Theory of the Casimir Effect and Solid-State Inter-atomic Distance

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Abstract

The Casimir effect is the force of attraction between two objects (in a vacuum, with no electric or magnetic fields) very close together (usually considered from about 10 A to 400 A apart). The Reciprocal System says that the cohesion of solids is due to the inward force of the space-time progression *inside* unit space; gravitation is *outward* within unit space, rather than inward, so it opposes the space-time progression here. Conventional theory says that the Casimir effect is due to "virtual particles" or "zero-point energy." Casimir's original idea was to measure the so-called "Van der Waals" effect.

keywords:

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Introduction and Literature Review

The starting point for this paper is Larson's work in Ref. [1], particularly the first four chapters. There, Larson derives the equation for the *internal pressure* of a solid. But this equation can also be *generalized* and applied to the "cohesive pressure" between two *separate* solids, e.g., two thin metallic plates, separated by a distance *less than the natural unit of space*. In Section 1, the equations will be derived for the forces of the space-time progression and gravitation *within* unit space, and in Section 2 they will be applied to an example situation. See Ref. [2], for the equations of the space-time progression and gravitation *outside* unit space.

Ref. [3], [4], and [5] give the conventional theories. These works are based on Quantum Mechanics and are quite bizarre. Experiments are difficult to perform and subject to considerable experimental error. Approximately, the Casimir Effect, in terms of pressure, is about 1 atm at a distance of about 1/2 unit of space (200 A) (Ref. [3]).

Nomenclature

A = face area of each of the two plates, cm^2

A_{eff} = effective area of the forces inside unit distance, cm^2

a, z, y = compressibility factors for element (or compound) of solid

F_P = force of the space-time progression inside unit space, dynes

F_G = force of gravitation within unit space, dynes

F_u = natural unit of force, dynes

P_dynes_cm2 = internal pressure between two solids at separation s, dynes/cm^2

P0_dynes_cm2 = internal pressure between two solids at separation s0, dynes/cm^2

$P_{Casimir\_dynes\_cm2}$ = *net* pressure between two bodies at separation s, dynes/cm^2

$P_{Casimir\_atm}$ = *net* pressure between two bodies at separation s, atm

s_A = separation distance between objects, A

s_cm = separation distance between objects, cm

s0_A = equilibrium separation distance between objects, A

s0_cm = equilibrium separation distance between objects, cm

s_u = natural unit of space (time-space region), cm

s_{t_u} = natural unit of space (time region), cm

t_m, t_e = rotational speed factors for individual element

Note: A black square in the upper right of an equation means that the equation is disabled from running in *Mathcad*. This is done because not all variables in the equation have, as yet, been given numerical values.

Unit Conversions and Physical Constants

$s_u := 4.558809 \cdot 10^{-6}$ cm $\quad l_R := 156.4444 \quad s_{t\_u} := \frac{s_u}{l_R} \quad s_{t\_u} = 2.914012 \times 10^{-8}$ cm

$F_u := 3.272230 \cdot 10^{2}$ dynes

$conv_{dynescm2toatm} := 9.871668 \cdot 10^{-7}$

1. Theory

In the Reciprocal System, there are two *primary* forces, the space-time progression and the gravitation force:

Outside unit space, s_u: the space-time progression is *outward*, the gravitational force is *inward*.

Inside unit space, s_u: the space-time progression is *inward*, the gravitational force is *outward*

Thus inside unit space, the *cohesive force* is the space-time progression. This force is *constant*, at the natural unit value:

$$F_P := F_u \qquad F_P = 327.223 \quad \text{dynes} \tag{1}$$

The gravitational force inside unit space (say for two separate atoms of the same element) is given in Ref. [1] as

$$F_G := .006392^4 \cdot \frac{\left(\ln(t_m)\right)^4}{\left(\frac{s\_cm}{s_u}\right)^4 \cdot \ln(t_e)^2} \cdot F_u \qquad \text{dynes} \tag{2}$$

The *equilibrium* atomic separation will occur when these forces are equal.

$$F_G := F_P \tag{3a}$$

$$.006392^4 \cdot \frac{\left(\ln(t_m)\right)^4}{\left(\frac{s0\_cm}{s_u}\right)^4 \cdot \ln(t_e)^2} \cdot F_u = F_P \tag{3b}$$

Solving for s0_cm:

$$\text{s0\_cm} := \frac{0.006392 \cdot F_u^{\frac{1}{4}} \cdot \ln(t_m) \cdot s_u}{F_u^{\frac{1}{4}} \cdot \sqrt{\ln(t_e)}} \quad \text{cm} \qquad (3c)$$

The F_u drop out:

$$\text{s0\_cm} := \frac{0.006392 \cdot \ln(t_m) \cdot s_u}{\sqrt{\ln(t_e)}} \quad \text{cm} \qquad (3d)$$

$$\text{s0\_A} := \text{s0\_cm} \cdot 10^8 \quad \text{A} \qquad (3e)$$

Closer than this distance, there will be a *net repulsion*.

To apply these equations to separate *macroscopic* bodies, we will have to work with *pressures*, rather than with forces. In Ref. [1], Larson derives the equation for the *internal pressure* of a solid in equilibrium. This is:

$$\text{P0\_dynes\_cm2} := \frac{(.1677916883 \cdot a \cdot z \cdot y) \cdot 10^{11}}{\left[\frac{(\text{s0\_cm})}{s_{t\_u}}\right]^3} \quad \text{dynes/cm}^2 \qquad (4a)$$

Generalized:

$$P\_dynes\_cm2 := \frac{(.1677916883 \cdot a \cdot z \cdot y) \cdot 10^{11}}{\left[\frac{(s\_cm)}{s_{t\_u}}\right]^3} \quad \text{dynes/cm}^2 \qquad (4b)$$

However, the force of the progression is *constant*, so this means that the *effective area* of the force, A_{eff}, must *change* as the internal pressure changes!

$$A_{eff} := \frac{F_P}{P\_dynes\_cm2} \quad \text{cm}^2 \qquad (5)$$

By symmetry, this must also be the *effective area for the gravitational force*. Of course, the A_{eff} combine to form the entire face area A of each of the two bodies.

The *net inward pressure* at separation distance s is then:

$$P_{Casimir\_dynes\_cm2} := \frac{(F_P - F_G)}{A_{eff}} \quad \text{dynes/cm}^2 \qquad (6a)$$

$$P_{Casimir\_dynes\_cm2} := \frac{\left[F_u - .006392^4 \cdot \frac{(\ln(t_m))^4}{\left(\frac{s\_cm}{s_u}\right)^4 \cdot \ln(t_e)^2} \cdot F_u\right]}{\frac{F_u}{\frac{(.1677916883 \cdot a \cdot z \cdot y) \cdot 10^{11}}{\left[\frac{(s\_cm)}{s_{t\_u}}\right]^3}}} \quad \text{dynes/cm}^2 \qquad (6b)$$

The F_u cancel out:

$$P_{Casimir\_dynes\_cm2} := \frac{\left[1 - .006392^4 \cdot \frac{\left(\ln\left(t_m\right)\right)^4}{\left(\frac{s\_cm}{s_u}\right)^4 \cdot \ln\left(t_e\right)^2} \cdot 1\right]}{\frac{1}{\frac{(.1677916883 \cdot a \cdot z \cdot y) \cdot 10^{11}}{\left[\frac{(s\_cm)}{s_{t\_u}}\right]^3}}} \qquad \text{dynes/cm}^2 \qquad (6c)$$

Experimental results are commonly stated in atm. So:

$$P_{Casimir\_atm} := P_{Casimir\_dynes\_cm2} \cdot conv_{dynescm2toatm} \qquad \text{atm} \qquad (6d)$$

2. Application

Let's suppose we have two very thin, very smooth vertical aluminum plates, 1 cm^2 each, separated by less than 1 natural unit of space in vacuum. Also, suppose that the rows and columns of the atoms of the two plane faces are lined up, and the plates are free to move horizontally. What is the pressure between them as a function of separation s? (Ignore the minor pressure due to massless, chargeless particles.)

For Al (from Ref. [1] or the Reciprocal System Database, Ref. [6]):

$t_m := 3 \qquad t_e := 3.5 \qquad a := 4 \qquad z := 5 \qquad y := 1$

The equilibrium separation is

$$\text{s0\_cm} := \frac{0.006392 \cdot \ln(t_m) \cdot s_u}{\sqrt{\ln(t_e)}} \quad \text{s0\_cm} = 2.860212 \times 10^{-8} \ \text{cm} \quad \text{s0\_A} := \text{s0\_cm} \cdot 10^{8} \quad \text{s0\_A} = 2.860212 \ \text{A}$$

Using Eqs. (6c) and (6d), we can plot the Casimir pressure between the two plates. It's best to divide the range into three parts.

From 100 A to s_u of separation:

$$\frac{\left[1-.006392^4\cdot\frac{\left(\ln\left(t_m\right)\right)^4}{\left(\frac{ss}{s_u\cdot 10^8}\right)^4\cdot\ln\left(t_e\right)^2}\cdot 1\right]}{\frac{1}{\frac{(.1677916883\cdot a\cdot z\cdot y)\cdot 10^{11}}{\left[\frac{(ss)}{s_{t\_u}\cdot 10^8}\right]^3}}}\cdot conv_{dynescm2toatm}$$

atm

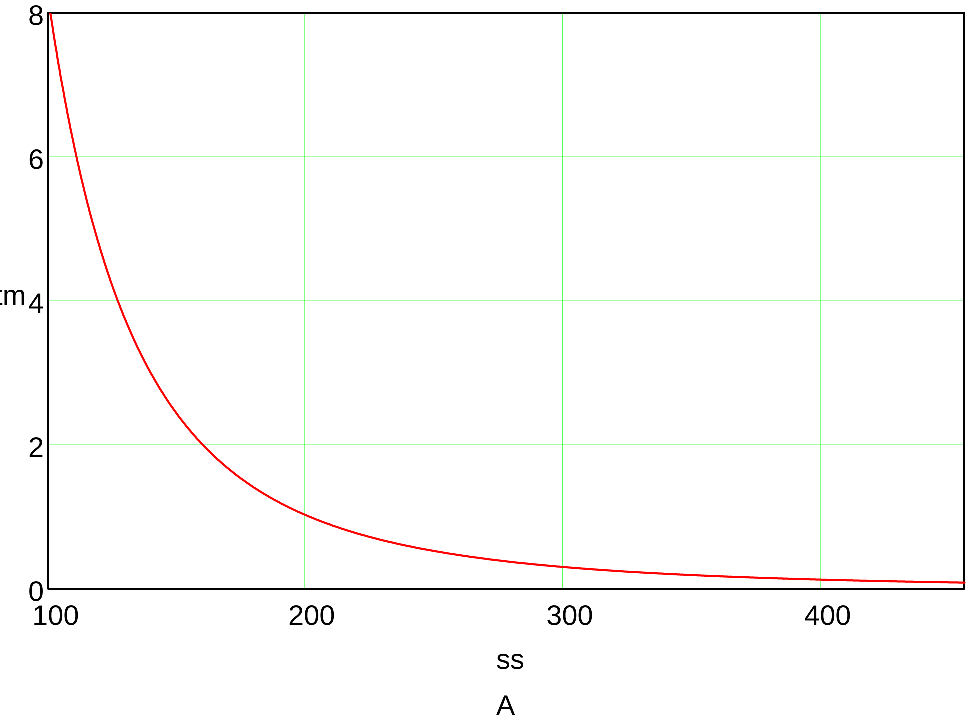

Figure 1. Casimir Pressure--first range

Notice that the pressure at about 200 A is 1 atm--which is in accord with the experiments.

From 20 to 100 A of separation:

atm

$$\frac{\left[1-.006392^{4}\cdot\frac{\left(\ln\left(t_m\right)\right)^{4}}{\left(\frac{ss}{s_u\cdot 10^{8}}\right)^{4}\cdot\ln\left(t_e\right)^{2}}\cdot 1\right]}{\dfrac{1}{\dfrac{(.1677916883\cdot a\cdot z\cdot y)\cdot 10^{11}}{\left[\dfrac{(ss)}{s_{t\_u}\cdot 10^{8}}\right]^{3}}}}\cdot conv_{dynescm2toatm}$$

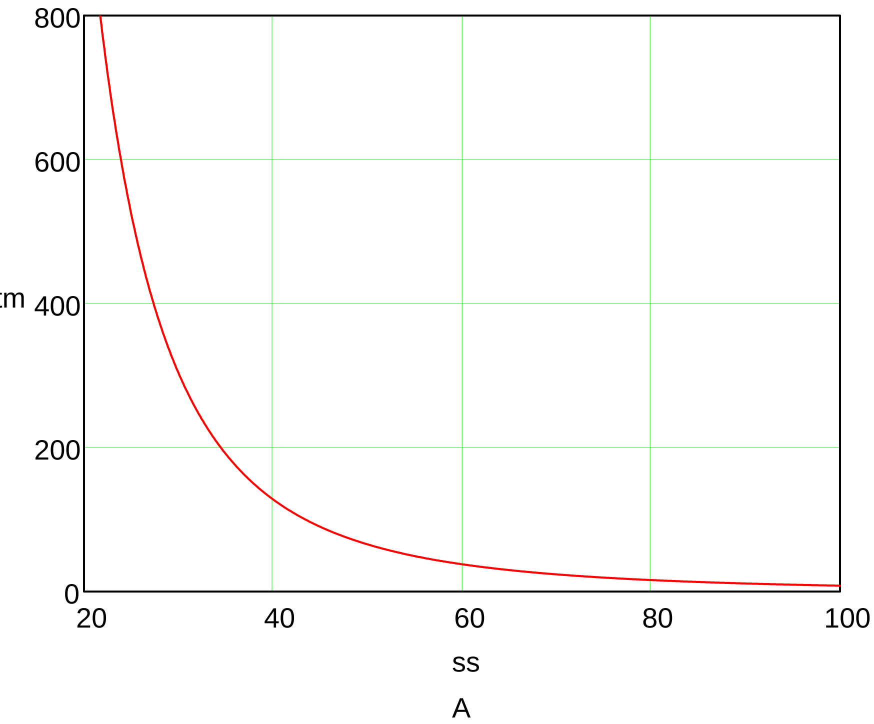

Figure 2. Casimir Pressure--second range

From to 1.4 A to 20 A of separation:

atm

$$\frac{\left[1-.006392^{4}\cdot\frac{\left(\ln\left(t_m\right)\right)^{4}}{\left(\frac{ss}{s_u\cdot 10^{8}}\right)^{4}\cdot\ln\left(t_e\right)^{2}}\cdot 1\right]}{\frac{1}{\frac{(.1677916883\cdot a\cdot z\cdot y)\cdot 10^{11}}{\left[\frac{(ss)}{s_{t\_u}\cdot 10^{8}}\right]^{3}}}}\cdot conv_{dynescm2toatm}$$

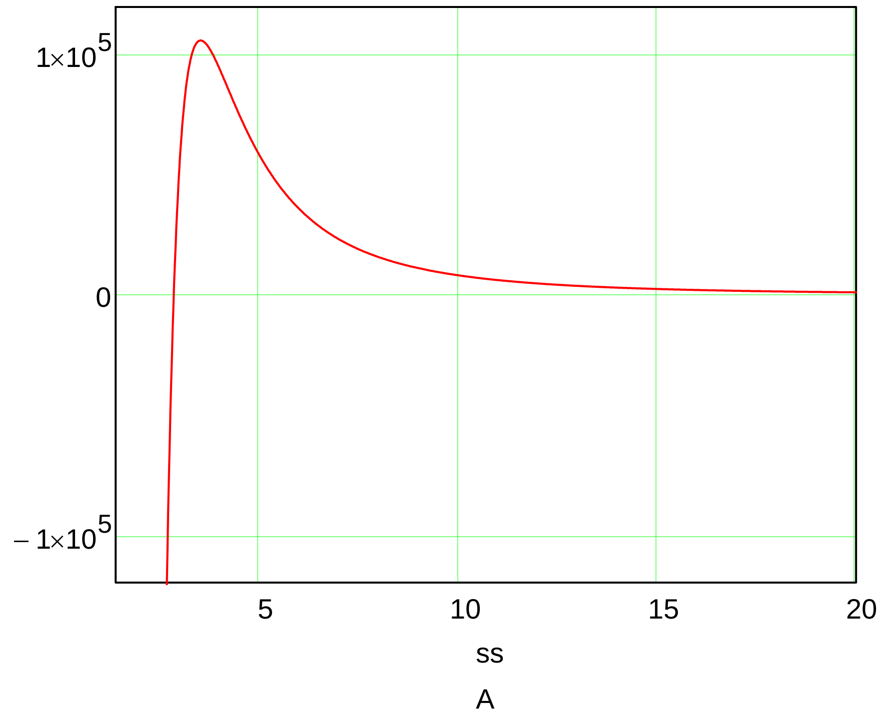

Figure 3. Casimir Pressure--third range

Notice how the net pressure goes negative when the separation is less than s0_A.

Conclusion

The Casimir Effect *between* two bodies is actually due to the *same interatomic forces* as that *within* a body: the space-time progression and the gravitational force. These two forces are oppositely directed from what they are in the region outside unit distance. A generalized form of the internal pressure of the space-time progression and the effective area of that force (and that of the gravitational force) have been derived from theory. The net pressure–the Casimir pressure--is plotted for three distinct ranges of separation for two parallel aluminum plates inside unit distance. The equations presented here are far simpler and far more useful than those derived from conventional theory. There is no need for any electrical theory of matter: the forces here are *not* electrical.

References

[1] D. Larson, *Basic Properties of Matter* (Salt Lake City, UT: International Society of Unified Science, 1988).

[2] R. Satz, "Calculation of the Gravitational Limits and Hubble Constant for the Local Group," www.reciprocalsystem.guru, last updated 06/03/2017.

[3] www.wikipedia. com, "Casimir Effect"

[4] V. Mostepanenko, N. Trunov, R. Znajek, *The Casimir Effect and Its Applications* (Oxford, UK: Oxford University Press, 1997).

[5] M. Bordag, G. Klimchitskaya, U. Mohideen, V. Mostepanenko, *Advances in the Casimir Effect* (Oxford, UK: Oxford University Press, 2009).

[6] R. Satz, *The Reciprocal System: Microcosmos Database* (Penndel, PA: Transpower Corporation, 2014).

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