ZPE-Casimir Inertial Drive

Horace Heffner July 2003

There has long been a search for a self contained infinite ISP inertial space drive. Such a drive is possible if inertia is indeed a zero point energy (ZPE), i.e. zero point field (ZPF) caused effect, as proposed by authors like Hal Puthoff. I suggest that if the zero point field can be excluded in part from a cavity, then inertia of free-moving bodies in that cavity should be reduced. The Casimir effect is produced by placing conductive surfaces close enough to exclude some of the longer of wavelengths of the ZPF, which is comprised of very short wavelengths. Plate separations greater than atomic dimensions do produce measurable Casimir attraction between conductive plates.

If the assumed principles are true, then an inertial drive can be made by directing a jet in to a Casimir cavity that is bounded such that the jet direction is fluidly reversed. A semicircular cavity shape should work nicely, using an inert gas, like helium or argon, as the propellant. Such cavities could be cut or etched into sandwiched layers of ultrathin dielectrics separating structurally strong metal layers. Alternately, they might be machined by electron beams.

Fig 1. shows a cross section of a single "ZPE thrust cell". An array of roughly semicircular groves of width roughly on the order of to 10^-6 meter are cut into a metallic surface. These are represented in Fig. 1 as the "Thin Cavity". A matched array of thick groves is cut into a strong low density faceplate that is placed over the array of thin cavities such that a continuous gas path is formed from one side of the plate to the other in each row cells, and the entire gas flow (for a given row) is directed through the thin cavity of each cell in that given row. The edge lateral walls of the thick cavities, noted as the "Cross Cavity Flow Barrier" in Fig. 1, are positioned so as to force the gas flow through the thin cavities. The two plates make a 2 dimensional array of thrust cells fed by gas at high pressure from the edges. The plates can be stacked to create a 3 dimensional array of thrust cells. The plates need to be made as light as possible, but the surface of the thin cell need to be conductive in order to exclude ZPF radiation of some frequencies from the cell.

The thrust cell widths might be on the order of 10^-5 m, and a layer of cells on the order of 10^-4 m. This gives a cell density of about 10^5 x 10^5 x 10^4 cells/meter^3 = 10^14 cells/m^3. The cavity depth might be about 10^-5 meter.

On each transition from thick cavity to thin cavity, the gas flow transfers momentum to the walls due to the angular acceleration. The gas "snakes" through the thrust cells. The momentum transferred in the thin cavities is upward in Fig. 1. The momentum transferred in the thick cavities is downward in Fig. 1. Since the same gas flows through all cavities in a row, the mass flow for the cells is identical. If there is no change of inertial mass in the thin cavities, then no net thrust results. However, if the inertial mass of the gas molecules/atoms is less in the thin cavities, then less momentum is transferred toward the top of Fig. 1 by the gas when in the thin cavities, and a net thrust develops downward in Fig. 1.

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       |       /        Thin Cavity             \
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       |    |                              |       |
       |    |      -->                     v       |            Thrust
       |    |               -->        \           |              |
       ------    ^                      \          ------         |
                /        ------------    v                        v
     Gas -->   /      ^  |          |         -->
                      |  |  Cross-  |
                         |  Cavity  |
         Thick Cavity    |  Flow    |  Thick Cavity
                         |  Barrier |
                         |          |     -->
     Gas -->             |          |            -->
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                 Entire Thrust Cell Layer Repeated
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                                |
                                v           Thrust cell layers can be
                                            stacked into 3D arrays.
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Fig. 1 - Cross Section Diagram of ZPE Thrust Cell Array

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If we use r=10^-5 m, and v= 10^-4 m/s, we get a centrifugal force F = m*(V^2)/r of about 10 N/kg. The gas flows through an orifice 10^-6m x 10^-5 m, or 10^-11 m^2. Argon is 1.784 g/l. At 10^-4 m/s the flow rate is 10^-14 g/s = 10^-17 kg/s. With an effective r of 10^-5 m, the mass of gas accelerating is the volume 10^-11 m^2 x 10^-5 m = 10^-16 m^3 times the density, or (10^-16 m^3)

(1.78x10^3 kg/(1000 cm^3)) (10^2 cm)^3/m^3 = 1.78x10^-10 kg. This gives a very rough thrust per cell of about (10 N/kg)(1.78x10^-10 kg)/2 = about 10^-9 N = 1x10^-10 kgf. Given 10^14 cells/m^3, we have (1x10^-10 kgf)(10^14 cells/m^3) = 10^4 kg of thrust per cubic meter of cells. However, if the inertial mass reduction is only 0.01 percent, then the thrust is only 1 kg per cubic meter of cells.

The principle problems and unknowns of the design at this point, then, are (1) the amount of inertial mass reduction that can be obtained, and (2) the flow velocity of gas that can be maintained through the thin cavity slots.

Update 7/26/2009:

The above calculation has some errors, and it is for much too large cells to produce much Casimir effect. The scale needs to be more on the scale of 10-7 m to have an effect. Here is a re-do of the calculation with approximate flow and pressure information:

Input pressure: 100 atm
Flow velocity: 0.0001 m/s
Equivalent pipe diameter: 1E-7 m
Path length: 1 m length
Density of argon at 100 atm: 0.167 kg/l = 167 kg/m^3
Viscosity of Argon: 0.02099 cP (centipoise)

Reynolds Number, R: 7.96 x 10^-5
Friction Factor, f: 8.04 x 10^5
Pressure at outlet: 495 psi
Pressure Drop: 974 psi
Volume Flowrate: 7.85 x 10^-16 l/s
Mass Flowrate: 1.31 x 10-16 kg/s

If we use r=10^-7 m, and v= 10^-4 m/s, we get a centrifugal force F = m*(V^2)/r of about 0.1 N/kg. The gas flows through an orifice of about 7.85x10^-15 m^2, at the flow rate of 10^-16 kg/s. With an effective r of 10^-7 m, the mass of gas accelerating is the volume (7.85x10^-15 m^2)*(0.5x10-7 m)/2 = 1.963x10^-22 m^3 times the density, or (1.963x10^-22 m^3) (167 kg/m^3) = 3.28x10^-20 kg. This gives a very rough thrust per cell of about (0.1 N/kg)(3.28x10^20 kg) = 3.28x10^-21 N = 3.34x10^-22 kgf. The cell size is about 2x10^-7 m, or about 5x10^6 per meter, or about 10^20 per m^3. Given 10^20 cells/m^3, we have (3.34x10^-22 kgf/cell)(10^20 cells/m^3) = 0.0334 kgf or 33.4 grams of thrust per cubic meter of cells. However, if the inertial mass reduction is only 0.01 percent, then the thrust is only 0.00334 grams of thrust per cubic meter of cells.

This design appears to be impractical. However, if a superfluid is used the density and velocity can be greatly increased, while simultaneously reducing the drive power requirements, except for refrigeration.

With sufficiently advanced nano-technology, the drive cells could each consist of a cavity with a thin disk that rotates half in the cavity and half out. The half of the disk inside the cavity would experience inertial mass reduction, and thus a reduction in centrifugal force. The actual mass changes occur at the entry and exits from the cavity, and thus have no instantaneous effect on the vertical centrifugal forces at that time. Any energy required or obtained entering the cavity due to Casimir forces is offset by the effect of opposite forces upon exiting the cavity.

A device based on cavity inertial mass change should work many orders of magnitude better using the spinning disk nano-technology approach, or possibly a using a superfluid. Both can increase the density and velocity by orders of magnitude, and thus the mass flow by orders of magnitude and the centrifugal force by orders of magnitude cubed.

These options all have the drawback that vast numbers of complex nano-structures need to be manufactured.

There is a superior method available for implementing the principle of applying anisotropic centrifugal force to Casimir cavity influenced inertial masses. This method consists of building up alternate layers of material, thin layers of conducting or super-conducting material, i.e. casimir cavity boundary layer material, while sandwiching between them layers of readily compressible material which is to be used as the inertial mass altering material. The method further consists of accelerating this material in one direction while compressed, and the other direction while not compressed. Compressing reduces the size of the Casimir cavities, thus increasing the effect and reducing the mass of the compressible material sandwiched between the plates.

The compressible material is likely best implemented as a structure of mixed property material, a vacuous (not dense) highly compressible mesh matrix material enclosing layers or pieces of the material that is to actually act as the inertial mass modifying material. For cooling purposes the mesh material might best be permeable to a cooling medium, or at least produce little heat from repeated compression and expansion.

Call the fully constructed material, which consists of layers of Casimir cavities, "thrust material". Having the material, it is then only necessary to compress it while accelerating in one direction, and release the compression when the material accelerates in the other direction. For example, the thrust material can be mounted around the edges of a wheel and compressed by piezo crystal action only when to one direction from the wheel axis. This produces a net force in the opposed direction. Diamond might make a good inertial mass modifying material due to its close packed structure, high electrical insulating properties, and excellent thermal conduction.

A fully solid state design is feasible. This design uses piezo crystals in two axes. The thrust material is compressed in the x axis for inertial mass reduction, and the much larger oscillated motion is produced by piezo action in the y axis. The thrust is developed in the y axis due to the reduced inertial mass on one half of the y axis cycle, caused by compression of the thrust material in the x axis direction during that half of the y axis cycle.

Update 8/9/2009:

Another design for a Casimir thruster, based yet again on the premise that matter within a Casimir cavity has reduced inertia, is based on oscillating a nano-structure beam into and out of a Casimir cavity. A microelectromechanical system (MEMS) beam can be electronically activated as a pendulum which oscillates in the MHz range. For example, see US Patent 6,531,668. An array of beams are created in a sheet array which can be placed over a plate with matching grooves in it located so as to act as cavities for the beams when acting as pendula. The beams then oscillate into and out of their repsective cavities. When the beams are down in their respective Casimir Cavities they all accelerate in a direction toward out of the cavity, and when out of the cavity they accelerate in a direction toward their cavities. This is an ideal arrangement for creating thrust in the direction towards out of the cavities, because the beam ends will have less mass when in the cavities.

For a very rough performance estimate, suppose silicon beams are used that are 100 microns long, thickness 2 microns, and width 5 microns. Assume only the far half of the pendulum is active in producing force, giving an active volume 50 microns long, with thickness 2 microns, and width 5 microns. Using 2.33 g/cm^3 for silicon, we have an active mass of 1.165x10^-12 kg. Assume it swings to a depth of 5 microns into the cavity, and at a rate of 4 MHz. Its total swing is 10 microns, so it covers that distance with an average velocity v of (10 microns)*(2 * 4 MHz) = 80 m/s. It changes from v to -v twice each 1/(4 MHz) = 2.5x10^-7 seconds, giving an average acceleration of 2*(80m/s)/(2.5x10^-7 s) = 6.4x10^8 m/s^2. Suppose the Casimir cavity inertial mass change is 1/100th the gross mass. The effective mass is then (1.165x10^-12 kg) * 0.1 = (1.165x10^-14 kg) . A net force f = m*a = (1.165x10^-14 kg)*(6.4x10^8 m/s^2) = 7.46x10^-6 N = 7.6x10^-7 kgf is produced.

Assume the cavity plates are 30 microns thick and the beam support plates are 30 microns thick, for a layer thickness of 60 microns or 16,600 layers per meter. Assume the beams are repeated every 10 microns laterally, or 100,000 per meter. Assume the beams are repeated every 150 microns, or 6,600 per meter. The number of beams per cubic meter is then 16,600 * 100,000 * 6,600 = 1.1x10^13. The total force per cubic meter of pendula is then (1.1x10^13) *(7.6x10^-7 kgf) = 8.3x10^6 kgf, or 8,300 metric tons. Now that is robust! If the Casimir cavity induced mass change is only 1/100,000, then the thrust per cubic meter of pendula is 8,300 kg. Still robust! This is clearly the preferred method.

Even at the fairly large element sizes chosen for performance estimating, this prospective performance is startling, though the example scale is too large to be maximally effective. Using nanotechnology the performance could be improved by orders of magnitude. For example, Casimir cavities of width less than 1/10 micron, 100 nanometers, would be necessary to achieve significant inertial mass reduction. This can be achieved by making smaller beams, but also by extending into parallel slits of width less than 100 nm, rows of planar protrusions from the beam, protrusions which are of less than 100 nm width extended from beams which are on the order of a micron wide. When this is done only a percentage of the pendulum mass is involved in actual inertial mass reduction, but, given the cubic power distribution of the zero point field, the effect should grow by at least the inverse square of the slit widths. The limits to advancement of technology of this kind are probably features on the order of 10-20 nm.

The density of silicon is 2.33 g/cm^3, or 2.33 metric tons per cubic meter. A thrust of 8.3 metric tons per cubic meter then readily permits building a craft capable of sustained acceleration above 1 g, or 9.8 m/s^2. Even without doppler shifting of the zero point field, this will result in exceeding light speed in c/g = 3x10^7 seconds, or about 355 days, one year. However, the zero point field will likely be blue shifted, thus increasing its energy density and thus the thruster performance.

The main problem with this design is that, though Hal Puthoff and others have theorized that inertial mass is reduced in a Casimir cavity, no one knows for sure if so and how much. This general design may provide a powerful test of Casimir cavity inertial mass reduction, down to very small percentages of inertial mass reduction.

A thruster can be used to drive the armature of a generator. Suppose a thruster can only withstand 10 g's, or about 98 m/s^2 acceleration. Given velocity v, and radius r, we have acceleration a:

a = v^2/r

and:

v = (a * r)^0.5

and power P is given by:

P = f * distance/time = f * v = f * (a * r)^0.5

For a specific thruster we have f and a as given, so power is limited only by the length of the radius at which the power is applied. If we have an arm radius of 10 m, and f = 8000 kgf, and a = 10 g, we have:

P = (8000 kgf) * ((10 g) * (10 m))^-2 = 2.46 MW

With 10 arms per level, and 10 levels per armature that is 246 MW per armature. If thrust can be bumped up to 80,000 kgf per thruster, then the power output per armature is bumped up to 2.46 GW. Alternatively, the g force and radius can be made larger. A significant unknown here is the power required to drive the pendula, but given they are driven in mechanical resonance, the power requirement should be small.