

Apparent Endless Extraction of Energy from the Vacuum by Cyclic Manipulation of Casimir Cavity Dimensions

Dr. Robert L. Forward
Forward Unlimited
8114 Pebble Court, Clinton, WA 98236
Phone/Fax: 360-579-1340
Email: FUn@whidbey.com

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ABSTRACT:

In 1983, Ambjørn and Wolfram produced plots of the energy density of the quantum mechanical electromagnetic fluctuations in a volume of vacuum bounded by perfectly conducting walls in the shape of a rectangular cavity of dimensions a_1 , a_2 , and a_3 , as a function of the ratios a_2/a_1 and a_3/a_1 . Portions of these plots are double-valued, in that they allow rectangular cavities with the same value of a_2/a_1 , but different values of a_3/a_1 , to have the same total energy. Using these double-valued regions of the plots, I show that it is possible to define a "Casimir Vacuum Energy Extraction Cycle" which apparently would allow for the endless extraction of energy from the vacuum in the Casimir cavity by cyclic manipulation of the Casimir cavity dimensions.

INTRODUCTION:

One of the yet untapped possible sources of energy for advanced propulsion systems is the quantum mechanical electromagnetic fluctuation energy in the vacuum of empty space. Since the electromagnetic fluctuation energy exists everywhere except inside conductors, such an energy source could be tapped anywhere the using vehicle goes. This paper describes a method of cyclically manipulating the dimensions of a Casimir cavity which appears to result in the extraction of energy from the vacuum contained within the Casimir cavity during one portion of the cycle, without the need to supply energy back into the Casimir cavity vacuum during the other portions of the cycle which return the cavity dimensions to their original state.

CASIMIR CAVITY ENERGY:

One of the macroscopically observable effects of the electromagnetic fluctuations of the vacuum predicted by the theory of quantum electrodynamics, are the forces produced by the vacuum fluctuation energy on the conducting walls of a "Casimir cavity". Casimir (1948) predicted that the vacuum between two conducting metal plates would have less energy than a similar region of vacuum not bounded by conducting plates. He also predicted that the two uncharged

conducting plates would experience an attractive force. Those forces were measured by Lamoreaux (1997), and they agreed with the Casimir predictions to within 5%. The two closely-spaced conducting plates of the standard Casimir experiment are an extreme example of a more general Casimir cavity such as a sphere or box. For this paper we will concentrate on rectangular Casimir cavities, where the two closely-spaced conducting plates would be replaced with a rectangular cavity in the shape of a pizza box.

The energy density of the electromagnetic vacuum fluctuation energy in a rectangular Casimir cavity has been calculated in detail by Ambjørn and Wolfram (A&W 1983). They assumed an empty, perfectly conducting, rectangular box of dimensions a_1 , a_2 , and a_3 . They then calculated the "energy divided by volume" of the vacuum in the box for the case of a number of different theoretically possible fields. The case we will use is when the vacuum inside the cavity contains the quantum mechanical fluctuations of a "massless vector field". We will assume that the A&W phrase "energy divided by volume" is equivalent to "energy density", and that the phrase "massless vector field" is the electromagnetic field.

A&W (1983) found that the energy density in a Casimir cavity can be either positive, negative, or zero, depending upon the shape of the cavity. When

they plotted curves of constant energy density as a function of the ratio of two of the sides with respect to the third, or a_2/a_1 vs. a_3/a_1 , they produced the plot of Figure 1. The dark region to the lower left indicates cavity shapes with a positive energy density, while the lighter region to the upper right indicates cavity shapes with a negative energy density. The zero energy density curve runs from $a_2/a_1=3.3$ on one axis to $a_3/a_1=3.3$ on the other axis.

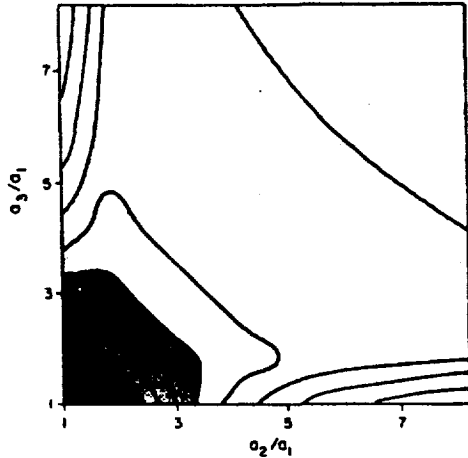


Fig. 1 - Plots of Constant Energy Density in a Rectangular Cavity of Dimensions a_1 , a_2 , and a_3 .

VARIABLE CAVITY VOLUME:

One of the more interesting aspects of the A&W plot are the convoluted, reentrant shapes of the constant energy density curves, especially in the negative energy region. These variations with cavity shape are not understood. As I will show later, they may give us a "handle" on extracting energy from the vacuum.

The zero energy density curve of Fig. 1 is of fundamental importance. Not only is the energy density zero for all Casimir cavity shapes on that curve, but the total energy in all the Casimir cavities with those shapes is also zero, no matter how big or small the scale of the cavity dimensions. The variation in shape, volume, and surface area of these special zero-energy Casimir cavity shapes is quite significant. As shown in Fig. 2, they range from a minimum volume "bread box" with relative dimensions of $1 \times 1 \times 3.3$, volume of 3.3, and surface area of 8.6; through a "shoe box" with relative dimensions of $1 \times 1.75 \times 3.4$, volume of 5.95, and surface area of 21.35; to a maximum volume "cake box" with dimensions of $1 \times 2.6 \times 2.6$, volume of

6.76, and surface area of 23.92. Why these specific shapes have zero energy density is unknown. Also shown in Fig. 2 is a cube, which has the smallest volume and the maximum positive energy density.

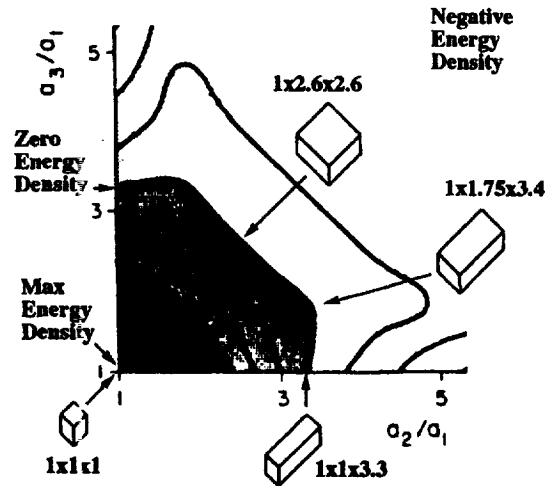


Fig. 2 - Variation of Cavity Shapes Along the Zero Energy Density and Zero Total Energy Curves.

In an effort to understand the shapes of the constant energy density curves, I calculated some constant volume and constant surface area curves and compared them with the zero and first negative value constant energy density curves. As can be seen in Fig. 3, the central portions of the constant energy density curves approximate a constant volume or constant surface area line, but deviate greatly when two of the dimensions are significantly smaller than the third.

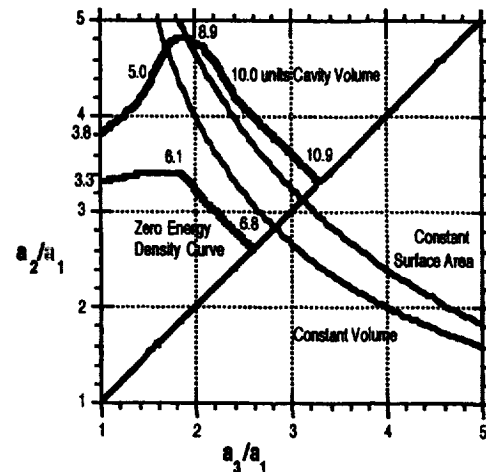


Fig. 3 - Constant Volume and Surface Area Lines

CASIMIR VACUUM ENERGY EXTRACTION CYCLE:

There are many conceivable vacuum energy extraction cycles which can be conjured up from studying Fig. 1, but the most convincing Casimir Vacuum Energy Extraction Cycle uses the zero energy density curve. The minimum volume rectangular cavity which lies on the zero energy density curve is the rectangle with relative dimensions of $1 \times 3.3 \times 1$. Since the energy density of this cavity is zero, then the total energy in the volume is zero, independent of the scale of the cavity. The vacuum inside this cavity shape seems to be similar to that of an unbounded vacuum.

We will now cyclically manipulate the dimensions of the cavity as shown in Fig. 4. We start with the cavity shape $a_1=1, a_2=3.3, a_3=1.0$. Holding a_1 and a_2 constant, we make an infinitesimal increase in the cavity dimension a_3 from 1.0 to 1.0+. This should require no energy since the Casimir energy in the cavity is zero, which usually means the forces on the walls of the cavity are zero. We have now moved into the region of the plot where the energy density in the cavity is positive. According to the usual interpretation, a positive energy density in a Casimir cavity produces an outward or repulsive force on the walls of the Casimir cavity. We now permit the walls determining the dimension a_3 to continue to move outward under the repulsive Casimir force. During this forced expansion mode, we can use either mechanical or electrical (Forward 1984) means to extract energy from the moving walls.

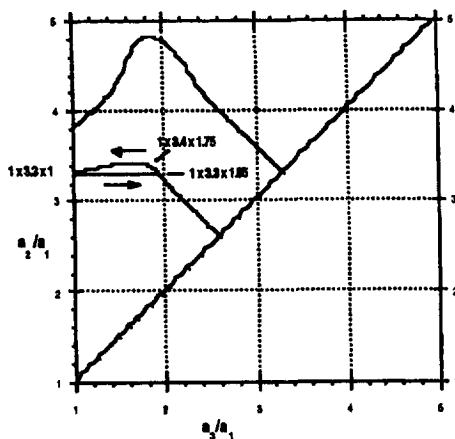


Fig. 4 - Zero Energy Curve Casimir Cycle

The outward force on the walls will grow larger as a_3 increases, then smaller, until a_3 reaches the point 1.85, but all during the change from 1.0 to 1.85, the force on the wall is outward, and energy can be extracted from the forcefully moved wall during that part of the cycle. Since the force on the wall is produced by the positive Casimir energy density of the vacuum, one can draw the conclusion that the energy extracted came from the vacuum.

With the shape of the cavity now at $a_1=1, a_2=3.3, a_3=1.85$, we are back to a cavity shape which is on the zero constant energy density curve. With zero energy density and zero total energy in the Casimir cavity, there should be zero force on the walls. We now hold a_1 constant at 1.0, and decrease a_3 from 1.85 to 1.75, while at the same time increasing a_2 from 3.3 to 3.4, in such a way as to have the shape of the resultant Casimir cavity always remain on the zero energy density curve. Since the forces on the wall are zero, no energy should be required to move those walls. We are now at the Casimir cavity shape given by $a_1=1.0, a_2=3.4, a_3=1.75$. We now continue the cycle by holding a_1 at 1.0, and decreasing a_3 from 1.75 to 1.0, while at the same time decreasing a_2 from 3.4 to 3.3 in such a manner that each intermediate shape corresponds to a point along the zero energy density curve. Since there is zero energy density in the Casimir cavity, there should be zero force on the walls and no energy should be required to move the walls during this portion of the cycle. We have now reached the beginning shape of $a_1=1.0, a_2=3.3, a_3=1.0$ and completed the cycle. During one portion of the cycle, when the walls determining a_3 were allowed to expand from 1.0 to 1.85 under the outward Casimir force, we were able to extract energy from the vacuum electromagnetic fluctuations in the Casimir cavity. During the rest of the cycle, when the shape of the Casimir cavity was adjusted so that the shape followed the zero constant energy density curve, there should be no Casimir forces on the walls of the cavity. If so, no energy was required to move the walls and no energy was returned to the cavity.

We thus seem to have identified a "Casimir Vacuum Energy Extraction Cycle" which obtains energy from the vacuum during one portion of the cycle, but is not required to return that energy during the remaining portions of the cycle, thus endlessly extracting energy from the vacuum with each cycle completed. This is an extraordinary conclusion if it is true. Extraordinary conclusions require extraordinary precautions during analysis as well as extraordinary proof obtained by

extremely careful experimental measurements. It could be the anomalous result was obtained because of either sloppy plotting by A&W (1983) or by my reading of more into their plots than is warranted. If one looks at the original plot of Fig. 1, the zero energy density line is very thick. Although it looks like the curve is double-valued at either $a_2/a_1=3.3$ or $a_3/a_1=3.3$, it could be that the actual data is always single-valued for all values of a_2 and a_3 . In contradistinction, the negative energy density curves are definitely double-valued, so the zero energy density curve is also probably double-valued. It is also possible that the A&W calculations are wrong, and the double-valued curves of constant negative energy density are wrong, and should look more like the single-valued quarter-circles seen in the positive energy density region. The recent calculations of Hacyan, et al. (1993), which generally agree with those of A&W, make that unlikely.

T.A.N.S.T.A.A.F.L ALERT!!!:

"There Ain't No Such Thing As A Free Lunch" -

This deliberately-illiterate "catch phrase" from one of Heinlein's books applies equally well to bar lunch counters, stock markets, grocery check-out stands, and physics. But... using the accepted theories and models for the behavior of Casimir cavities under the influence of the quantum mechanical electromagnetic fluctuations of the vacuum, I have described a method of manipulating the shape of a Casimir cavity in a cyclical manner so that I can extract either electrical or mechanical energy from the forces acting on the walls of the Casimir cavity, while at the same time periodically returning the Casimir cavity to its original state. Since such a procedure would generate more energy than it uses, it is highly probable that something is wrong. The most likely candidate is that the Casimir forces on the individual walls of a cavity with zero total energy are not zero. But I know of no reference to this. There may be other explanations.

CONCLUSIONS:

We have constructed a physics paradox using the presently accepted theories of the electromagnetic fluctuations of the vacuum. The resolution of that paradox, at a minimum, could lead us to a better understanding of the electromagnetic fluctuations of the vacuum, or, at a maximum, could provide an essentially unlimited supply of energy for space propulsion.

There is new physics to be learned in the accurate study of the electromagnetic fluctuations of the vacuum in Casimir cavities. Microelectronic fabrication techniques can construct the microscopic and sub-microscopic conducting wall cavities needed to put the existing theories to an accurate test. What are needed are some good ideas for experiments, backed up by good theoretical models for those experiments, which will produce numerical estimates which can then be checked by careful experiments.

ACKNOWLEDGMENTS:

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