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Extracting electrical energy from the vacuum by cohesion of charged foliated conductors

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Any pair of conducting plates at close distances (<1 μm) experience an attractive Casimir force that is due to the electromagnetic zero-point fluctuations of the vacuum. A "vacuum-fluctuation battery" can be constructed by using the Casimir force to do work on a stack of charged conducting plates. By applying a charge of the same polarity to each conducting plate, a repulsive electrostatic force will be produced that opposes the Casimir force. If the applied electrostatic force is adjusted to be always slightly less than the Casimir force, the plates will move toward each other and the Casimir force will add energy to the electric field between the plates. The battery can be recharged by making the electrical forces slightly stronger than the Casimir force to reexpand the foliated conductor.

I. CASIMIR FORCE

In 1948 Casimir predicted that the electromagnetic zero-point energy fluctuations of the vacuum should have observable effects on macroscopic objects. Specifically, he predicted that there would be an attractive force between two conducting plates.[1,2] The Casimir interaction energy per unit area u between two conducting plates separated by a distance a, and the resulting force per unit area or pressure P, are

$$u=\frac{U}{A}=-\frac{\pi}{1440}\frac{hc}{a^3}\ , \tag{1}$$

$$P=\frac{F}{A}=-\frac{du}{da}=\frac{\pi}{480}\frac{hc}{a^4}\ , \tag{2}$$

where $h=6.626\times10^{-34}$ J sec and $c=3\times10^{8}$ m/sec. This is a fundamental force that exists in the vacuum between any pair of conductors that "may be interpreted as a zero point pressure of electromagnetic waves."[1]

Casimir's results were later expanded by Lifshitz to include forces between dielectrics. The force per unit area between two dielectric plates with a dielectric constant e when separated by a distance a is[3]

$$P_{dd}=\frac{F}{A}=-\frac{\pi}{480}\frac{hc}{a^4}\frac{(e-1)^2}{(e+1)^2}f(e)\ , \tag{3}$$

where $f(e)$ is a function that tends to 1.0 when e is very large and 0.35 when $e<4$.

The Casimir and Lifshitz equations take into account the retardation effects in the electromagnetic field. The equations apply down to separation distances corresponding to one radian of the shortest-wavelength radiation λ that interacts significantly with the conductor or dielectric,[3–5]

$$a_{\min}=\lambda_{\min}/2\pi\ . \tag{4}$$

When the separation is less than $a_{\min}$, then the equation for the pressure reverts to the nonretarded force previously calculated by van der Waals[6] and London[7] between atoms. For two plates, the pressure due to the unretarded electromagnetic vacuum-fluctuation force is[8]

$$P=\frac{F}{A}=\frac{C}{6\pi a^3}\ . \tag{5}$$

Where C is an empirical constant that depends upon the material in the plates.

II. EXPERIMENTAL VERIFICATION OF THE CASIMIR FORCE

The experimental measurement of the Casimir force has been attempted a number of times with varying degrees of success. Usually the experiment is carried out between a curved dielectric lens and a flat dielectric plate[9] or two crossed dielectric cylinders.[10] The closest separation distance at which force levels have been measured was 1.4 nm using two crossed cylinders of mica.[10] The data show good agreement with the $1/a^4$ Lifshitz law from 30 to 20 nm with a break in slope at 15 nm changing to a $1/a^3$ London—van der Waals law from 10 down to 1.4 nm. At a separation distance of 1.4 nm, the measured force between the two mica cylinders was over 10 kN/m^2.

Good experiments on conducting plates have proved to be extremely difficult. Some recent experiments[11] used conducting surfaces made of flat silicon-crystal plates and amorphous silicon deposited on a glass lens. The force showed a $1/a^4$ dependence down to 300 nm. The data then deviated strongly, probably indicating a lack of surface smoothness.

Thus, although experiments on dielectric plates are in good agreement with theory down to very short spacing (and quite high force levels), there are no good experiments on metal plates down to the spacings (1—20 nm) that would show the predicted deviation from the $1/a^4$ retarded field law to the $1/a^3$ nonretarded field law. If new experiments could be carried out that demonstrate the existence of the very strong forces that theory predicts for conductors at separation distances of 20 nm and below, then these forces may be a new source of energy.

With recent advances in microcircuit technology, including the development of molecular-beam-epitaxy "atomic spray guns" that can lay down monolayers of atoms, it should now be possible to prepare samples of metals that are sufficiently flat to carry out Casimir-force experiments at separation distances of less than a nanometer. As far as is known, however, no such experiments are being planned.

III. EXTRACTION OF ENERGY FROM THE VACUUM-FLUCTUATION FIELDS

The Casimir force has some of the properties of the gravity force. It is purely attractive, independent of the material in the plates, and varies as the inverse power of the separation distance (although the variation with separation distance goes as a higher power than the gravity force).

There is no rigorous proof known that the vacuum-fluctuation field is a conservative field such as the gravity field. It is highly probable that it is conservative, however, otherwise it would be possible to design machines using the Casimir force that would allow an infinite amount of energy to be extracted from the vacuum.

Even if the vacuum-fluctuation field is a conservative field, that does not mean we cannot use it to obtain energy. The gravity field of the earth is a conservative force field and yet hydroelectric dams extract energy from the gravity field by using water coming from a region of high gravitational potential. In reality, of course, the energy extracted from a hydroelectric dam came originally from the sun, which evaporated the water from the oceans at a low gravitational potential and placed it in lakes at a high gravitational potential. The hydroelectric dam is then seen as a mechanism that uses the gravitational force of the earth as a "catalyst" to convert the gravitational potential energy of the water into kinetic energy that can in turn be converted into electricity by the turbines.

Hydroelectric dams are also used for energy storage. During times of low electrical demand, electricity can be used to pump water back up to a lake at high gravitational potential.

In the same manner, we can prepare a conductor in a foliated state which is in a "high" vacuum-fluctuation potential-energy state due to its large surface energy. We can then use the Casimir force as a means to convert the potential energy into kinetic energy as the foliated conductors cohere into a solid block of conductor that is in a "low" vacuum-fluctuation potential-energy state. The part of the hydroelectric turbines can be played by any mechanism that can convert kinetic energy into electricity. For this paper we will use the electrostatic repulsion force between two conducting plates with the same polarity of charge.

IV. VACUUM-FLUCTUATION BATTERY

We now propose a general concept for the construction of an aluminum-foil "vacuum-fluctuation battery." A large number of leaves of ultrathin aluminum foil are arranged in a stack with the leaves separated by a few micrometers. Each leaf is connected electrically to an active bidirectional power supply and the shape and position of the leaf is monitored by sensors. The power supply gives each leaf a small amount of positive charge. The positive charge will create an electrostatic repulsion between the plates that will keep the plates separated despite the attempt of the Casimir force to pull them together. This electrostatic suspension system is unstable, of course, so that the position of each leaf will have to be electronically stabilized by feedback from the position sensors through the active power supply. Stability may also be enhanced by unique geometries, or by partial mechanical support of the leaves using frames of insulating material such as aluminum oxide.

The voltages applied to the end leaf and the next-to-the-end leaf are then adjusted so that the electrostatic repulsion between these two leaves is lowered until the electrostatic force is slightly less than the Casimir force at that distance. The Casimir force will draw the two leaves together, doing work against the repulsive electric field between the plates. By adjusting the electric field to always be slightly less than the Casimir force, the active bidirectional power supply can extract electrical energy out of the plates as they move from large separation distances (where the vacuum-fluctuation potential energy is near zero), to the minimum separation distance (where the vacuum-fluctuation potential energy is large and negative). The process is repeated by the next leaf until the foliated conductor is condensed into a solid block. Alternately, all the leaves could be brought together at the same time, like compressing an accordion.

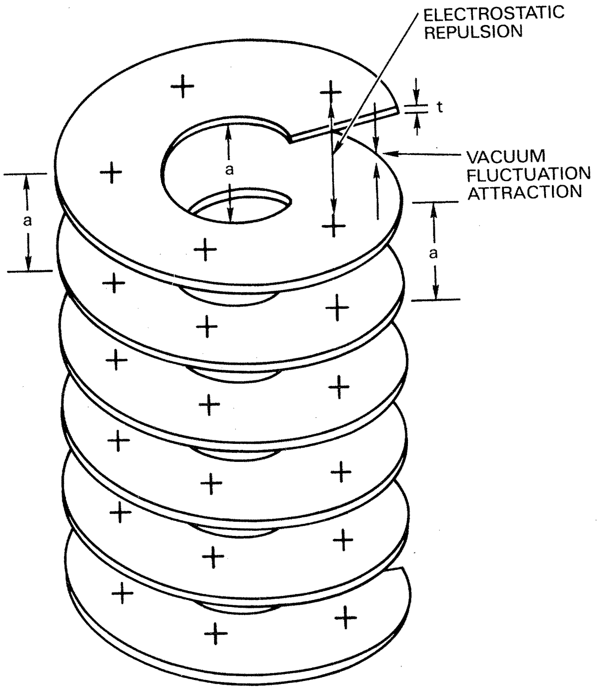

FIG. 1. Spiral design for a vacuum-fluctuation battery.

Thus, by cohering the multitude of aluminum leaves in a foliated conductor into a single block of aluminum under the careful control of an electronic servo system, it is possible to extract electrical energy from the vacuum.

If the collapse process is halted before the aluminum films cohere, then the vacuum-fluctuation battery can be "recharged" by making the applied electrostatic force slightly larger than the Casimir force. The leaves will be pushed apart at the cost of supplying energy from the bidirectional power supply.

Another version of the vacuum-fluctuation battery that might be easier to fabricate and have more stability would be a wide flat spiral of foil (see Fig. 1) built along the lines of a Slinky$^{\mathrm{TM}}$ toy. In this structure there is only one conductor to be contacted since each turn of the spiral acts against the neighboring turns. The spiral configuration allows a substantial compaction of the foil from large spacings to small spacings while maintaining uniform spacing.

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