Casimir's Un-Attractive Theory & Transparent Quantum-Radiometers

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This paper proposes a simple experiment to prove whether or not the Zero-Point Energy Field has an existence independent of nearby matter, and perhaps to discover if we can use this energy. Many scientists believe that such an Independent Quantum-Vacuum would exert Radiation Pressure on matter. The proposed experiment would obtain a net force from the Quantum-Vacuum because, like Nichols Radiometer, one side of a solid plate reflects more electromagnetic radiation or/and other particles than the other side, not because the incident electromagnetic flux itself is greater on one side. Unlike Nichols Radiometer, which absorbs unreflected light, a Transparent Quantum Thruster is mostly transparent to the photons that are not reflected; these unreflected photons, exert little- or no- opposite force on the Thruster. Therefore, the only remaining forces come from the two competing radiation-pressures of the virtual photons that are reflecting unequally from the two sides, causing a net radiation-pressure to act toward the more reflective side, a pressure that is potentially millions of times more powerful than the very-small visible-light radiation-pressure that is experienced by Nichols Radiometer, (not Crookes Radiometer.)

1. Introduction

This paper proposes an experiment that may clarify the true nature of the Quantum-Vacuum. There is large contrast in what different scientists believe about the Quantum Vacuum or The Zero-Point Energy Field, or the Electromagnetic Quantum Flux. Many believe that its mathematical artifacts are little more than place holders or physically meaningless terms in their equations, to be discarded, along with other physically unreal mathematical artifacts. Many scientists believe that the Quantum-Vacuum, also called the Zero-Point Energy Field is little more than a reaction field that is caused when matter is disturbed by fields that the matter caused in the first place; for example, it is said that a charged particle accelerates and gives off a field that then comes back and acts on the particle, much as though it was encountering an independent field.

Other scientists, including Einstein, Bohr, Dirac and many other notables believed and many others still believe that the Quantum-Vacuum, also called the Quantum-Flux or the Zero-Point Energy Field is a vast sea of energy that fills all parts of the known Universe. Respected scientists such as John Wheeler thought that the Electromagnetic Quantum-Flux might form the very fabric of space itself.

Stochastic Electrodynamics (SED) is dedicated to finding ways to explain all of the fundamental forces in terms of Vacuum Phenomena, ranging from Gravity to the Nuclear Strong Force. This idea of Quantum-Flux Radiation Pressure has been suggested as the underlying causal mechanism for the fundamental forces. For example, some hold that the Nuclear Strong Force consists of the Radiation-Pressure of the Casimir Force forcing like-charged particles together; indeed, their Coulombic Repulsion has a factor of the inverse of the distance d squared, whereas the Casimir "Attraction" has a factor of the inverse of the distance to the fourth power; therefore, at a certain critical distance, the supposed radiation pressure of the Casimir Attraction might exceed the Coulombic repulsion, just as the Strong Force is said to do.

If space is really filled with electromagnetic radiation, then perhaps we can measure the radiation-pressure it exerts on matter. Indeed, many in this second group of scientists believe that the Casimir Effect proves that these so-called "Virtual" Photons or Particles of the Quantum-Vacuum exert a completely Real Radiation-Pressure on the Casimir Moving Plate. Indeed, testing the existence of the radiation pressure of the Quantum-Flux was the entire point of Henrik Casimir's original Two-Plate Experiment.proposal; furthermore, Radiation Pressure was the original basis from which he calculated his historical Casimir Two Plate Formula in that same paper. The same formula is still in use today.

The Radiation-Pressure Interpretation of the Casimir Effect holds that the radiation-pressure of the Quantum-Flux is reduced between the "Plates" so that the unaltered, stronger radiation-pressure, on the outside surface of the plates, pushes the plates together more-forcefully than the weaker radiation-pressure that exists between the plates that tries to push them apart; thus, the one plate is moved toward the other plate because the extra radiation pressure moves it, not because it is literally "attracted" to the other plate.

According to the Radiation Pressure Interpretation, the Radiation Pressure of the Quantum Vacuum acts on the plates; the plates are not exerting forces on each other; instead, the plates act on the Quantum-Flux; the plates reduce the radiation-pressure of the Quantum-Flux that is inside the gap between the plates. In other words, according to the Radiation Pressure Interpretation, these so-called "Virtual" Photons are exerting very-real Radiation-Pressure on both sides of the moving plate, but less pressure on on the side that faces the other plate, thus producing the net radiation-pressure force that moves the one plate toward the other plate.

If there really is an independent Quantum-Flux, then the Radiation-Pressure Interpretation of the Casimir Force does not violate the Laws of motion any more than would a Solar Sail. We are simply collecting the momentum of photons that have already been independently generated, are already present and are already on independent trajectories. In other words, in the terminology of Newton: The moving Casimir Plate is merely being "Acted upon by an outside force."

The point is this, if the plates do not really exert forces on one another, if they do not actually "attract" one another, but it is the radiation-pressure of the Quantum-Flux that moves the one moving plate, then maybe we can find another method to exploit this radiation-pressure that does not require a second plate.

2. No Thermodynamic Violations Allowed!

Assuming there really is a virtual photon flux that does not rely on matter for its existence, then using the Radiation-Pressure of the Quantum-Vacuum to move Casimir's plate is not violating energy conservation any more than a Solar Photo-electric Cell. Using the Energy of the Quantum Vacuum is just like using Solar Power, except here, we aren't pretending to know where these photons come from.

No machine can create or destroy matter or energy; therefore, no thermodynamic engine actually consumes energy. Really, thermodynamic engines merely convert low-entropy energy into high-entropy energy. If moved by Radiation Pressure, Casimir's moving plate is no exception; rebounding photons will be red-shifted relative to their original frequency. Then, the Quantum Vacuum Process will take them back (make them wink-out) just as it supposedly does after its photons strike any other collection of atoms, (assuming the physical reality of the Quantum-Vacuum.)

Thus, an independent Quantum Vacuum can be modeled as a high-energy reservoir when it "emits" low entropy virtual photons and modeled as a low-energy reservoir when it "removes" them after they have become high-entropy virtual photons from having performed work. Casimir's moving plate can be modeled as an engine that is exploiting energy that is "passing between" these two energy reservoirs.

As for Entropy, until proven otherwise, we would simply assume that the entropy of the entire independent Quantum Vacuum is increasing when the Vacuum performs work on Casimir's moving plate, just as we routinely assume concerning any other so-called energy "source;" just as we assume when we discuss, (gravely, in hushed tones,) the pending thermal death of the Universe. Furthermore, there is no problem with the fact that the plate is locally reversing entropy because many processes, including plants, decrease local entropy at the expense of global entropy, all of the time; why not let Casimir's plate do so as well?

Confusingly, Casimir himself entitled his seminal paper: "On the attraction between two perfectly conducting plates." This word "attraction" in this original context denotes nothing more than that the plates move toward each other and not apart. This is very evident because at the beginning of the paper he writes: "these expressions may also be derived through studying by means of classical electrodynamics, the change of electromagnetic zero point energy." which is what he devotes the rest of the paper to accomplishing. The penult statement in the paper is: "This force may be interpreted as a zero-point pressure of electromagnetic waves."

Since Casimir's original paper, researchers have advanced other theories of how this may work. Understandably, many scientists seem very uncomfortable with the notion that "empty" space can move a physical object, let alone that it might be so generous as to deplete itself and leave energy behind for us to use. The presence of a Second "Plate" in the Casimir Experiments makes alternatives to the Radiation Pressure Interpretation possible, because the Second "Plate" suggests the possibility that the electrically neutral "plates" are exerting electric forces on one another, that the Casimir Effect is merely a further extension of the long-range London Forces interpretation of Van der Waals Forces.

Some find this explanation doubtful because it is seriously hard, if not impossible, to make physical sense of it, even though the math works. This doubt arises because, physically speaking, a transient random charge on the one neutral surface is not much closer to transient opposite-charges on the second surface than to nearby like-charges on that same second surface. This is a serious problem unless the randomly fluctuating charge domains are close to the size of the separation distance of the plates. Such large domains seem unlikely at the separations of hundreds and even thousands of nanometers that typify most Casimir Experiments. There is nothing in the Casimir Formula to allow for differences in Charge-Domain size among various metals. Indeed, this is one of the defining characteristics of the Casimir Effect, that it models an ideal conductor in which one would tend to expect rather small random charge fluctuation domains.

The Electrical Attraction of Electrically Neutral Plates Theory seems considerably more fashionable than the Radiation Pressure Model, but no more certain than it. Therefore, it is unclear whether the Radiation-Pressure Interpretation of the Casimir Effect is true, or whether this even matters, since all of these theories quantitatively predict substantially equivalent experimental outcomes. A different approach is required to clarify the nature of these seemingly equal-but-different gauges of the Casimir Effect. Therefore, we shall begin by eliminating the second plate so there is no longer another plate for the first plate to be attracted-to or repelled-from.

Quantum-Vacuum Radiation-Pressure is verified if this stand-alone plate can be made to move, without using any other object, to attract or repel it, except for the special objects we call the "Virtual" Photons of the Quantum-Flux; Even so, how can a stand-alone object possibly obtain a net radiation-pressure force from an unaltered, uniform, omni-directional Quantum-Vacuum? Wouldn't this omni-directional uniform radiation-pressure inevitably exert equal and opposite forces on all sides of any stand-alone object? Its equal-but-opposite radiation pressure forces are represented by the opposing red arrows in Fig. 1.

Fortunately, Nichols Radiometer experimentally overcame this objection over a century ago; two versions of Nichols Radiometer are represented above and below this paragraph; Nichols Radiometer proved the general principle that we can sometimes obtain a net force on an object, that is not caused because the light shines on its opposite sides with different intensities; but rather, a net force (indicated by the green arrows,) arises because

the textures or/and materials of the two sides respond differently to the same intensity of light. A linear force can also be obtained by the arrangement in Fig. 2.

Fig. 1. Rotational Motion

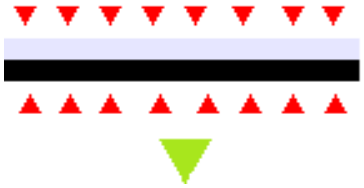

Fig. 2. Linear Motion

To avoid confusion, we must differentiate between two very-different mechanical radiometers. Nichols Radiometer is often confused with Crookes Radiometer: We know that Crookes Radiometer works because of a weird sort of convection that only takes place in a partial vacuum. We truly know that Crookes Radiometer Effect is different from Nichols Radiometer Effect because its net force acts toward its more light-absorbent surface, which is consistent with this strange kind of heat-convection.

In contrast, Nichols Radiometer moves in the opposite direction because its net force is directed toward the more-reflective surface; this is consistent with the theory that reflecting photons are considered to experience elastic collisions; the elastic collisions of photons impart twice as much momentum to its more-reflective surface as identical photons that are absorbed by its opposite, less-reflective surface, absorption being an example of an inelastic collision. We know this is true because experimental torsion-balance measurements are very consistent with this explanation to a high degree of accuracy.

These facts are foundational to modern physics. This is the classic experiment that proves that light, though not having mass, still has momentum; it also proves that electromagnetic radiation, in general, exerts radiation-pressure on matter. Really, among those who affirm the reality of a self-existent Electromagnetic Quantum-Vacuum, a fair burden of proof requires them to prove that virtual-photons would not exert radiaton-pressure on matter, just as would any other electromagnetic radiation.

It is likely that Virtual Photons are not absorbed by matter in the same way that "real" photons are absorbed; therefore, the Transparent Quantum Thruster will be transparent to the photons that are not reflected from its less-reflective side, since photons that are passing through a transparent material will not exert very much force on the material.

Thus, one side will reflect virtual-photons better than the opposite side, perhaps over a broader range of angles, perhaps reflecting a broader spectrum, perhaps reflecting a more energetic range of wavelengths. In some embodiments, the opposite side may be almost totally non-reflective.

The less reflective side allows virtual photons that are not reflected to pass through the transparent material of the thruster, so as to minimize the impartation of undesirable forces to the the Thruster. Therefore, the side that reflects more of the Energy of the virtual photons of the Quantum-Flux experiences more Radiation-Pressure, assuming that there really is an independent Quantum-Flux.

In some embodiments, the Thruster Plate may be considerably thinner than the wavelengths that are being reflected or transmitted from the two sides; it can be mechanically supported by materials that are also transparent to these wavelengths. It does not matter whether or not the non-reflected "virtual" photons pass all the way through the thruster before "winking out."

If the material of the Thruster Plate is transparent to the wavelengths we are discussing, then virtual-photons are free to form within it; therefore, we must prevent Total Internal Reflections from acting on the back side of the more-reflective surface. This can be accomplished by using materials that have indexes of refraction that are less than one.

3. Deriving Open-Boundary Radiation-Pressure

When Max Planck first modeled Black Body Radiation, he treated atoms as harmonic oscillators. After much effort, he finally matched experimental results with the following formula for the energy of a single photon.

1. Planck's Harmonic Oscillator Formula

$$E(\omega)=\hbar\omega\left(n+\frac{1}{2}\right);\ n=\{0,1,2,3\ldots(n+1)\} \tag{1}$$

2. Therefore, according to Quantum Mechanics, the Zero Point Energy Field is defined in terms of harmonic oscillators. The photons which comprise this Field have a ground state, a zero-point energy that is defined as follows: The Zero-Point Energy of a photon is the case where $n=0$. This leaves a Zero-Point Energy per mode of a given frequency:

$$E_m(\omega)=\frac{\hbar\omega}{2} \tag{2}$$

3. Modes of one frequency, ω to $\omega+d\omega$, per unit volume: [2, 3]

$$dm(\omega)=\frac{\omega^2}{\pi^2c^3}d\omega \tag{3}$$

4. Energy density $P(\omega)$ of all modes $m(\omega)$ of one frequency ω in a physically unbounded volume of "empty" space, disregarding thermal energy:

$$dP(\omega)=E_m(\omega)dm(\omega)=\frac{\hbar\omega^3}{2\pi^2c^3}d\omega \tag{4}$$

5. Integrate $dP(\omega)$ over a range of frequencies ω' to yield:

$$P(\omega)=\frac{\hbar}{2\pi^2c^3}\int_0^{\omega}\omega'^3d\omega'=\frac{\hbar\omega^4}{8\pi^2c^3} \tag{5}$$

6. Convert frequency $\omega=c/\lambda$ to wavelength λ.

$$P(\lambda)=\frac{\hbar c}{8\pi^2\lambda^4}=4.0\text{ x }10^{-28}\frac{1}{\lambda^4}\text{ Pa},\quad \lambda\text{ in m} \tag{6}$$

7. Calculate the ideal net pressure $P_{\text{Net}}(\lambda_1,\lambda_2)$ in $\lambda_1<\lambda<\lambda_2$

$$P_{\text{Net}}(\lambda_1,\lambda_2)=P(\lambda_1)-P(\lambda_2) \tag{7}$$

8. Determine the force, based on material characteristics $R(\lambda)$

$$F_{\text{Net}}(\lambda_1,\lambda_2)=\left[R(\lambda_1)P(\lambda_1)-R(\lambda_2)P(\lambda_2)\right]A \quad (8)$$

The more reflective side is made of material with a fractional index (The index of refraction is less than one.) Therefore, if this more reflective side is smooth enough, it will exhibit an External Total Reflection. This means that, at that are sufficiently shallow angles relative to the surface, all incident radiation is reflected. *R* is the percentage of the total potential pressure of the targeted wavelengths that is acting on a surface.

A very narrow band of the Soft X-Ray Spectrum will be targeted, perhaps 1.1 to 1.2 nm. Even if obtaining Total Reflections from very shallow angles only, we can realistically hope to obtain a net force of several hundred kPa. The following chart assumes that we are only able to use 0.5% of the total radiation pressure that is attributable to each 0.1 nm bandwidth.

We are only concerned with the few narrow bandwidths that most strongly interact with materials we are using. Such an approach will lead to underestimating the total pressures that are acting on our thruster; but we should rather under-promise and over-deliver. In practice, even if we were to do a summation of the additional pressures of ever larger wavelengths, additional increments of pressure rapidly approach zero due to the $1/\lambda^4$ term. When doing a summation of ever-smaller wavelengths, we rapidly reach a point where the wavelengths simply pass through matter and contribute little or no net force to the thruster.

Materials having fractional indexes of refraction can be used to produce Total External Reflections, while at the same time preventing internal reflections since the surrounding space has a higher index of refraction than the material.(Total Reflections only take place when light is bouncing off of the transition to a second medium that has a lower index of refraction.) It seems likely that we can find combinations of materials that cause a Total Reflection of virtual radiation of certain bandwidths off of one side of a plate at a broader range of angles, or/and broader spectrum, or and more-energetic spectrum than off of its opposite side.

The reflecting and non-reflecting surfaces can be comprised of layers of material that may be as thin as a quarter wavelength. This would guarantee that the non-reflecting virtual photons could pass all the way through the system before imparting undesired forces. These thin layers will be deposited on transparent materials for support.

Indeed, many layers can be stacked, separated by transparent materials, using the techniques of the semi-conductor manufactures; so even if this effect is very slight, the many small forces of many thin layers can be, perhaps inexpensively, combined into much larger forces over enormous combined areas.

The prospect of adapting known technology to this approach appears very promising. Meta-materials have revolutionized high-energy optics. Mirrors that reflect as much as 60% in selected X-ray and VUV wavelengths are commercially available, already. Experts on the Quantum-Vacuum of QED or/and SED working together with experts in optical meta-materials can easily design and build the Thrusters, that are herein proposed.

At soft x-ray wavelengths to very high-energy VUV wavelengths, the Radiation-Pressure of the Quantum-Vacuum exerts enormous pressures on open surfaces—surfaces that are not inside small cavities.

ZPE Radiation Pressures of Select Ranges of Wavelengths

Wavelength nm			Pressure atm
1.0	to	1.1	12.3
1.1	to	1.2	7.8
1.2	to	1.3	5.1
1.3	to	1.4	3.5
1.4	to	1.5	2.4
1.5	to	1.6	1.7
1.6	to	1.7	1.3
1.7	**to**	**1.8**	**1.0**
1.8	to	1.9	0.7
1.9	to	2.0	0.6

Fig. 3. Realistically attainable net pressures (in Atm.). Chart lists a realistic 0.5% of available radiation pressure in these ranges.

4. Conclusion

Conservatively speaking, we may be limited to obtaining net pressures that are about 0.5% of the total virtual radiation pressure that is present in any selected virtual bandwidth. This limitation arises mainly because, at this point in development, we can only depend on being able to reflect more-energetic wavelengths at very shallow angles. Less -energetic wavelengths would reflect at steeper angles to the surface, but in many cases, 0.5 percent of a large pressure can be better than sixty percent of a much smaller pressure. On the other hand, on the chart below, it is likely that adjacent bandwidths will substantially contribute to the total force.

References

[1] E. Merzbacher, **Quantum Mechanics**, pp. 186-199 (Wiley, 1961).

[2] E. Kreyszig, **Advanced Engineering Mathematics**, 2nd Ed., pp. 168-177 (Wiley, 1967).

[3] P. W. Milonni, "Why Spontaneous Emission", *Am. J. Phys.* **52** (4): 340-343 (Apr 1984).