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Electromagnetic Motion as an Extended Casimir Effect

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Electromagnetic theories are incomplete at the most fundamental level because they do not explain how electromagnetic forces physically cause motion. They do not even explain what causes the motion. Our choices as to what causes motion are limited, as quantum fluctuations are the only things that are known to occupy otherwise empty space. Then we have only one experimentally confirmed force that arises from interactions between quantum fluctuations. That force arises from the Casimir effect and its motion is due to differentials in van der Waals pressure on bodies of matter. We can intuitively understand how pressure differentials occur when space is polarized with electric and magnetic fields. That allows us to explain motion due to electromagnetic forces as an extension of the Casimir effect. If that is true, we can also extend the principles of the Casimir effect to explain acceleration due to gravity by combining it with Fatio's push gravity theory. Then by acknowledging that the strong nuclear force is also consistent with a short-range Casimir effect, we can show that all three forces are part of the electromagnetic force with all force motion as an extended Casimir effect.

1. Introduction

Two of the most important unanswered questions in physics are; What causes electromagnetic motion and how does it cause motion? With our vast knowledge of electromagnetic theory no one ever answered these questions convincingly. Few even ask these questions as they are difficult or uncomfortable to deal with due to theoretical biases of the past. Without the answers, our knowledge of physics at the most elementary level is incomplete.

Historically, they were not asked because electromagnetic forces work in a vacuum when there is no directly observable matter present. In the last century, most physicists denied the existence of Planck type quantum oscillators in otherwise empty space. The denial of the existence of quantum fluctuations meant that those physicists denied the existence of the one thing that can explain electromagnetic acceleration.

Particles do not have jet packs to propel themselves. They do not have radar to detect other particles. Nor do they have equipment for measuring electric and magnetic fields. They do not have a supercomputer to process the massive amounts of data they would have to collect before determining a trajectory and impulse for their nonexistent jet packs.

So instead, physicists came up with the idea that electromagnetic forces are mediated by virtual photons, but photons only carry one bit of data since their frequency, wavelength, and energy are interdependent. Photons do not know the velocity of their source or detector nor do they know their direction of travel.

We can infer the velocity difference between the source and detector based on red or blue shift. But we have to know the emission energy and it requires a spectrometer which particles do not possess. Measuring angle of incidence requires an experimental arrangement not possessed by elementary particles either. They also do not come with a data packet and data port.

Virtual photons, which notably are Planck oscillators, can only travel the length of their wavelength or they would violate the principle of conservation of energy. So, even if they could communicate information, it would only be the distance between objects.

There must be a physical explanation that overcomes these difficulties and pushes objects in a manner consistent with the mathematics of electromagnetic theory. Fortunately, we are now quite confident that space is filled with Planck type oscillators forming what we commonly call the quantum field or zero-point field.

2. The Casimir Effect

There is no more compelling evidence for the existence of quantum oscillators in space than the proven existence of the Casimir effect. The landmark 1948 paper by Hendrik Casimir and Dirk Polder was titled "The Influence of Retardation on the London-van der Waals Forces."[1] This simple sounding title belies the importance of their discovery.

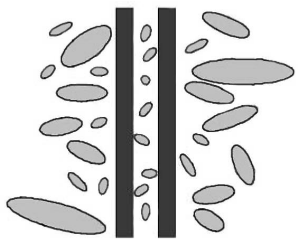

Fig. 1. A simple illustration of the Casimir effect between two plates. Longer quantum dipole wavelengths are excluded between the plates leading to a pressure differential that pushes the plates together.

The basic two-plate example of the Casimir effect is shown in Figure 1. But to fully appreciate the importance of the Casimir effect to physics, we need to review the premises that underlie the paper's title.

a. Quantum fluctuations exist throughout space.
b. Quantum fluctuations have a continuum of energies and are not monoenergetic.
c. Quantum fluctuations form dipoles.
d. Van der Waals forces occur between quantum fluctuation dipoles.
e. Local Van der Waals forces can be reduced (retarded).
f. Van der Waals forces can be reduced due to the physical dimensions of a cavity. (Later it was found they can increase as well.)
g. Van der Waals forces lead to something we can think of as van der Waals pressure.
h. Van der Waals pressure pushes on bodies of matter.
i. Normal van der Waals pressure pushes uniformly on all sides of an object so that it does not move.
j. Changes in local van der Waals forces leads to changes in local van der Waals pressure.
k. Changes in local van der Waals pressure can cause pressure differentials.
l. Differential van der Waals pressure on a body causes the body to move when not otherwise constrained.
m. Quantum van der Waals pressure is undetectable when there are no pressure differentials.
n. Quantum van der Waals pressure does not heat objects.
o. Quantum fluctuations can do work by accelerating bodies.

Any one of these points is important on its own but taken together the Casimir-Polder theory was a tour de force. Even today it is not clear if most physicists appreciate that the Casimir effect incorporates each of these important points, which is why they are delineated here.

Once the Casimir effect was proven to exist, each of these underlying premises were proven to be true. Importantly to the next section, the Casimir effect has been shown to be identical to van der Waals forces, proving that space is filled with quantum dipoles.

If for no other reason than a process of elimination, quantum dipoles are the answer to the first question as to what causes charged or magnetized bodies to move in response to electromagnetic forces. They are the only thing known to be physically present in otherwise empty space. The question of what are the quantum dipoles will be dealt with in later sections.

3. Electric and Magnetic Fields

During the last century, when many physicists assumed space was empty, it was generally thought that electric and magnetic fields were mathematical tools rather than physical reality. Now that we know space is filled with quantum dipoles we must reconsider that assumption.

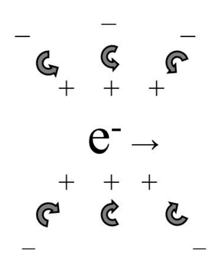

Fig. 2. As an electron moves through space nearby quantum dipoles are polarized and rotate.[2]

The quantum dipoles in space must necessarily respond to electric and magnetic fields. As illustrated in Figure 2, dipoles orient themselves in the presence of electric charges creating a state of polarization. Dipoles rotate in response to the motion of electric charges, or electric currents. When a dipole rotates it becomes a tiny magnet with its poles perpendicular to its plane of rotation. These quantum magnets then align themselves as magnetic dipoles with north and south poles.

The patterns formed by electrically or magnetically polarized quantum dipoles are identical to the well-known Faraday field lines. More importantly, we must conclude that polarized and rotating quantum dipoles are the physical manifestation of the Faraday fields.[2]

So, the existence of quantum dipoles throughout space answers another question that is even more fundamental than the first two. What are the electric and magnetic fields?

4. Extending the Casimir Effect Theory

With the exception of mechanical forces where there is physical contact at the macro level, standard force models in physics fail to account for how bodies are physically accelerated. This includes gravity and the strong force in addition to electromagnetism. The one exception is the Casimir effect as it physically relates motion to interactions between quantum fluctuations based on electromagnetic theory. Those interactions are the well-known van der Waals forces.

In order to answer the question of how bodies are accelerated as a result of electromagnetic forces, we can attempt to extend the basic principles underlying the Casimir effect and see where that leads. To begin, we must recognize that differentials in vacuum pressure do not necessarily have to arise due to the physical dimensions of a cavity, but more frequently come about in other ways.

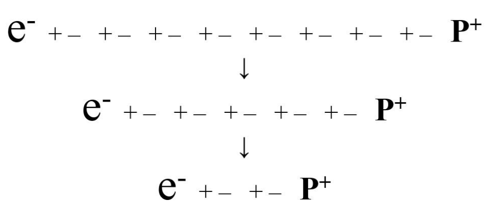

Fig. 3. Attraction within a series of quantum dipoles polarized between opposite charges, in this case an electron and proton, leads to a local reduction in van der Waals pressure.

The first electromagnetic acceleration interaction to consider is the attraction of oppositely charged bodies. In this case, quantum dipoles are polarized in a line between the electrically charged bodies. There are also polarized arcs following the familiar Faraday field line pattern. Each quantum dipole is in turn attracted to adjacent quantum dipoles.

As each quantum dipole collapses toward annihilation the charges move inward and adjacent quantum dipoles move inward to fill the voids, as illustrated in Figure 3. This gradually reduces the number and/or size of dipoles between the electrically charged bodies. Note that new dipoles do push back during the first half of their existence, so there are oscillations typical of van der Waals forces that slow the process.

The overall process causes a reduction in local van der Waals pressure between the opposing charges. The van der Waals pressure on the outer sides of each charged body is greater. Consequently, there is a van der Waals pressure differential pushing electrically charged bodies together. The source of acceleration is similar to the Casimir Effect, but a different mechanism is responsible for the decrease in local van der Waals pressure between the bodies.

Next, we can consider repulsion between like charges. In this case, quantum dipoles are polarized around each charge, but when they meet in the middle, they are deflected creating gaps in space. Those gaps are immediately filled with new quantum dipoles. Since the field is neutral at that point, the initial dipole orientations are random so the quantum dipoles push in all directions against the adjacent dipoles, as illustrated in Figure 4.

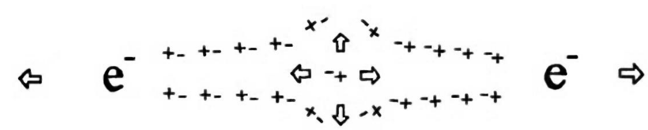

Fig. 4. Quantum dipoles align between two electrons. Where they meet in the middle the dipoles are deflected and the gap is filled with new quantum dipoles that increase the local van der Waals pressure.

This process causes an increase in local van der Waals pressure between two like charges. The force on the outer side of the electrically charged bodies is now lower than the force in between. So once again, there is a quantum pressure differential, but this time the charged bodies are pushed apart. Again, the source of the acceleration is similar to the Casimir effect, but with a different cause of the local pressure increase.

Once we recognize that rotating quantum dipoles form tiny magnets we find that magnetic acceleration is caused by the same kinds of quantum pressure differentials as electric acceleration.

Rotating quantum dipoles are polarized with respect to the poles of a physical magnet. Between north and south poles of two physical magnets the quantum magnets line up in a manner that is analogous to the dipoles shown in Figure 3. Like the electrostatic force, reduction in local pressure between physical magnets causes them to be pushed together due to the greater van der Waals pressure on the outer ends of the magnets.

Then if we put two physical magnets close together with like poles together, north to north or south to south, we have a situation like that shown in Figure 4. The quantum magnets in the middle deflect away from each other and the gaps are filled with more quantum dipoles that push in all directions through the usual van der Waals forces. This leads to a local increase in quantum van der Waals pressure between the physical magnets that pushes them apart.

Once we recognize that space is filled with quantum dipoles it is easy to see how electromagnetic motion is accounted for as an extension of the principles behind the Casimir effect.

5. Extended Casimir Effect Discussion

While the physical description of the extended Casimir effect is intuitively obvious, proving it mathematically is substantially more complicated. The major problem is that any physical explanation of electromagnetic acceleration must be consistent with the inverse square law, as well as the cubed law for rotating dipoles within close range and even higher orders for van der Waals forces. Note in particular that van der Waals forces that have been mathematically described to date do not adhere to the inverse square law.

Looking at it the other way, any physical explanation for electromagnetic motion must adhere to the inverse square law. Consequently, in as much as quantum fluctuation dipoles are the only known thing in otherwise empty space that could be responsible for physically causing acceleration, we must conclude that there is an underlying force that follows the inverse square law. We only need to figure out how to derive it mathematically.

The alternative approach would be to say that no physical explanation of acceleration adheres to the inverse square law. In that case, acceleration must be caused by magic, or something similarly non-physical and non-scientific. Magic is not an option. Nor can we fall back on non-existent jet packs. So, we know that something in space must physically interact in a way that follows the inverse square law. Based on present physics knowledge, that something must be quantum fluctuations and our best model to follow is the Casimir effect.

Quantum dipoles must be polarized such that they mimic the Faraday field lines. Actually, it is the other way around with the Faraday field lines mimicking the quantum dipole alignment. These Faraday fields do follow the inverse square law. Intuitively speaking, we should expect that van der Waals forces propagating along field line paths whose intensity varies in a manner that is consistent with the inverse square law would decrease less rapidly than van der Waals forces between randomly oriented dipoles.

Another solution was proposed by the author based on the recognition that matter and antimatter behave like a type of dipole at short range. Like particles repel due the Pauli exclusion principle and degeneracy pressure and matter and antimatter attract when they annihilate.[3] Refer to the cited paper for more in-depth discussion.

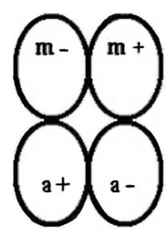

Fig. 5. An electron-like quantum dipole on the left and a proton-like dipole on the right repel each other in this configuration due to the 780 keV potential between electrons and protons (**m** is matter and **a** is antimatter).

Quantum dipoles may be of two types. One type has matter with negative electric charge on one side and antimatter with positive charge on the other, like a quantum electron-positron pair. The other type has matter and positive charge on one side of the dipole and antimatter with negative charge on the other side. This type of quantum dipole can be thought of as a proton-antiproton pair or, under the quark model, an up-anti-up pair of quarks.

These two types of dipoles repel each other at close range regardless of their orientation. In one orientation they repel due to electric charge and in the other due to matter orientation, as illustrated in Figure

5. The repulsive force between an electron and positron is known to have a 780 keV potential.

This leads to a van der Waals force that falls off much less rapidly than other known van der Waals forces. Conceivably, it may lead to a van der Waals pressure force that adheres to the inverse square law, although a mathematical proof of that has yet to be performed.

In any case, in order to physically explain electromagnetic acceleration there must be a physical source of acceleration that adheres to the inverse square law. It is our job to figure out what it is, not to deny a fundamental truth.

6. The Fatio-Casimir Effect

There is yet another theory explaining how pressure differentials in space come about that was originally proposed by Nicolas Fatio de Duillier.[4] His theory was later popularized be Georges Le Sage. Fatio proposed a model for gravity where gravity is due to a shadowing effect between bodies. In his model, space is filled with corpuscles that push on bodies, but the bodies block some pressure that would have otherwise been directed at another nearby body as illustrated in Figure 6. In that way, the pressure pushing the bodies apart is reduced, and they are consequently pushed together by the stronger outer pressure. This theory is sometimes referred to as push gravity or shadow gravity.

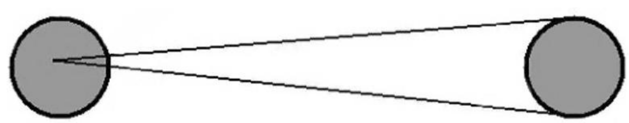

Fig. 6. An illustration of how shadow gravity reduces the local pressure between bodies by blocking some of the pressure coming from the direction of the opposite body.

Fatio's theory is like Casimir's in many ways except that Fatio's theory requires that there is a pressure force that adheres to the inverse square law. A physical explanation of electromagnetic acceleration based on the extended Casimir effect also requires an inverse square law varying pressure. So, if the extended Casimir effect is true for electromagnetism, Fatio's theory is also true.

In that case, however, Fatio's corpuscles are actually quantum dipoles and the underlying pressure force is a new type of van der Waals force. Hence, we should think of it as a Fatio-Casimir effect. The Fatio-Casimir effect is a quantum electromagnetic theory of gravity, which, unlike current gravitational theories, includes a mechanism for gravitational acceleration.

Note that the major objection to Fatio's theory in the past was the idea that his corpuscles obeyed kinetic gas laws and would heat bodies of matter. The amount of heat produced in this kinetic gas approach to his theory would be tremendous such that all matter could only exist as plasma. We know that the Casimir effect exists and that quantum van der Waals forces do not heat everything turning it into plasma. Quantum dipoles do not heat bodies of matter. This is one of the important conclusions related to the Casimir Effect listed in Section 2.

Since Newton's and Einstein's theories of gravity failed to include a physical mechanism for acceleration due to gravity, we need to figure it out even if it requires a paradigm shift in our thinking about gravity. Graviton theory does not explain acceleration either. A complete Fatio-Casimir effect theory would explain gravity as well as gravitational acceleration, although it would be an electromagnetic phenomenon rather than a separate gravitational force.

This opens up the possibility of describing the inverse square law pressure force in space in much the same way that Fatio did, which avoids the difficulties involved with a van der Waals force derivation.

Note that the non-linear components of general relativity theory are distinct from Fatio-Casimir gravity, while being consistent with a non-electric variant of forces following electromagnetic force principles. Later in life, even Einstein had come to think that gravity may follow electromagnetic principles.[5]

7. The Strong Short-Range Casimir Effect

The Casimir effect occurs over a full range of distances, particularly when we include the Fatio-Casimir effect. However, the short-range Casimir effect at femtometer (fm) distances receives little consideration.

If we consider two spheres which each have a diameter of 0.88 fm and are 0.7 fm apart we find that the Casimir force pushing them together is 1240 newtons using the proximity force approximation.[6] By way of comparison, if those spheres happened to be electrically charged with the same unit charge, they would repel each other with a force of 42 newtons. So, under these conditions, the attractive Casimir effect is 30 times stronger than electromagnetic repulsion.

Note that these initial conditions were not chosen at random as 0.88 fm is the charge radius of the proton and 0.7 fm is the closest approach due to the strong nuclear force before a close-range strong repulsive force related to the Pauli exclusion principle overcomes the attractive strong force. Thus, the strong nuclear force is accounted for entirely or in part by the strong short-range Casimir effect.

Note that this does not mean that protons and neutrons are spheres or spherical shells. For the Casimir effect to occur in the nucleus it is only required that protons and neutrons scatter other particles in a manner that approximates the scattering of a sphere or spherical shell. The proton charge radius has been proven to exist due to scattering experiments, so they must scatter quantum dipoles in a similar manner leading to a Casimir effect. It is impossible for anything that is known to scatter particles and light to not participate in the Casimir effect.

The proximity force approximation treats the nearest surfaces of the spheres as small parallel plates and it is more accurate at distances that are much smaller than the diameter of the spheres. It does not take into account that if the spheres are spherical shells then they are Casimir cavities with reduced internal van der Waals pressure. Also, this approximation does not factor in the forces on the outer surfaces of the spheres like we do with the Fatio-Casimir effect. It is possibly that the total Casimir force between two 0.88 fm diameter spherical shells is greater than 1240 newtons, by a factor of 2 or 3.

8. The Quantum Dipoles

In the preceding sections it was unnecessary for us to know what the quantum dipoles are in order to understand how the Casimir effect can be extended to explain acceleration due to forces. It was only necessary that space is filled with dipoles that interact to produce van der Waals forces.

Dipoles must also have the energy of a Planck oscillator, $\mathbf{E}=\boldsymbol{hf}/\mathbf{2}$, and they cannot exist longer than the time allowed by the relation $\mathbf{\Delta E \Delta}\boldsymbol{t}=\boldsymbol{h}/\mathbf{2}$ so the principle of conservation of energy is not violated. The second relationship should be familiar from Heisenberg's uncertainty principle, which tells us that it is not possible to directly observe quantum fluctuations in a complete way, so we are left examining partial evidence and indirect evidence of them.

In standard quantum field theory, the quantum oscillators are treated as matter-antimatter particle pairs. This fits the requirement that they form electric charge dipoles when they are pairs of particles with non-zero electric charge. In papers written about the Casimir effect these are generally classed as Dirac Fermion particle pairs with the original Dirac Fermion pair being the electron-positron pair.

Traditionally the quantum vacuum has been treated as photon pairs, which is problematic since any pair of photons exceeds the energy or time constraints listed above. To meet the energy and time limits, a virtual photon can only be a single half-wavelength photon as illustrated in Figure 7.

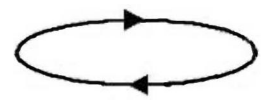

Fig. 7. A virtual photon is identical to a quantum Dirac-Fermion matter-antimatter particle pair.

A virtual half-wavelength photon has a rotating electric and magnetic field, so it also looks like a dipole. In fact, if we insist on there being a physical cause of the rotating electric and magnetic field, then a half-wavelength photon is a dipole. In this way, virtual photons can also be thought of as being identical to Dirac Fermion matter-antimatter particle pairs. Then a majority or possibly all quantum dipoles can be thought of as Dirac Fermion matter-antimatter particle pairs.

9. Conclusion

In order to truly understand electromagnetic forces we must be able to answer the questions; What causes electromagnetic motion and how does it cause motion? To answer the what question, we must find something that exists throughout space that causes motion. We only have convincing evidence for one thing that is present throughout space and that is the quantum field of Planck oscillators, the zero-point field.

To answer the how question we must consider the one force that has been experimentally verified to exist that arises entirely from the quantum field and causes bodies to move. That force arises from the

Casimir effect. The Casimir effect is due to van der Waals pressure differentials that come about due to pressure changes in cavities.

Then by examining how electric and magnetic fields propagate by way of the same dipoles that fill space, we readily see that polarization of quantum dipoles leads to pressure differentials. And those pressure differentials must be the cause of electromagnetic motion. For the extended Casimir effect to account for all electromagnetic motion we still need to show explicitly that a component of quantum dipole pressure adheres to the inverse square law.

Given the current lack of an alternative space medium and alternative forms of interactions physically causing motion, we can look at it another way. Space must produce pressure that causes bodies to move in a manner that is consistent with the inverse square law. As physicists we cannot leave the question unanswered, so it is our job to mathematically derive the physical force responsible for electromagnetic motion.

From there we find that the principles of the Casimir effect outlined in Section 2 can be applied to Fatio's theory of gravity, whereby the shadowing effect between bodies of matter causes the pressure differentials that cause motion. Gravity as a Fatio-Casimir effect is an electromagnetic quantum gravity theory that allows us to unify gravity with electromagnetic theory.

We can also acknowledge that the Casimir effect works at short ranges. Not only that, it becomes very strong at short ranges, much stronger than the Coulomb force. As such, there is an opportunity to explain acceleration due to the strong nuclear force as a Casimir effect.

Consequently, all motion due to forces is explainable as an extension of the Casimir effect. This conclusion is reached without adding anything to standard quantum field theory where space is filled with quantum matter-antimatter particle pair dipoles.

The next step is modeling the extended Casimir effect mathematically. The author is interested in collaborating with other physicists who have good ideas about how to proceed with this project.

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