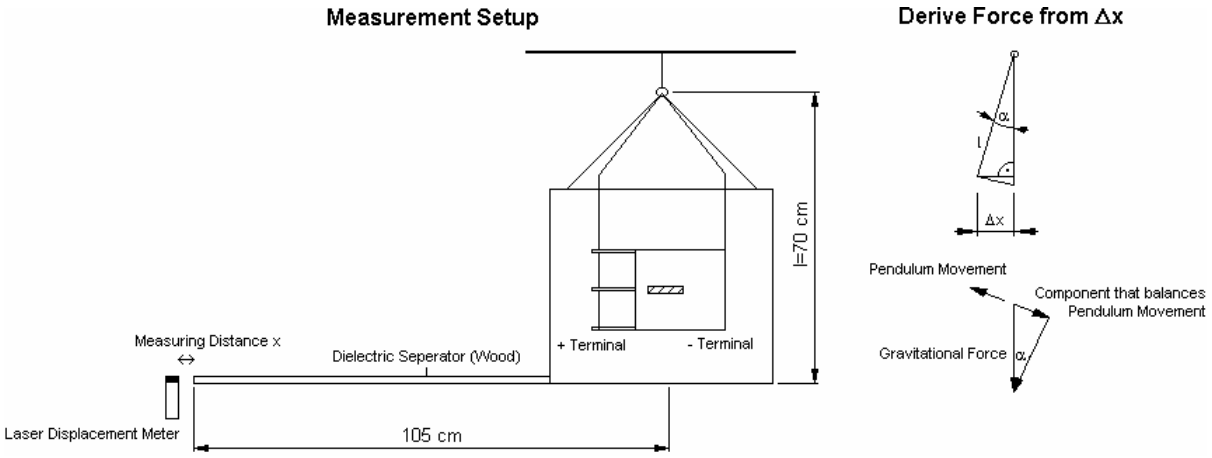

FIGURE 4. Geometry of Force Measurement.

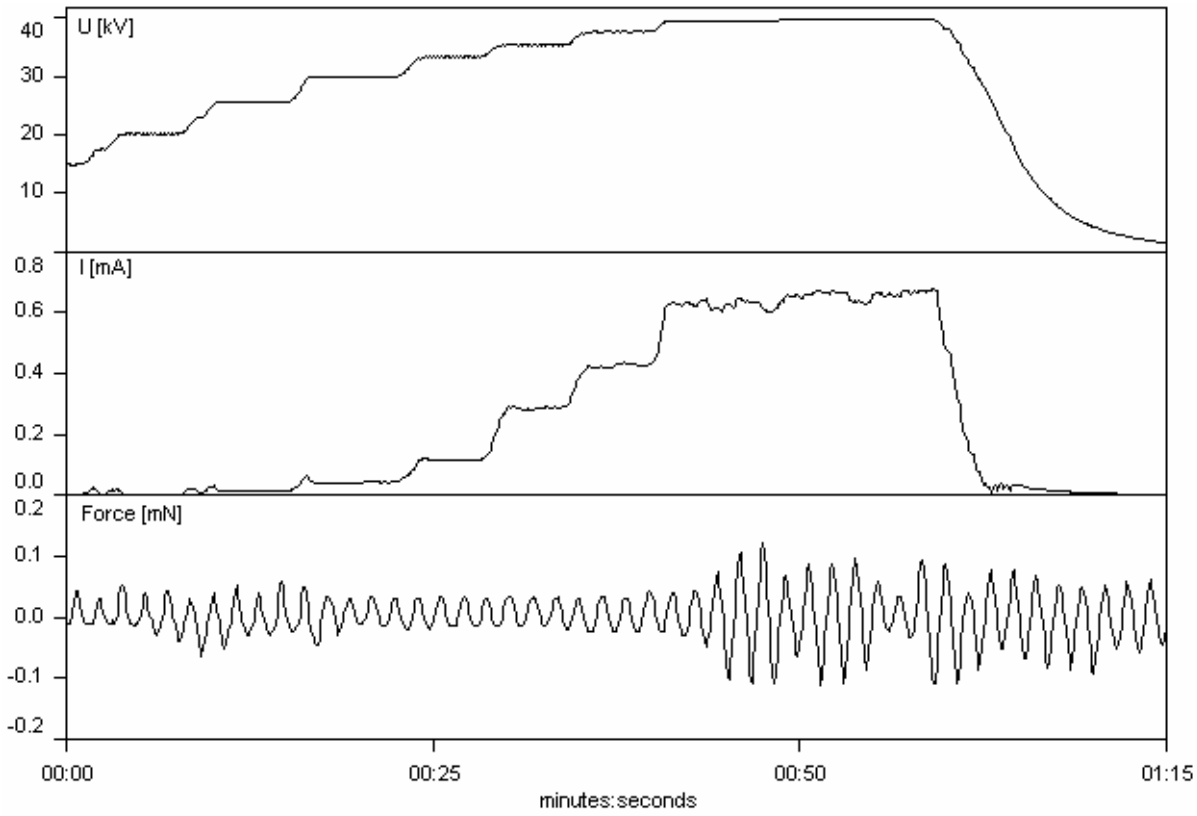

FIGURE 5. Measurement of Potential (top), Current (Middle), and Force (Bottom).