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Apparent Method for Extraction of Propulsion Energy from the Vacuum

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APPARENT METHOD FOR EXTRACTION OF PROPULSION ENERGY FROM THE VACUUM

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ABSTRACT

In 1983, Ambjørn and Wolfram (Annals Physics, Vol. 147, pp. 1-32) published plots of the energy density of the quantum 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 energy density and 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. Such a device would allow for the onboard generation of propulsion energy anywhere in space from an energy source that is literally massless.

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.

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CASIMIR CAVITY ENERGY

One of the macroscopically observable effects of the electromagnetic fluctuations of the vacuum predicted by the theory of quantum electrodynamics, is the force produced by the vacuum fluctuation energy on the conducting walls of a "Casimir cavity". In 1948, Casimir[1] 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 recently measured by Lamoreaux[2] and the measurements 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. A cavity representative of the two closely-spaced conducting plates of the Lamoreaux

experiment would be a rectangular cavity in the shape of a pizza box.

The energy density of the vacuum electromagnetic fluctuation energy in a rectangular Casimir cavity has been calculated in detail by Ambjørn and Wolfram (A&W)[3]. They assumed an empty, perfectly conducting, rectangular box of dimensions a_1, a_2, and a_3. They then calculated the energy density of the quantum fluctuation fields in the box for a number of different theoretically possible fields including the electromagnetic field.

A&W found that the energy density of the quantum fluctuations in the electromagnetic field inside a rectangular cavity with perfectly conducting walls 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 Fig. 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.

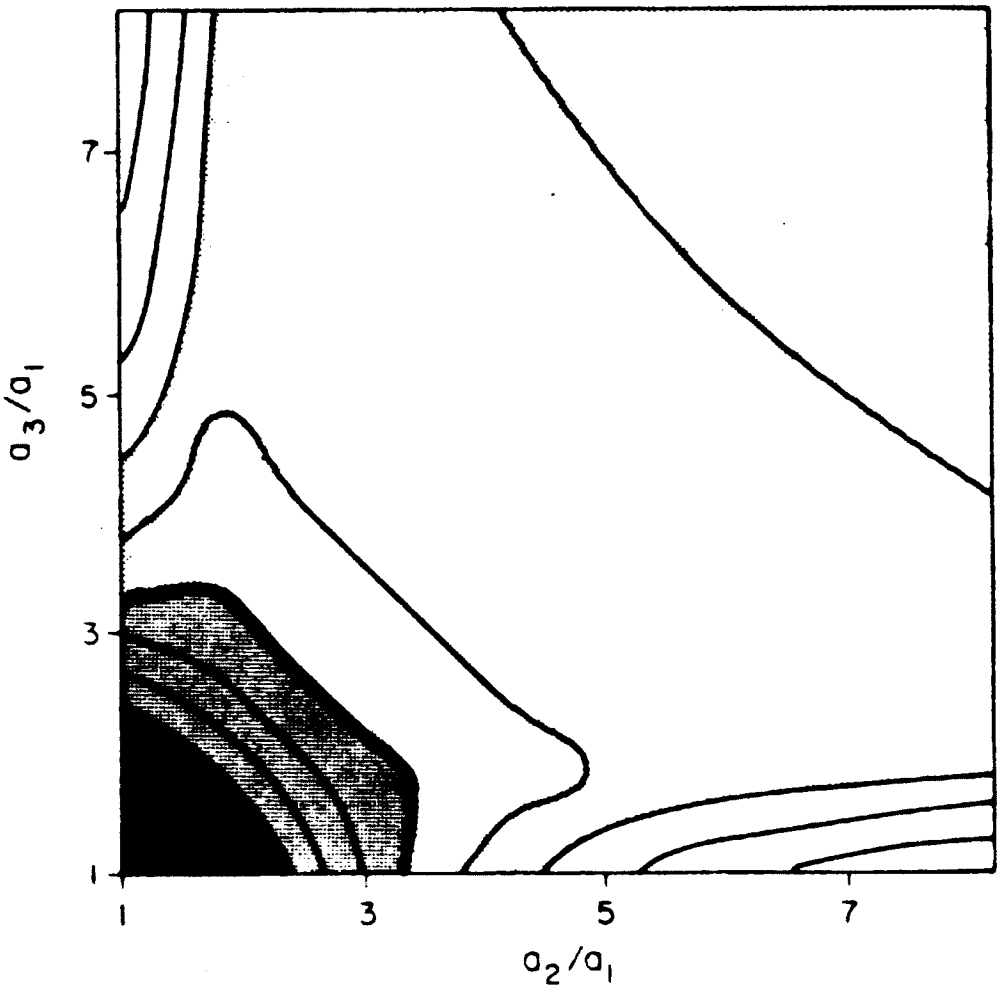

Fig. 1 - Plots of Constant Energy Density in a Rectangular Cavity of Dimensions a_1, a_2, and a_3.

VARIABLE CAVITY VOLUME AT CONSTANT ENERGY DENSITY

One of the more interesting aspects of the A&W plot of Fig. 1 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 by 1 by 3.3 length units, volume of 3.3 units cubed, and surface area of 8.6 units squared; through a "shoe box" with relative dimensions of 1 by 1.75 by 3.4 units, volume of 5.95 units cubed, and surface area of 21.35 units squared; to a maximum volume and maximum surface area "cake box" with dimensions of 1 by 2.6 by 2.6 units, volume of 6.76 units cubed, and surface area of 23.92 units squared. 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.

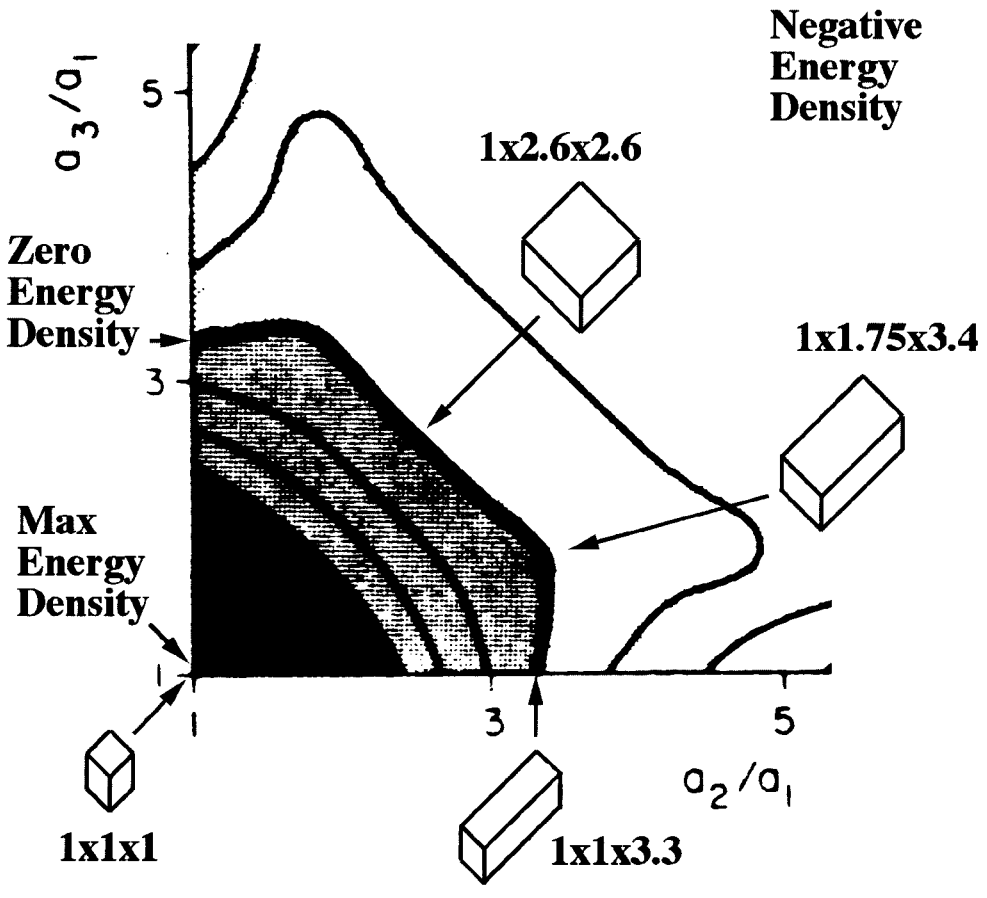

Fig. 2 - Variation of Cavity Shapes Along the Zero Energy Density and Zero Total Energy Curve.

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, as shown in Fig. 3. The minimum volume rectangular cavity which lies on the zero energy density curve is the rectangle with relative dimensions of 1 by 3.3 by 1. Since the energy density of this cavity is zero, then the total energy in the volume is zero. We will now cyclically manipulate the dimensions of the cavity. 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 should mean the forces on the walls of the cavity are zero. We have now moved into the region of the A&W plot where the energy density in the cavity is positive. According to the usual interpretation[1,3] of the relationship between the energy density in a Casimir cavity and the forces on the walls of a Casimir cavity, a positive energy density in a Casimir cavity should produce 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[4] means to slowly (thus avoiding any possible dynamic effects) extract energy from moving walls.

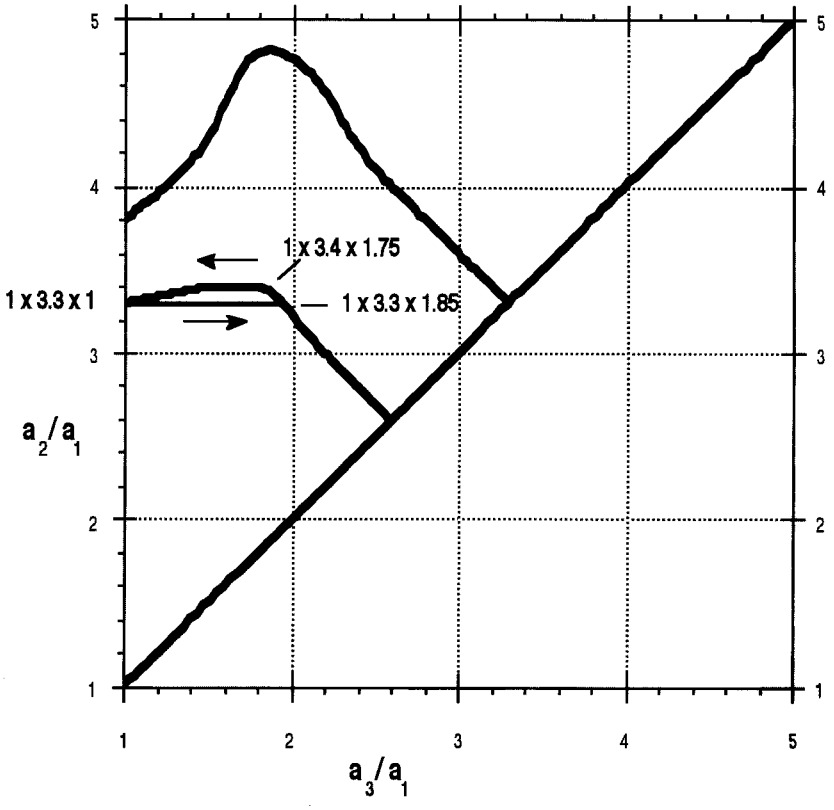

Fig. 3 - Zero Energy Curve Casimir Vacuum Energy Extraction Cycle

The outward forces on the walls will grow larger as a_3 increases and moves the cavity shape into a region of higher positive energy density, then the forces will grow smaller as the cavity shape approaches the zero energy density line at the point a_3=1.85, but all during the change of a_3 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 reasonably 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 should be 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 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, and 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 electromagnetic fluctuations of the vacuum 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 have been no Casimir forces on the walls of the cavity. If so, no energy should have been required to move the walls and no energy was returned to the cavity.

We thus seem to have identified a paradoxical "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, by just repeating the cyclic process of manipulating the dimensions of a Casimir cavity, it seems we could endlessly extract energy from the vacuum, gaining a certain increment of energy 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. An early draft of this paper was circulated to a number of experts in the field of quantum fluctuation energy and Casimir calculations. All agree with the author that there must be some flaw in the logic presented above, but the flaw is not obvious. It is hoped that the publication of this paper will bring this paradox to the attention someone clever enough to spot the error.

It could be the anomalous result was obtained because 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, Jauregui, and Villarreal[5] which generally agree with those of A&W, make that unlikely.

In any case, Stephen Wolfram, one of the co-authors of A&W, had an associate redo the A&W analysis using Wolfram's newer, more powerful Mathematica program. The reanalysis verified the A&W paper. The details of the numerics were slightly different, but the overall results remain the same, including the double-valued reentrant shape of the energy density curves. Thus, the paradox cannot be explained away by an error in the A&W paper, and the double-valued nature of the A&W zero energy curve still remains to cause the paradox. Wolfram points out, however, that Section 5 of A&W mentions there is a divergence in the field

strength at the walls of the cavity and this may be the source of the paradox.

Another explanation suggested for the paradox is that the Casimir forces on the individual walls of a cavity with zero total energy are not zero, although on page 19 of A&W[3] it specifically states that: "...we considered only the total Casimir energy of a cavity, and not the energy density as a function of position. Forces exerted on walls confining a field depend only on this total energy.". There may be other explanations for the paradox, but what they may be is not obvious.

CONCLUSIONS

We have constructed a physical paradox using the presently accepted theories for calculating the forces on the walls of an empty conducting rectangular box produce by the energy density of the electromagnetic fluctuations in the vacuum constrained by the walls of that box. 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 propulsion energy from literally nothing.

There is new physics to be learned in the accurate study of the electromagnetic fluctuations of the vacuum in Casimir cavities. Modern microelectromechanical fabrication techniques can construct the microscopic and submicroscopic 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 together will produce firm numerical estimates for the forces on the walls of conducting cavities of different shapes, which can then be checked by careful experiments.

ACKNOWLEDGMENTS

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CASIMIR CAVITY - REGIONS OF DIFFERENT ENERGY DENSITY

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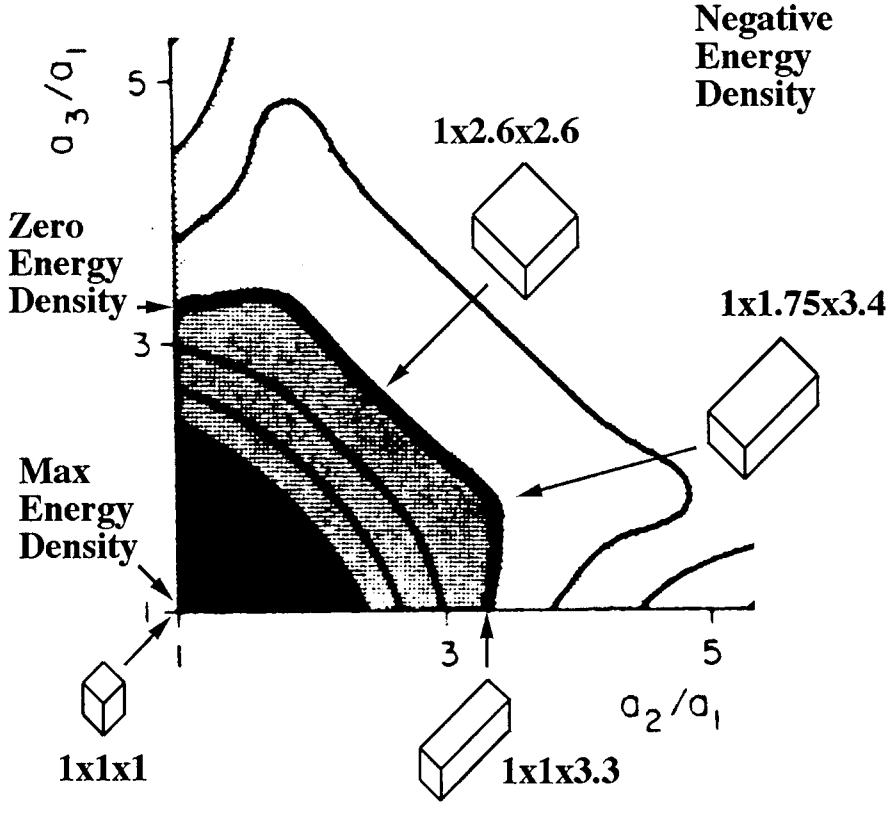
- Energy density positive
  - Walls repelled outward
  - Cube (1 x 1 x 1)
  - Sphere
- Energy density zero
  - No force on walls
  - Bread box (1 x 1 x 3.3)
  - Cake box (1 x 2.6 x 2.6)
- Energy density negative
  - Walls attracted inward
  - Pizza box (1 x >3.5 x >3.5)
  - Two "infinite" plates



CASIMIR CAVITY - LINES OF CONSTANT ENERGY DENSITY

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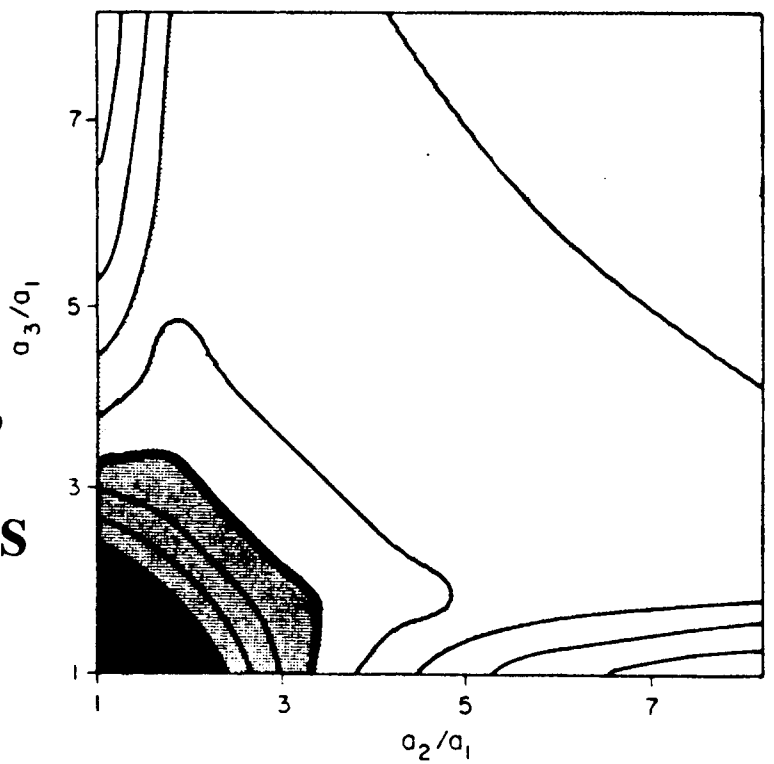
- Ambjørn & Wolfram
  - Annals Physics 147, 1983
  - (Yes, that Wolfram)
- Rectangular Cavity
  - a_1 x a_2 x a_3
- Massless vector field (EM)
- "Energy divided by volume"
- Constant energy density lines
  - Cavity volume varies
  - Cavity surface varies
  - Total cavity energy varies



CONSTANT VOLUME AND CONSTANT SURFACE LINES

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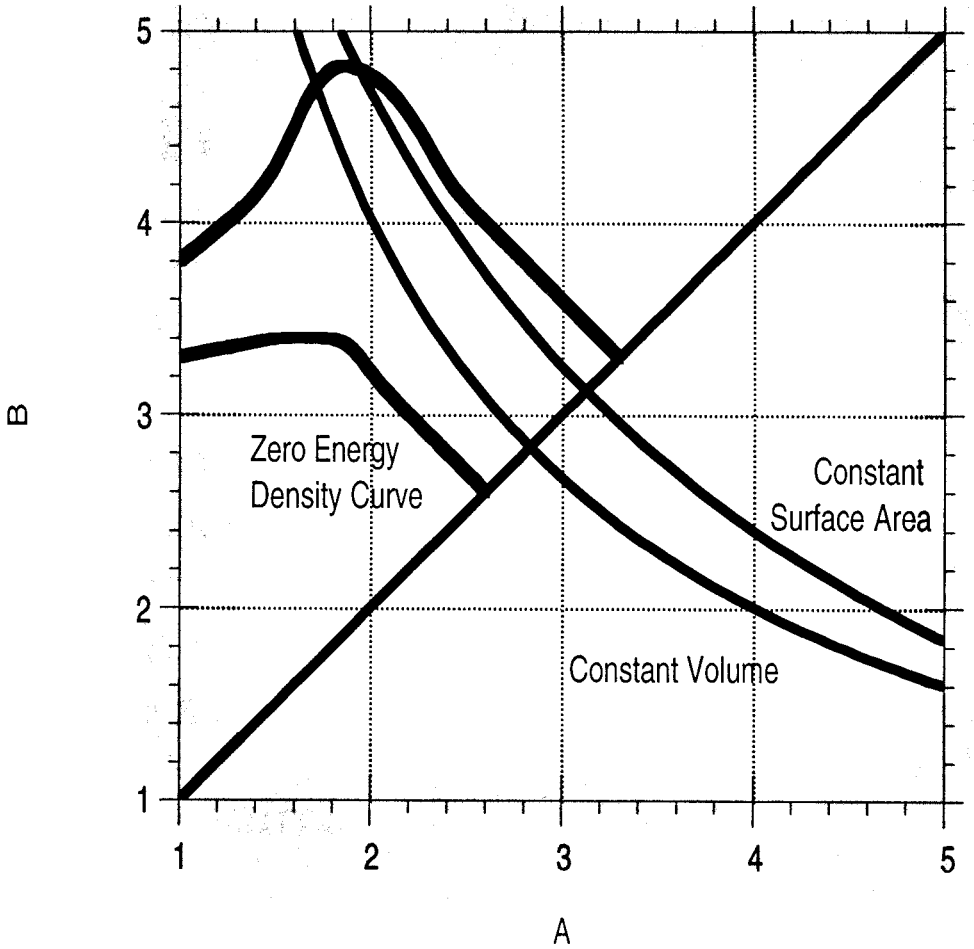

VACUUM ENERGY EXTRACTION CYCLE USING ZERO ENERGY DENSITY LINE

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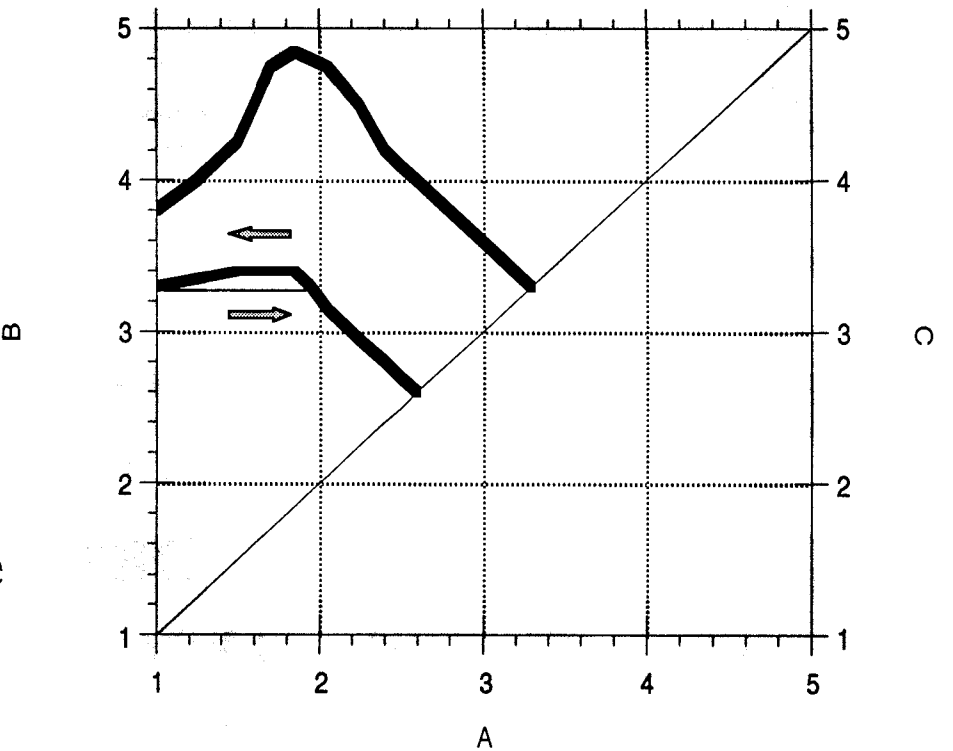
- Start at 1 x 1 x 3.3 point
  - Zero energy density
  - Zero total energy
- Increase a_2 from 1 to 1+
  - In positive energy region
  - Walls repelled outward
- Hold a_1 at 1, a_3 at 3.3
- Allow a_2 to move to 1.85
  - Extract energy from motion
- Stop at 1 x 1.85 x 3.3 point
  - Back on zero energy line
- Return along zero energy line
  - Through 1 x 1.75 x 3.4 point
  - No forces on walls
  - No energy input required
- Stop at 1 x 1 x 3.3 point
- Repeat



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

(There Ain't No Such Thing As A Free Lunch - Heinlein)

- **We know we can't get something for nothing.**
- **Where is the flaw?**
- **Concentrate on zero energy density curve.**
  - **Also zero <u>total</u> cavity energy for any size volume.**
  - **No forces on walls.**
  - **Should take no energy to move along curve.**
  - **But, both volume and surface area change.**
- **Possible solutions to paradox**
  - **Ambjørn & Wolfram wrong? No!**
  - **Surface energy of walls needs to be included?**
  - **Fluctuation energy does not exist in vacuum?**

WOLFRAM REANALYSIS

- **Wolfram had staff reanalyze cavity vacuum energy**
  - **Same equations**
  - **New Mathmatica**
  - **Some changes**
  - **Still double-valued**
  - **Paradox still exists**