Gravitational Theory of the Casimir Effect: from the Virtual Quantum Vacuum to the Deterministic Physical Vacuum

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Abstract

The Casimir effect is interpreted generally through the consideration of indeterministic quantum events that are justified by the indeterminacy principle and by the concept of quantum vacuum. That explanation is based on the hypothesis of existence of statistical fluctuations of energy around the point of zero energy that generate virtual pairs of particle-antiparticle. With this research let us intend to prove the Casimir effect can be explained by the interaction mass-mass of the symmetry MLM without the necessity to make use of virtual and probabilistic paradigms.

1. Introduction

Let us start from the observation that the Casimir effect is a real physical effect based on plausible experimental proofs. Our research regards the theoretical interpretation of the effect that according to present theories would be due to energy statistical fluctuations into the so-called quantum vacuum. In order to understand the physical nature of that effect it needs to specify the definition of vacuum starting from the concept of physical vacuum[1]. The physical vacuum is the physical space without matter, energy and sources. Sources are physical entities that are able to generate a field: mass for instance generates a gravitational field, charge generates an electric field, current generates a magnetic field. The absolute vacuum is a metaphysical concept of philosophy or an abstract concept of geometry and it consists in the absence of matter, of energy, of sources and of any type of field. The absolute vacuum doesn't exist in the physical reality because also only one source into space generates a field that is present in different measure in every part of space. The physical vacuum instead is integral part of the physical universe, it is characterized by specific mechanical, electric and magnetic properties: the coefficient of mechanical resistance, the dielectric constant or permittivity and the magnetic permeability. Quantum vacuum in the postmodern meaning instead would be a physical vacuum in which there are fluctuations around the zero point of energy in the absence of sources and those fluctuations would generate pairs of virtual particles. Pairs particles-antiparticles, that are generated in this process, would have shortest life but it doesn't means they are virtual and unreal. Consequently it is manifest the great contradiction that concerns the quantum vacuum that is characterized by the existence of real particles that would be generated in the absence of real sources.

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This paper doesn't dispute the existence of a physical phenomenon that is called "Casimir effect" and that consists in an attractive action between two plates when a physical vacuum is produced between the plates but the indeterministic postmodern interpretation of that phenomenon is disputed here and an alternative solution in the order of the deterministic contemporary physics is proposed. In postmodern physics in fact the effect is explained generally through the spontaneous creation of pairs of virtual particles in the quantum vacuum that would produce a difference of pressure push inside and outside plates that would generate the attractive force. That explanation would be a direct consequence of the indeterminacy principle and of casual statistical fluctuations around the zero point of energy. A similar situation happens with regard to the tunnel effect in the Esaki junction whose behaviour is explained through probabilistic and indeterministic concepts, but the research of causes of that effect led me to formulate the "deterministic theory of the tunnel effect in the Esaki junction"[2]. That paper has represented a great impulse and a right motivation in order to make a similar work for the Casimir effect. When I began to research an alternative interpretation of the Casimir effect I was convinced to can find an electrostatic solution thinking about a phenomenon of electrostatic induction. I based my convinction on a different explanation of the effect that for a few researchers would be due to the Van der Waals forces among polarized molecules of plates, but that approach raised a series of mathematical and physical problems.
I realized then a different approach could represent the solution to the problem.
In fact while I was intent on my calculations I had suddenly the idea to calculate the gravitational interaction mass-mass of the symmetry MLM between the two plates as per the law of gravitation. With my surprise the calculation was in good concordance with outcomes of numerous experiments on the Casimir effect. I had found like this the expected solution to the problem.

2. The Casimir effect in the theory of quantum vacuum

The Casimir effect was discovered initially (1948) by the physicist Hendrik Casimir who observed an attractive force between two parallel plates after having achieved a situation of physical vacuum between the two plates.
In normal physical conditions, that is in the absence of vacuum (fig.1), pressure p of medium, in which the two plates are placed, is the same whether on the internal surface or on the external surface of the two plates. There is a perfect equilibrium of pressure and no movement between the two plates is observed. When vacuum is produced in the physical space of the experiment (fig.2) and the distance between the two plates is small enough, an attractive process between the two plates is observed, that is absent in normal physical conditions. That attraction is described by the force[3]

$$F = \frac{\pi hcS}{480d^4} \qquad (1)$$

where $h=6.63 \times 10^{-34}$ Js is the Planck constant, $c=3 \times 10^{8}$m/s is the physical speed of light, S is the surface of the two plates, d is the distance between.

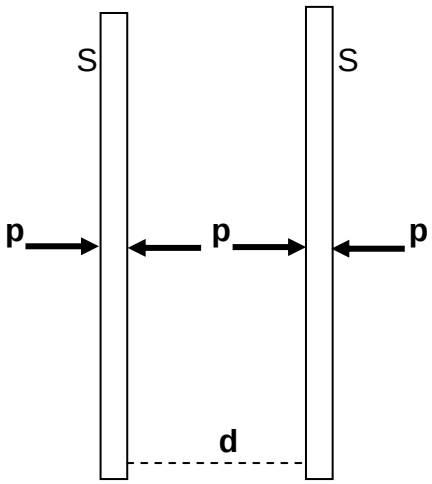

Fig.1 Two parallel plates are in normal physical conditions, i.e. in the absence of vacuum. Pressure p inside and outside the two plates, due to medium, is the same and no effect is observed.

The effect is explained in the theory of quantum vacuum through the spontaneous creation of virtual pairs of particle-antiparticle because of the presence in quantum vacuum of statistical fluctuations of energy with respect to the zero point. It would happen in quantum vacuum whether inside the two plates or outside and in normal physical conditions of sufficient distance between the two plates the pressure on internal surfaces of the two plates is equal to the pressure on external surfaces.

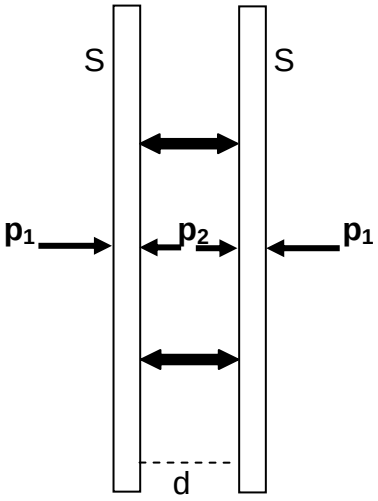

Fig.2 In physical space in which two parallel plates are placed a situation of physical vacuum has been produced. In that case in the current interpretation a difference of pressure inside and outside the two plates would exist for small distances d and it would be due to virtual particles..

When the distance between the two plates is smallest, under the micrometre, inside the two plates only virtual particles with smallest sizes can be, while outside all particles with any size are possible. It implies a substantial difference of pressure by virtual particles on the two surfaces (internal and external surface) for the benefit of pressure on external

surfaces: $p_1>p_2$ (fig.2). The difference of pressure causes an action of attractive push between the two plates that come to contact.
Calculations show that between two parallel plates with surface $S=100cm^2$ at the distance $d=1\mu m$ the pressure difference is $p=p_1-p_2=1.3x10^{-3}$ Pascal and the Casimir force is $F=1.3x10^{-5}N$. Between two plates with surface $S=1m^2$ at the distance $d=1\mu m$ the difference pressure is $p=1.3x10^{-3}$ Pascal and the Casimir force is $F=1.3x10^{-3}N$.
It is manifest that the Casimir effect in the theory of quantum vacuum is a consequence of the indeterminacy principle and of basic concepts of quantum mechanics based on an indeterministic and probabilistic interpretation of the physical universe. Moreover it is manifest that explanation doesn't consider adequately the fact that the great majority of elementary particles has smallest sizes and that the spontaneous creation of virtual pairs of particle-antiparticle would have to be possible also in the absence of vacuum because fluctuations of energy would have to be present also in this physical situation around a non-zero point of energy.
In Deterministic Quantum Physics (DQP)[4] we have demonstrated a deterministic and causal view of the universe is possible also in the order of phenomena that happen in the microcosmos and therefore a deterministic interpretation of the Casimir effect would have to be possible too.

3. Deterministic theory of the Casimir effect

Let us observe the two plates in the Casimir experiment have a mass m that is the same for the two plates if they are perfectly equal. As per the law of gravitation we know two equal masses m, with spherical symmetry, attract either one with a force that is given by

$$F = \frac{G\, m^2}{d^2} \qquad (2)$$

where $G=6.67x10^{-11}\ Nm^2/kg^2$ is the gravitation constant and d is the distance between barycentres of the two masses (fig.3).

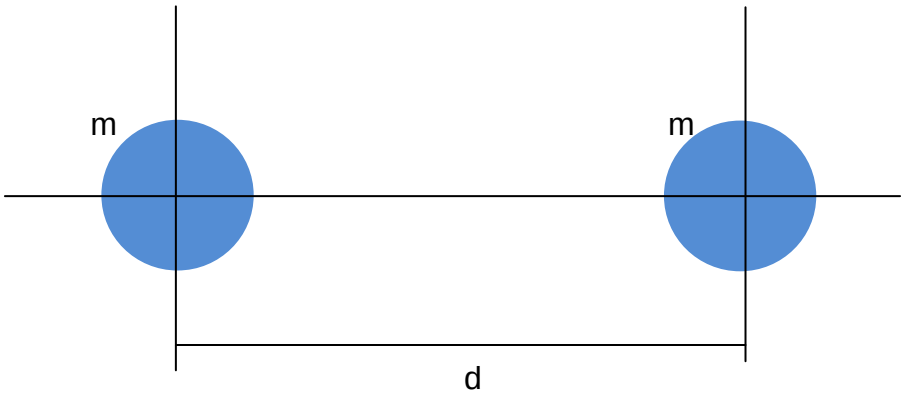

Fig.3 Two masses, supposing that they have spherical symmetry, attract either with the gravitational force that depends on masses and on the inverse square of the distance between barycentres

If the two masses don't have a spherical symmetry but they have shape of parallel plates like in the Casimir experiment (fig.4), then it is more suitable to consider the attractive force F_p that operates between two masses that are distributed on surfaces rather than masses that are supposed punctiform.
In the event of small plates this attractive force is smallest and it is additional to the internal and external pressure force p that is due to medium and is the same on the two plates. In normal physical conditions, i.e. in the presence of medium, because of the smallest value of the gravitational force and because of the resistance of medium this force F_p has no practical consequence.

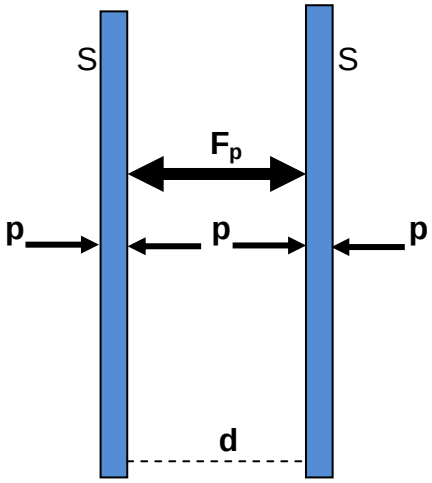

Fig.4 Also two parallel plates attract either with the same universal gravitational force

If now we produce a situation of physical vacuum into the physical space of the experiment then the phenomenon changes (fig.5).

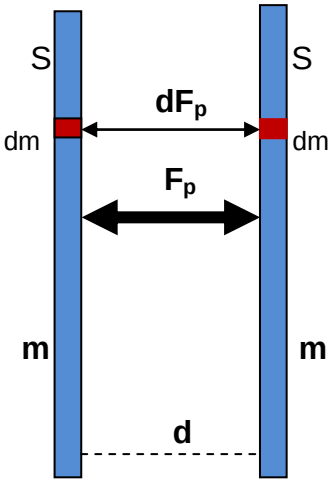

Fig.5 In conditions of physical vacuum into the space where the two plates are placed, the gravitational force between the two plates isn't stopped by the medium and consequently an approach and a contact between the plates is observed for small values of the distance.

In fact in that case the pressure p between the two plates, whether inside or outside, due to the medium, stops to to exist and considering an infinitesimal element of mass dm on both plates, the attractive gravitational force dF_p between the two massive elements is given by

$$dF_p = \frac{G\, dm^2}{d^2} \qquad (3)$$

and extending the interaction to all mass of the two plates, through a procedure of integration, we have

$$F_p = \int_{m^2} \frac{G\, dm^2}{d^2} \qquad (4)$$

Because d is constant, we can write

$$F_p = \frac{Gm^2}{d^2} \qquad (5)$$

If both plates have, for instance, a mass of $4.4x10^{-3}$ kg, and they are placed at a reciprocal distance of 1μm, we deduce from the (5) an attractive force $F_p=129x10^{-5}$ N, that is independent of the surface and depends on masses and on distance. For a surface $S=1m^2$ it produces a pressure $p=129x10^{-5}$Pascal$=12.7x10^{-9}$Atm, and for a surface $S=10^{-2}m^2$ the Casimir force produces a pressure $p=129x10^{-3}$Pascal. That force is able to cause the approach of the two plates and, under the quantitative aspect, it is consistent with the Casimir conventional force for unitary surfaces. Besides the Casimir conventional force increases with surface while the Casimir deterministic force increases with mass, it isn't in conflict because it is supposable that increasing surface also mass increases.
In the deterministic theory of the Casimir effect the physical vacuum that is produced between the two plates has no useful function in order to generate energy and consequent virtual pairs of particles from statistical fluctuations with respect to zero point of energy. Vacuum has only the function to allow the action of the small force due to the gravitational attraction between the two plates that, in normal conditions in the presence of medium, is forbidden by the resistance of medium between the two plates.
The accurate study of the Casimir effect shows this effect is essentially an example of the interaction mass-mass in the order of the group symmetry MLM (Mass-Light-Mass)[5], in the event that masses are distributed. There isn't need to suppose, unlike the theory of the so-called quantum vacuum, wheither statistical fluctuations of energy around the zero point or the spontaneous creation of pairs of virtual particles. This study proves once again the accurate analysis of considered physical phenomena allows significant simplifications of physical and mathematical models where instead an inadequate analysis involves the necessity to make use of probabilistic and indeterministic models that complicate the theoretical treatment and don't give adequate explanation of the event.

4. Indeterminism and determinism

Present physics shows a dichotomy between the indeterministic view and the deterministic view of the universe, besides a widespread muddle between quantum phenomena and indeterministic phenomena is present in postmodern physics for which it is believed at length any quantum phenomenon is necessarily indeterministic. The indeterministic view is based essentially on Heisenberg's Indeterminacy Principle that affirms it is impossible the simultaneous knowledge of two correlated physical quantities of an elementary particle, like position and momentum, position and wave number, energy and time. For macrophysical systems instead it is possible to define simultaneously those correlated quantities and any attempt to expand the indeterministic paradigm to physics of ordinary systems foundered.

Let us examine now the following question: is essential the indeterministic model in the universe of elementary particles? As we have demonstrated in this paper the answer is no! This conclusion in actuality was demonstrated also in Deterministic Quantum Physics[3], in fact DQP proves indetermination is only experimental, i.e. due to the inadequacy of present instruments of measure that don't allow a simultaneous measuring for instance of position and speed for elementary particles while it is altogether possible for ordinary systems. In QM instead, if for example the speed of a particle is known, it is impossible to know its position as per the indeterminacy principle and this impossibility not would be due in QM to the inadequacy of measuring instruments. It follows that the only possible road is to assign a value of probability to every possible position. Schrodinger's Wave Mechanics, that is another formulation of QM, then allows to calculate those values of probability through the wave equation.

The group of tools consisting of the operator method, of the matrix method and of wave mechanics represented the beginning of Quantum Mechanics that was based on a indeterministic and probabilistic view of the nature and of the physical universe that involved then the generalized indeterministic theorization of all physical events like the so-called tunnel effect. This effect in fact inside the indeterministic interpretation proves if a charge particle (for instance an electron) doesn't have sufficient energy for surmounting a physical obstacle constituted by an opposite barrier of potential energy, anyway in the order of QM there is always a small non-zero probability that the electron is able to surmount that barrier. This explanation of the tunnel effect is a manifest negation of basic principles of classic physics and of logic and it represented the definitive cover-up of the Principle of Cause and Effect, determining like this the transition from the philosophy of a causal nature to the philosophy of a casual and probabilistic nature.

Starting from this indeterministic view, quantum vacuum then supposes the spontaneous creation of virtual pairs of particles-antiparticles from statistical fluctuations of energy around the zero point without the necessity of defining sources of those fluctuations and like this it represents a further development in that direction of research that is based on casualness. Besides this approach is completely in disagreement with laws of electromagnetism that demonstrate that any electromagnetic phenomenon is generated by suitable sources.

The "Deterministic Theory of the Tunnel Effect in the Esaki Junction"[1] and just this paper on the Casimir effect represent together with the DQP an important answer to this indeterministic approach of physics of elementary systems. First of all DQP represents a scientific criticism of Heisenberg's theory relative to the mathematical model of photon that then, as per the concept of De Broglie's wavelength, was applied also to charged elementary particles. In fact DQP demonstrates the physico-mathematical model of photon is represented more efficiently by a wave function of the "rational trigonometry" than by a wave function of the ordinary trigonometry that is perfect from the mathematical viewpoint but it presents some inconsistency from the physical viewpoint. This new approach eliminates the intrinsic indetermination represented by the wave packet and by frequency scattering. In actuality already the Planck relation contradicts that indeterministic interpretation because it associates only one frequency with every energy quantum (E=hf). This first aspect eliminates definitively the intrinsic indetermination of the nature and proves the existence only of a working and experimental indetermination due to the present inadequacy of measuring instruments that can be surmounted gradually step by step thanks to the great evolution of technology also in the field of the measuring instruments.
Secondly criticism relative to whether the tunnel effect or the Casimir effect confirms the cogency of the Principle of Cause and Effect , as per the fact that every effect is completely defined, in the absence of perturbations, by the cause that has determined it and the probabilistic mathematical model maintains its cogency only in the order of the prediction of future events in the presence of stochastic perturbations and/or of further unknown causes that change in chance manner the result of the experiment and of the expected value, independently of measuring errors that anyway are present in every measuring process.
In the deterministic model therefore the present impossibility to measure and to know simultaneously two quantities that are correlated, means only those quantities cannot be used simultaneously in equations and in the description of the behavior of microphysical systems and of elementary particles. It doesn't exclude nevertheless they can be used separately. Besides other important physical quantities, like for instance frequency spectra associated with the behavior of elementary particles, can be measured with greatest precision and used in the description of the physical behavior of particles.

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