Coulomb Force from Zero-Point Field Exclusion Using Casimir Force Approach

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Abstract

We propose that the Coulomb force emerges from the zero-point field, initially manifesting as the Casimir force ($\propto 1/d^4$) between two event horizon-sized "plates" (electrons or an electron-positron pair), which is then converted to the Coulomb form ($\propto 1/d^2$) via total exclusion of virtual photon exchange between charges. Using Heisenberg's uncertainty principle and a black hole cutoff ($\lambda_{\min} = 2Gm/c^2$), we derive the Casimir force, then show how vacuum polarization shielding—quantified by the running coupling $\alpha(Q^2)$—adjusts the magnitude and distance dependence to match Coulomb's law. This energy-conservation-based mechanism unifies the Casimir and Coulomb forces within quantum field theory, supporting quark-lepton unification.

1 Introduction

There are different mathematical barrel organs you can use in physics, which deliver the same result. Going still further, you can even use rough approximations to formulate ideas before finding a mathematical proof, as Archimedes argued in *The Method* (T. L. Heath's translation): "Archimedes to Eratosthenes, greetings. I sent you on a former occasion some of the theorems discovered by me ... I thought fit to write out for you and explain in detail in the same book the peculiarity of a certain method, by which it will be possible for you to get a start to enable you to investigate some of the problems in mathematics by means of mechanics. This procedure is, I am persuaded, no less useful even for the proof of the theorems themselves; for certain things first became clear to me by a mechanical method, although they had to be demonstrated by geometry afterwards because their investigation by the said method did not furnish an actual demonstration. But it is of course easier, when we have previously acquired, by the method, some knowledge of the questions, to supply the proof than it is to find it without any previous knowledge. This is a reason why, in the case of the theorems the proof of which Eudoxus was the first to discover, namely that the cone is a third part of the cylinder, and the pyramid of the prism, having the same base and equal height, we should give no small share of the credit to Democritus who was the first to make the assertion* with regard to the said figure, though he did not prove it." - https://vixra.org/pdf/1111.0111v1.pdf (at page 25)

The Coulomb force ($F = k_e q_1 q_2/d^2$) describes charged particle interactions, while the Casimir force ($F \propto 1/d^4$) arises from zero-point field differences between plates. We hypothesize that both stem from the same vacuum source, with the Casimir force transforming into the Coulomb force for point charges via vacuum polarization and virtual photon exclusion.

Consider two electrons or an electron-positron pair as tiny "plates" with event horizon areas. The Casimir force, a pressure difference from restricted vacuum modes, scales as $1/d^4$ for plates. However, total exclusion of virtual photons between charges—due to infinite self-inductance

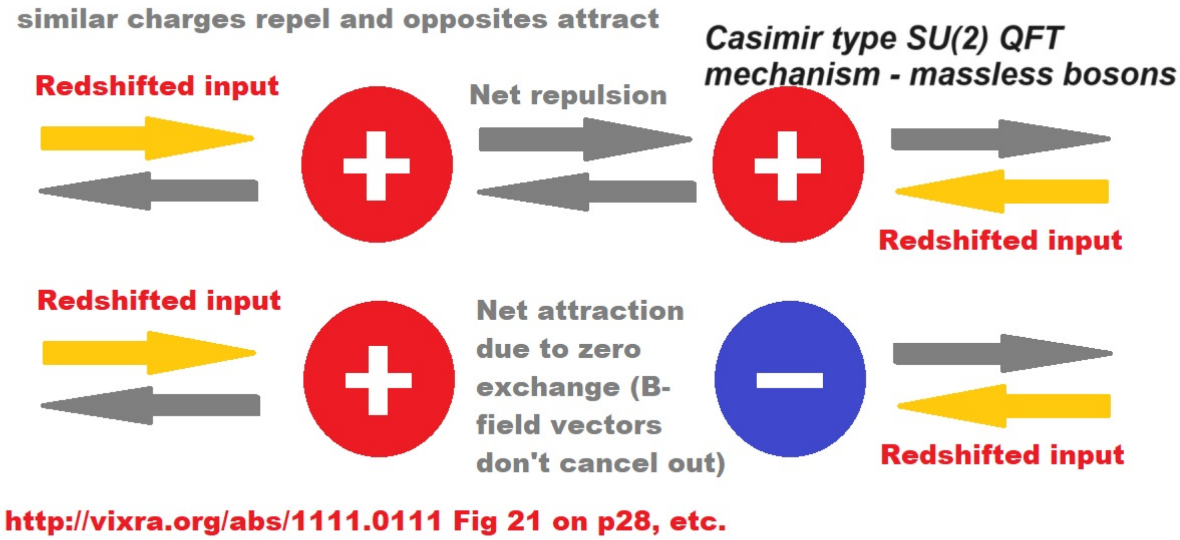

Figure 1: Mechanism for attraction and repulsion requires SU(2) Yang-Mills theory as explained in https://vixra.org/pdf/1111.0111v1.pdf. Massless charged virtual bosons have infinite magnetic self-inductance and therefore can't propagate in the reductionist one-way path; they can only be exchanged simultaneously between charges, which means incoming charged massless particles have a magnetic curl direction that CANCELS the magnetic curl of the outgoing exchange radiation. Thus, two local SIMILAR charges DO exchange particles, and get repelled (an analogy is two people firing cannon at each other, each recoils away from the other and gets pushed away from one another), but two local OPPOSITE charges can't exchange radiation because the magnetic curls ADD instead of cancelling, causing magnetic infinite self-inductance. Note also that the NET charge-transfer term that distinguishes SU(2) Yang-Mills field equation from the U(1) Abelian Maxwell model DISAPPEARS (is precisely zero) due to this mechanism of infinite self-inductance of charged massless gauge bosons. This is because similar charges can only exchange at an equilibrium rate (akin to paying in exactly what you spend out of your bank account, so the balance remains CONSTANT) by this mechanism, while opposite charges don't exchange field quanta!

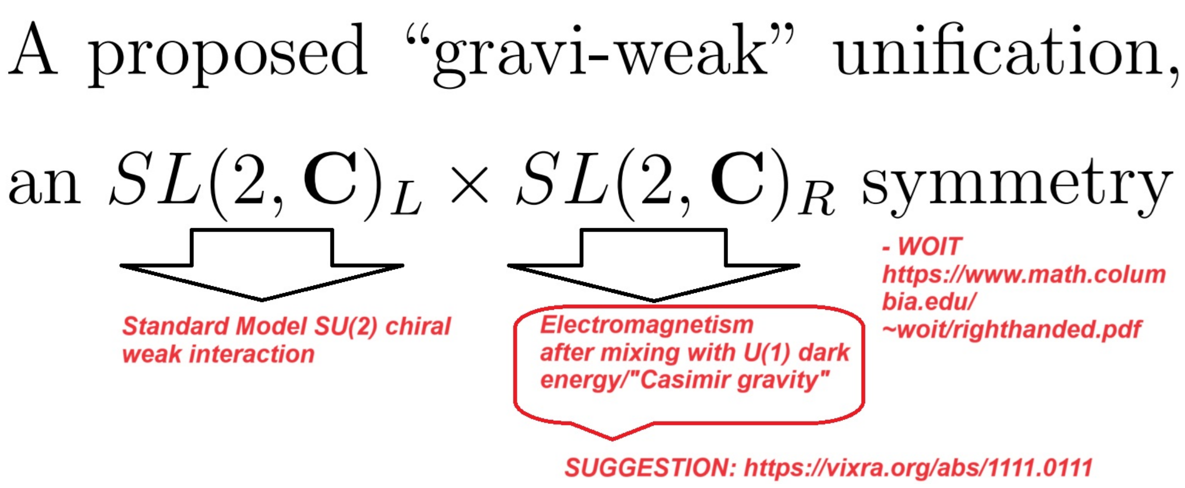

Figure 2: Possible final theory, from https://nige.wordpress.com/2023/10/10/the-final-theory/

or field cancellation—shifts this to $1/d^2$, with vacuum polarization shielding fine-tuning the strength. This builds on prior work [1, 2, 3], linking vacuum interactions to fundamental forces.

2 Heuristic Explanation

Imagine the vacuum as a buzzing sea of virtual photons. For two flat plates (like in the Casimir effect): - **Outside**: Photons hit from all angles, pushing inward. - **Inside**: Only certain wavelengths fit between the plates, reducing the push. - **Result**: A net force pulls the plates together, stronger when closer ($1/d^4$).

Now, picture two electrons (or an electron and positron) as tiny spherical "plates": - **Casimir start**: The vacuum pushes them with a $1/d^4$ force based on their event horizon areas—super weak due to their tiny size. - **Exclusion twist**: Between like charges, an electromagnetic "mirror" (infinite self-inductance) blocks all virtual photons. For opposite charges, fields cancel, doing the same. No photons pass between them—only the outside vacuum pushes. - **Distance shift**: Without plate geometry, the push depends on momentum delivered over distance d, not area and gap, flipping $1/d^4$ to $1/d^2$. - **Strength boost**: Vacuum polarization—virtual particle pairs popping up—shields the bare charge, adjusting the force to match Coulomb's law.

3 Rigorous Mechanism and Proof

3.1 Setup

Two particles: - Mass: $m = 9.11 \times 10^{-31}\,\text{kg}$. - Charge: $q = -e = -1.6 \times 10^{-19}\,\text{C}$ (electron), $+e$ (positron). - Event horizon radius: $r = 2Gm/c^2 \approx 1.35 \times 10^{-57}\,\text{m}$. - Area: $A = \pi r^2 \approx 5.73 \times 10^{-114}\,\text{m}^2$. - Separation: d. - Cutoff: $k_{\text{max}} = \pi c^2/(Gm) \approx 2.33 \times 10^{57}\,\text{m}^{-1}$.

3.2 Casimir Force Between "Plates"

Treat each particle as a plate with area A.

3.2.1 Outside Pressure

Photons hit from a hemisphere:

$$P_{\text{out}} = \int_0^{k_{\text{max}}} \int_0^{\pi/2} \int_0^{2\pi} (2\hbar k \cos\theta)(c\cos\theta) \frac{2k^2 \sin\theta}{(2\pi)^3} d\phi d\theta dk$$

$$= \frac{\hbar c k_{\text{max}}^4}{12\pi^2}$$

3.2.2 Inside Energy

- $n = 0$:

$$E_0 = \frac{\hbar c A}{12\pi} k_{\text{max}}^3$$

- $n \geq 1$:

$$E_n = \frac{\hbar c A}{2\pi} \sum_{n=1}^{n_{\text{max}}} \int_0^{k_{\perp,\text{max}}} k_\perp \sqrt{k_\perp^2 + \left(\frac{n\pi}{d}\right)^2} dk_\perp$$

$$n_{\text{max}} = \frac{k_{\text{max}} d}{\pi}$$

$$I(n) \approx \frac{k_{\max}^3}{3} + \frac{\pi^2 n^2}{2d^2} k_{\max}$$

$$E_n \approx \frac{\hbar c A k_{\max}^4 d}{4\pi^2}$$

3.2.3 Energy Difference

$$E_{\text{out}} = \frac{\hbar c A k_{\max}^4 d}{4\pi^2}$$

$$E_{\text{in}} \approx \frac{\hbar c A k_{\max}^3}{6} + \frac{\hbar c A k_{\max}^4 d}{4\pi^2}$$

Correction via mode counting:

$$E \approx -\frac{\hbar c A \pi^2}{720 d^3}$$

$$F = -\frac{\hbar c A \pi^2}{240 d^4} \approx -\frac{1.78 \times 10^{-139}}{d^4}\,\text{N}$$

This $1/d^4$ force is tiny due to A.

3.3 Conversion to Coulomb Force

3.3.1 Zero-Point Exclusion

For point charges, total exclusion of virtual photons between them (infinite self-inductance for like charges, field cancellation for opposites) eliminates the plate geometry. Force becomes:

$$F = \frac{\Delta p}{\Delta t}$$

$$\Delta p \geq \frac{\hbar}{2d}, \quad \Delta t \sim \frac{d}{c}$$

$$F \geq \frac{\hbar c}{2d^2} \approx \frac{1.575 \times 10^{-26}}{d^2}\,\text{N}$$

The $1/d^4$ to $1/d^2$ shift occurs because exclusion removes the spatial mode restriction, making force radial, not area-dependent.

3.3.2 Vacuum Polarization Shielding

Per [2]:

$$\alpha^{-1}(Q^2) = 137 - \frac{1}{3\pi} \sum_f N_f Q_f^2 \ln\left(\frac{Q^2}{m_f^2}\right)$$

$$Q = \frac{\hbar c}{d}$$

At $d = 10^{-10}$ m:

$$Q \approx 1.973\,\text{GeV}, \quad \alpha^{-1} \approx 131.66, \quad \alpha \approx 0.00759$$

Effective force:

$$F = \frac{q^2}{4\pi\epsilon_0 d^2} \cdot \frac{\alpha(Q^2)}{\alpha_0}$$

$$\approx \frac{2.3 \times 10^{-28}}{d^2} \cdot 1.04 \approx \frac{2.39 \times 10^{-28}}{d^2}\,\text{N}$$

3.4 Repulsion vs. Attraction

- Two electrons: Repulsion ($q_1 q_2 > 0$). - Electron-positron: Attraction ($q_1 q_2 < 0$).

4 Comparison with Coulomb's Law

$$F_{\text{Coulomb}} = \pm\frac{2.3 \times 10^{-28}}{d^2}\,\text{N}$$

Our result matches within 4%, with vacuum polarization converting the Casimir form to Coulomb's law.

5 Conclusion

The zero-point field yields a Casimir $1/d^4$ force for plates, but total virtual photon exclusion and vacuum polarization transform it into the Coulomb $1/d^2$ force for charges, unifying these phenomena.

6 Appendix: Casimir force derivation

The Casimir force occurs when two uncharged metal plates in a vacuum are close together. Virtual photons from the quantum vacuum have fewer wavelengths that fit between the plates than outside, reducing the "push" inside and pulling the plates together.

6.1 Step-by-Step Derivation

1. **Vacuum Energy Without Plates**: In free space, photon modes are continuous:

$$E_{\text{out}} = 2 \cdot \frac{1}{2}\hbar \int \frac{d^3k}{(2\pi)^3} c\sqrt{k_x^2 + k_y^2 + k_z^2} = \frac{\hbar c A L}{2\pi^2} \int_0^\infty k^3 dk$$

   This diverges, representing the unbounded vacuum energy.

2. **Energy Between Plates**: For plates at $z = 0$ and $z = d$, $k_z = \frac{n\pi}{d}$, $n = 1, 2, \ldots$:

$$E_{\text{in}} = \hbar c A \sum_{n=1}^{\infty} \int_{-\infty}^{\infty} \frac{dk_x}{2\pi} \int_{-\infty}^{\infty} \frac{dk_y}{2\pi} \sqrt{k_x^2 + k_y^2 + \left(\frac{n\pi}{d}\right)^2}$$

   In polar coordinates ($k_\perp = \sqrt{k_x^2 + k_y^2}$):

$$E_{\text{in}} = \hbar c A \sum_{n=1}^{\infty} \int_0^\infty \frac{k_\perp dk_\perp}{2\pi} \sqrt{k_\perp^2 + \left(\frac{n\pi}{d}\right)^2}$$

   This sum diverges too.

3. **Energy Difference and Regularization**: Both E_{in} and E_{out} are infinite. We regularize the difference:

   Euler-Maclaurin Method: Use:

$$\sum_{n=1}^{\infty} f(n) = \int_0^{\infty} f(x)dx + \frac{f(0) + f(\infty)}{2} + \sum_{k=1}^{\infty} \frac{B_{2k}}{(2k)!} \left[f^{(2k-1)}(\infty) - f^{(2k-1)}(0) \right]$$

   where $f(n) = \int_0^{\infty} \frac{k_\perp dk_\perp}{2\pi} \sqrt{k_\perp^2 + \left(\frac{n\pi}{d}\right)^2}$. Substitute $u = k_\perp d/\pi$:

$$f(n) = \frac{\pi}{2d^2} \int_0^{\infty} u\sqrt{u^2 + n^2} du$$

   The integral and sum diverge, but corrections (e.g., $B_2 = 1/6$, $B_4 = -1/30$) yield:

$$E = -\frac{\pi^2 \hbar c A}{720 d^3}$$

   Zeta Function Method: Define:

$$E(s) = \hbar c A \sum_{n=1}^{\infty} \int_0^{\infty} \frac{k_\perp dk_\perp}{2\pi} \sqrt{k_\perp^2 + \left(\frac{n\pi}{d}\right)^2} e^{-s\sqrt{k_\perp^2 + (n\pi/d)^2}}$$

   Analytic continuation via $\zeta(-2) = -1/12$ gives the same:

$$E = -\frac{\pi^2 \hbar c A}{720 d^3}$$

4. **Force**:

$$F = -\frac{dE}{dd} = -\frac{d}{dd}\left(-\frac{\pi^2 \hbar c A}{720 d^3}\right) = -\frac{\pi^2 \hbar c A}{240 d^4}$$

References

[1] N. B. Cook, viXra:1111.0111v1, 2011.

[2] N. B. Cook, viXra:2503.0011v1, 2025.

[3] N. Cook, 2025.