**Open Access Journal of Physics**
**Volume 2, Issue 3, 2018, PP 15-24**
**ISSN- 2637-5826**

# Polarization of Vacuum

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**ABSTRACT**

*The study of the vacuum polarization phenomenon and the nature of its quantum structure is an actual problem in modern physics. Ignoring this fact often leads to erroneous interpretation of the experimental data. In quantum electrodynamics (QED), the instability of a physical vacuum is characterized by the formation of pairs of elementary particles. The article contains descriptions of experiments, that allow substantiate the quantum structure of vacuum and the reality of particles arising in a vacuum as a result of its polarization. The idea of "virtuality" of particles is connected with the inability of quantum field theory to describe the real mechanism of vacuum polarization.*

**Keywords:** *vacuum; dark matter; polarization; electron; positron; proton; resonance*

## Introduction

In classical electrodynamics, vacuum is a "medium" with absolute dielectric and magnetic permeability ($\varepsilon_a$, $\mu_a$), which are equal to the dielectric and magnetic constant ($\varepsilon_o$, $\mu_o$). The electric strength of the vacuum is infinite, that is, theoretically the electric field of any intensity cannot cause conduction currents in a vacuum due to the lack of charge carriers. In other words, the electric field strength **E**, the magnetic field strength **H**, as well as the density of electromagnetic energy in vacuum defined by them, can be infinitely large. It should be noted that these conclusions are obtained from the standpoint of the classical electrodynamics of Maxwell's linear field and, in the light of the latest achievements of quantum electrodynamics (QED), are incorrect. In QED, the instability of a physical vacuum under the influence of cosmic radiation, relativistic protons and electrons, peak electric fields, or high-intensity laser radiation is characterized by the avalanche formation of electron-positron pairs in a vacuum [1,2,3]. Nils Bohr was right when he stated 80 years ago that "it is impossible to attain a tension of the order of Es for the field that generates electron-positron pairs." ( $E_s = m^2/e = 1{,}32\cdot10^{16}\ \mathrm{V\cdot cm^{-1}}$ the characteristic quantum-electrodynamics Sauter's field) [3]. It should be noted that any quantum process of pair production from vacuum is accompanied by various many partial processes. In QED there is still no complete clarity on how to solve the problem of the production of pairs of elementary particles and antiparticles in a vacuum under the action of external fields, relying on the corresponding the Klein-Gordon-Fock and Diract equations.

## Polarization of Vacuum and Transformation of Vacuum Into Matter

In quantum theory, vacuum polarization is a collection of virtual processes of creation and annihilation of pairs of particles in a vacuum caused by quantum fluctuations. Nobel laureate R. Feynman presented such fluctuations geometrically in the form of diagrams [4]. Feynman constructed diagrams abstracting from real physical processes, so he pictured vacuum with a wavy line, and the virtual fluctuation that appeared in it is shown by a ring or a loop formed by symmetrical arrows (Fig. 1). However, the wave image implies that this wave moves, and on the diagram of this movement is not indicated, therefore the ring can arise only if it is formed from a point. This means that the vacuum should be shown on such a diagram by a certain point object, which is transformed into a ring of fluctuations. Feynman, depicting such a fluctuation separately, depicted it in the form of a ring in which an electron and a positron move in one orbit, in one direction one after another, at diametrically opposite points of this ring. Considering the electron-positron pair, it is necessary to pay attention to the fact that in addition to the charge, each elementary particle has a spin, which indicates that the particle has a rotation and has an axis of such rotation. The claimed zero parameters of the vacuum quantum are fully realized. Two opposite electric charges cancel each other, and both spins add up with the opposite sign and both rotations are also mutually compensated. With respect to mass compensation, the explanation is this: each of the pair particles is a quantum gyroscope, which means. That the axis of rotation of the particle is strictly defined in space and remains unchanged. In order for an electron and a positron to perform a joint gyroscopic rotation in a pair, the axes of their rotation must coincide.

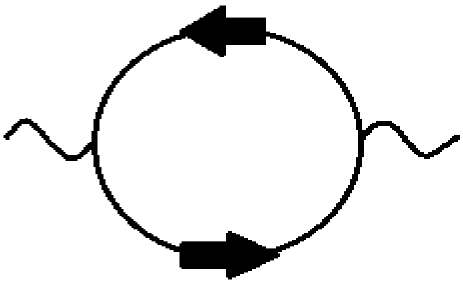

**Figure1.** *The Feymann's of diagram. The electron-positron pair (virtual ring)*

At the same time, the quantum vacuum is transformed into a quantum particle by the Heisenberg's relation. By virtue of the uncertainty principle in a vacuum, virtual particles can exist. In this case, even the creation of charged particles in pair with its antiparticle is possible. Such a production of a pair of particles on the Feynman's diagram is represented by a virtual ring. A virtual ring, supposedly, can exist for a very short time - within the quantum uncertainty $\delta t \sim \hbar / \delta E$, so as not to violate the law of conservation of energy.

In quantum electrodynamics, vacuum polarization consists in the formation of virtual electron-positron pairs under the influence of a quantum of the electromagnetic field of a photon or under the influence of a peak electric field. In 2011, it was found that in the presence of a strong magnetic field $H \approx 10^{16}$ T from virtual particles of a quantum vacuum, relatively stable particles are formed (lifetime $16 \cdot 10^{-23}$ sec.) [5]. At the same time, experiments show that if an external field acts on the vacuum, then the creation of real particles is possible due to its energy [1,2,3]. Precisely because the vacuum is not a virtual but a real physical object (dark matter) and has a structure, the vacuum polarization leads not to virtual, but real radiation corrections to the laws of quantum electrodynamics [5].

In the theory of gravitation, vacuum polarization is also present, and theoretically it is manifested at extremely small Planck distances ~ $10^{-35}$m. It is assumed that the processes of gravitational polarization of vacuum play an important role in cosmology [5].

With the polarization of the vacuum and its transformation into matter, the change in the energy of the vacuum w can be represented as a sum:

$$w = w^p + w^e \quad (1)$$

where $w^p$ is the vacuum polarization, $w^p << E^2 / 8\pi$;

$w^e$ is the change in the energy of the substance at the production of particles

$$w^e = eET\varkappa, \quad \varkappa = \frac{e^2E^2T}{4\pi^3}\exp(-\pi\frac{m^2}{\hbar E}) \quad (2)$$

The creation of particles is the main reason for the change in the energy of the vacuum. The small value of the reverse reaction $w^p$ implies the limitation on the electric field strength for a given time T ($E_s \approx 10^{16}$ V · $cm^{-1}$ is the critical Schwinger's field) [1].

In studies conducted in 1996-99 on the SLAC linear accelerator, only a few electron-positron pair creation events were detected at a laser pulse intensity of $10^{17}$ W· $cm^{-2}$. Due to the fact that within the framework of the ELI and XCELS projects the laser radiation intensity available for experiments has increased to $10^{23}$ W · $cm^{-2}$ and higher, it has become possible to study the nonlinear vacuum effects that have so far not been experimentally studied. Thus, at the level of ultrahigh intensities $10^{26}$ W · $cm^{-2}$, the effect of scattering of a laser pulse on an electron beam with an energy of 46.6 GeV (nonlinear Compton effect) causes such cascades of successive hard-photon emissions that the creation of secondary electron-positron pairs in vacuum is a chain reaction that continues up to up to the moment of complete loss of energy by charged particles. This is very reminiscent of the extensive atmospheric showers generated by cosmic particles. They are called S-cascades (from the English shower - a shower) [2,3]. In this comparison of space observations with the results of laboratory studies demonstrates deep analogies, evidencing, at a minimum, the unity of the physical principles of the behavior of matter in a wide range of densities and temperatures. Perhaps the creation of electron-positron pairs in a vacuum is a manifestation of the instability of dark matter. Today, according to the results of the experiments at CERN, many physicists believe that dark matter is connected with the study of the microworld at the smallest distances, and everything suggests that dark matter can act as a

vacuum in experiments in near-Earth space [6]. The very definition of dark matter falls under the description of the properties of vacuum in quantum electrodynamics - not to radiate and be invisible, to have mass and to possess a structure, to exhibit elastic properties in the propagation of electromagnetic waves. The quantum structure of the vacuum is due to particles in the low-energy state. The instability of a vacuum under the influence of cosmic radiation, relativistic protons and electrons or peak electric fields is a purely quantum phenomenon. In quantum electrodynamics this phenomenon is characterized by the formation of electron-positron pairs in a vacuum. The direction of motion of secondary electron-positron pairs produced in a vacuum (dark matter) can be determined by the nature of the effect that caused the polarization of the vacuum. Under the influence of rigid photons (bosons), the deformation of the vacuum occurs in the transverse direction to the propagation of the perturbation, which determines the direction of motion of electron-positron pairs (Fig.2a). This can be seen by analyzing the observation data on the fluxes of secondary electron-positron pairs with a soft energy spectrum in quantum-dynamic cascades in an intense laser field or in the near-Earth environment under the action of cosmic-ray photons in the PAMELA and AMS-02 experiments [7,8]. If vacuum polarization is caused by the motion of relativistic charges or by a peak electric field strictly oriented in one direction, then the secondary electron-positron pairs produced in vacuum will move in the direction opposite to the momentum of the primary charged particles, with zero transverse momentum $p^{\perp}=0$, since deformation the vacuum will occur in the longitudinal direction (Fig.2b).

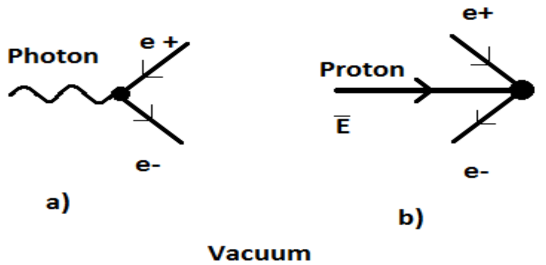


**Figure2.** *Polarization of vacuum*

- if vacuum polarization is caused by the motion of photon
- if vacuum polarization is caused by the motion of relativistic proton or by a peak electric field strictly oriented in one direction E

An experimental confirmation of this could be the appearance of a flow of backward electrons with a "soft" energy spectrum in multiwave Cherenkov generators (MWCG). One of the peculiarities of the work of MWCG using an electron beam of microsecond duration with an initial charged-particle energy $W_e \sim 2$ MeV and a common current I ~ 20 kA is a relatively short radiation pulse in the three-centimeter wavelength range with a record power level of up to 15 GW [9]. The most recent information message on the comprehensive testing engine Em Drive “Measurement of Impulsive Thrust from a Closed Radio-Frequency Cavity in Vacuum» was published in Journal of Propulsion and Power in 2016 [10]. The authors of Harold White, Paul March, James Lawrence, Jerry Vera, Andre Sylvester, David Brady and Paul Bailey (NASA Johnson Space Center, Houston, Texas 77058) concluded: " the quantum vacuum a dynamic mediumand could potentially be modeled at the microscopic level as an the electron-positron plasma. If the vacuum is indeed mutable and degradable as was explored, then it might be possible to do / extract work on / from the vacuum, and thereby be possible to push off of the quantum vacuum and preserve the laws of conservation of energy and conservation of momentum...” [10].

## EXPERIMENTS

Let us consider some effects due to the polarization of the vacuum, that is, having their roots in the structure of the vacuum (dark matter):

### The Photoelectric Effect and the Creation in the Vacuum of an Electron-Positron Pair

The experimentally established red "photoeffect" boundary for a vacuum (dark matter) corresponds to a photon with energy $Wpfot \geq 1$ Mev $= 1.6493 \cdot 10^{-13}$ J. At this energy, the photon is converted in a vacuum into an electron-positron pair [11]:

$$Wphot = h\ \nu = \mathrm{Wdef} = e_0\ \mathrm{Edr} \qquad (3)$$

where h is the Planck constant

ν is the photon frequency

$e_0$ is the dipole charge

E is the electric field strength

Analysis of the spectral curves of secondary electrons and positrons, presented in the work [8], makes it possible to determine the resonant energy of photons providing the maximum of pair production in a vacuum (dark matter). The frequency corresponding to the resonance energy of the photon (ν) and the natural frequency of the structural element of the vacuum (dark matter) is defined as the frequency of the Schrodinger and de Broglie wave functions:

$$\nu = W / h \text{ or } \omega = W / \hbar \text{ and } \lambda = 2\pi c / \omega \qquad (4)$$

$W_r \approx 20$ GeV $= 33 \cdot 10^{-10}$J, $\nu_r = 4.7 \cdot 10^{24}$ Hz, $\omega_r = 2.82 \cdot 10^{25}$ Hz, $\lambda_r = 6.39 \cdot 10^{-17}$ m [11].

Resonant maximum of the total energy spectrum of secondary electrons and positrons at the photon energy Wp ≈10-20 GeV (Fig. 16), as well as maxima of energy spectra obtained separately for positrons (Fig. 21) and electrons (Fig. 22) in experiments AMS-02 (2011-2015) convincingly confirm the quantum structure of the vacuum [8]. Direct experimental determination of the resonant dependence of the production of N pairs of elementary particles on the frequency ν is almost completely suppressed by modern physics. Following the deceptive logic of modern theory, this dependence is drawn in the form of a monotonically increasing curve. However, an analysis of the results of the AMS -02 experiment made it possible to establish that neither electronic nor positron spectra can be described by a power law with a single exponent in the entire energy range under study [8].

## The Casimir's Effect

The effect of the interaction between two uncharged metal plates was predicted by the Dutch physicist Hendrik Casimir in 1948. The most accurate experimental measurement of the Casimir's force was made in 1998. Umar Mohideen and colleagues from the University of California at Riverside, in a series of experiments, brought a sphere covered with aluminum or gold to a distance of 0.1 microns from a flat disk covered with these materials. The result of the attraction between the sphere and the disk was manifested in the deviation of the laser beam. The deviation of the results from the theoretical prediction did not exceed 1%. The distance between the plates, on which the Casimir's force begins to manifest itself, is of the order of several micrometers. However, the force grows rapidly with decreasing distance. At distances of the order of 10 nm - hundreds of sizes of a typical atom - the pressure created by the Casimir's effect turns out to be comparable with the atmospheric one. The Casimir's force acting per unit area for two parallel ideal mirror surfaces in absolute vacuum is equal [12]:

$$Fc = \frac{\hbar c \pi^2}{240 r^4} = \frac{10^{-23}}{r^4} \text{ (N)} \qquad (5)$$

where ħ is the reduced Planck constant, $\hbar = h / (2\pi)$ $\hbar = 1{,}0546 \cdot 10^{-34}$ J / Hz

c is the speed of light in a vacuum. c = 299792458 m / s

r is the distance between surfaces.

In quantum field theory this effect is explained using the concept of virtual particles. In the space between closely located mirror-polished surfaces, virtual photons are constantly born and disappear, along with virtual particles and antiparticles. corresponding to all wavelengths of the electromagnetic spectrum. At certain resonant wavelengths (integer or semi-integer number of times stacked between the plate surfaces), electromagnetic waves amplify. All at all other wavelengths, the birth of virtual photons is suppressed. This is due to the fact that in the space between the plates only standing waves can exist, the amplitude of which on the plates is zero. As a result, the pressure of virtual photons on the inner surfaces of the plates is less than the pressure on the plates from the outside, where the production of photons is unlimited. The closer the plate surfaces to each other, the less between them is the virtual photon in resonance and the stronger the force of attraction between the plates. However, the explanation of the Casimir effect from the viewpoint of quantum field theory using virtual particles encounters obvious contradictions, since the transfer of energy from "vacuum fluctuations" to parallel plates by pressure requires real particles with real energy characteristics. Despite the fact that in the formula for the Casimir's force (5) there is no fine structure constant α - the main characteristic of the electromagnetic interaction - this effect, however, has an electromagnetic origin. As shown in the monographs [12], when the finite conductivity of the plates is taken into account, a dependence appears for α, and the standard expression for the force appears in the limiting case $\alpha >> mc/ 4\pi\hbar n r^4$ , where n is the electron density in the plate. In our explanation, we will proceed from the assumption that free conduction electrons in metal plates excite the quanta of the vacuum (dark matter) surrounding them, as a result of which electron-positron pairs are created, creating an electrical conductivity in the vicinity of the conduction electrons. The closer the electrons of neighboring plates to each other, the greater the conductivity is created in a vacuum, which decreases with increasing distance between the plates. Thus, conduction electrons from the surface layers of mirror-polished plates excite near themselves the quanta of vacuum (dark matter) and as a result, closely located plates enter into electromagnetic interaction. Thus, conduction electrons from the surface layers of mirror-polished plates excite near themselves the quanta of vacuum (dark matter) and as a result, closely located plates enter into each other's electromagnetic interaction. The sign of the interaction force of the plates Fc depends on the mutual direction of the electric dipole moments of the conduction electrons belonging to the two plates d1 and d2. For d1 ↑↓ d2, Fc is the attractive force, for d1 ↑↑ d2 Fc is the repulsive force (the last variant is unstable with respect to perturbing effects). This conclusion agrees with the experimental data. In the course of the experiments, it was found that both uncharged parallel metal plates [12, 13] are attracted so, under certain conditions, and repulsion [14]. The last effect is called "Casimir-Livshits effect". In the framework of the electromagnetic model of vacuum (dark matter), as a quantum structure, it can be regarded as an analogue of superfluid medium $^3$He-B [11]. First of all, it should be noted that the experimentally installed electric polarization of the medium in the core of the vortex in superfluid $^3$He-B is due to deformation of the atoms $^3$He consisting of electrically oppositely charged electrons and protons. A similar mechanism of electric dipole moment of the exist in the vacuum (dark matter), the microscopic structure of which are electrically oppositely charged electrons and positrons , forming a dipole. The relative motion of the particles that make up a Cooper pair in superfluid $^3$He-B corresponds to the p-state. In this state between the electrically like charged particles of  with spins oriented in the same direction, there are forces of attraction, and between the electrically oppositely charged particles with spins oriented in the same direction of the force of repulsion. The result of these forces is the appearance of an electric dipole moment. The interaction of vacuum quanta due to the presence of electric dipole moments affects the viscosity of the medium and under certain conditions makes it possible to reveal in a vacuum the superconductivity effect (the Meissner's effect, the Josephson's effect, the London's effect). Since the conduction electrons of the plate are electrically charged, their electric fields act on the electric dipoles, which they create as a force moment, and the electric polarization of the vacuum arises in the space between the plates. This means that the pairs of microparticles constituting the quantum vacuum "stretch" along the electric field. For two parallel metal plates, the electric force due to the existence of the electric polarization of the vacuum (the formation of electric dipole moments around the conduction electrons of the plates) is defined as the Casimir force and can be expressed by the relation [15]:

$$Fc = Fd = \frac{3d1d2}{r^4}, \qquad (6)$$

where d1 and d2 is are, respectively, the total electric dipole moments of the conduction electrons (dipole moment e is $d_e$=eL=eħ/p) of the first and second plates (d1 ↑↓ d2 or d1 ↑↑ d2);

r is the distance between the plates , r ⊥ d1 (d2). In the experiments , value r ≈ $10^{-9}$ m.

If the plates are identical, then d1 = d2. Let us find the expression for d1 (d2) [17]:

$$d1 = d2 = \frac{\mu_\beta U_r}{cp} N_0 \zeta. \qquad (7)$$

where $N_0$ is the concentration of conduction electrons in the metal. $N_0 \approx 10^{22}$;

ζ is the thickness of the surface layer of the plate, equal to the atomic size. $\zeta \approx 10^{-10}$ m;

$\mu_\beta$ is the Bohr magneton. $\mu_\beta = e\hbar / (2m_e c)$;

$U_r$ is the energy of conduction electrons in metals. $U_r$ is equal to the Fermi energy - $\varepsilon_r$

$\varepsilon_r = \hbar^2(3\pi^2 N_0)^{2/3} / (2m_e)$ ;

p is the amount of motion of the conduction electron in the metal. $p = \sqrt{2m_e \varepsilon_r}$

Substituting the expression for the electric dipole moment d1 (d2) into formula (6), we have:

$$Fc = Fd = \frac{3\mu_\beta^2 \varepsilon_r}{r^4 c^2 2m_e} N^2_0 \zeta^2 \qquad (8)$$

The use of formula (8) is valid provided that the dimensions of the dipoles produced by the conduction electrons are much smaller than the distance between the plates. For plates of unit area, taking into account only the electrons located in the surface layer of the plate with a thickness equal to the atomic size of $10^{-10}$ m and at a concentration of conduction electrons in metals of the order of $10^{22}$, substituting the values of the constants in the formula (8), we have [17]:

$$Fc = Fd = \frac{4 \cdot 10^{-23}}{r^4} \quad (N) \qquad (9)$$

Expression (9) is consistent with the expression (5) determining the Casimir force acting per unit area of two uncharged parallel metal plates, the distance between which in the experiment does not exceed several atomic diameters [12,13]. Thus, to the known explanations of the Casimir force using the concept of virtual particles [12] or Wan der Waals forces [13], we can add an explanation that takes into account the interaction of quantum objects due to the presence of electric dipole moments in particles produced by vacuum polarization. Note that in the concept of Casimir forces, which is connected with virtual particles, the assumption about the possibility of adding up the energy of all virtual particles of the vacuum associated with plates is introduced, a similar assumption is made in the electromagnetic description of Casimir's forces, it is considered that the dipole moments of the electrons of each plate are oriented in one direction, that is, they are added together.

## The Uehling's Effect and the Lamb's Shift

The Uehling's effect is connected with vacuum polarization and consists in deviating the electrostatic potential of point charges in vacuum from the value corresponding to the Coulomb's law. Uehling first calculated the deviation from Coulomb's law for the hydrogen atom. The currently accepted structural phenomenon of vacuum, it is considered that a substance immersed in vacuum displaces a quantum of vacuum. In the nuclei of atoms, the density of matter is relatively large, so the vacuum quanta turn out to be almost completely replaced by the elements of the nucleus. This lack of quanta of vacuum and manifests itself as a discrepancy or correction to Coulomb's law. The Uehling's effect gives a correction to the Lamb shift of 27 MHz [16].

The Lamb's shift of energy levels represents small differences in the electron energies in the hydrogen atom and hydrogen-like ions for certain electron states in which, according to the Dirac equation, the energies must coincide. In 1947, Willis Lamb and Robert Rutherford conducted an experiment using microwave radiation to stimulate radio frequency transitions between the quantum levels of the hydrogen atom. The difference in energy found by Lamb and Rutherford for the transition was ~ 1060 MHz. The Lamb shift of the energy levels in atoms was the first experimental confirmation of the ideas of quantum field theory, in particular, quantum electrodynamics. The magnitude of the shift is proportional to $\alpha^3 R$, where α is the fine structure constant, R is the Rydberg's constant. The main contribution to the magnitude of the shift is produced by two radiative effects:

1) the emission and absorption by a bound electron of virtual photons, which leads to a change in the effective mass of the electron and the appearance of an anomalous magnetic moment in it;

2) the possibility of virtual creation and annihilation in vacuum of electron-positron pairs (vacuum polarization), which distorts the Coulomb potential of the nucleus at distances on the order of the Compton wavelength of the electron ($\sim 4 \cdot 10^{-4}$ cm).

Even more powerful than in the hydrogen atom, the electromagnetic interaction occurs between the electrons and the nuclei of heavy atoms. Researchers from the laboratory of GSI (Darmstadt, Germany) passed a beam of uranium atoms (charge number 92) through the foil, as a result of which atoms lost all but one of their electrons, turning into ions with a charge of +91. The electric field between the core of such an ion and the remaining electron reached the value $10^{16}$ V · cm$^{-1}$. The measured Lamb shift in the ion was 468 ± 13 eV - in accordance with the predictions of quantum electrodynamics.

## The Participation of Vacuum (Dark Matter) in the Effect of Transformation of Electromagnetic Energy

The excitation of vacuum quanta (vacuum polarization) in this case takes place on the basis of an induction phenomenon, similar to the manifestation of an electromagnetic field in a transformer, which shows that the electromagnetic field is transmitted in vacuum not only by photons (quanta of light), but also by magnetic lines of force - magnetons (quanta of electromagnetic fields). ) It is ironic, but the differential equations of Maxwell are not able to correctly describe the phenomenon of electromagnetic induction in a conventional transformer, because the vortex

field **E** (r) induction in the space around the transformer is induced regardless of the presence in the this space of magnetic fields variable in time **H** (r), that is, when provided d**H**

/ dt = 0. In other words, for any point r of space around the transformer for differential Maxwell's equations, the induction eddy electric field **E** must be absent. However, the reality of the existence of magnetic fields in electrically sensitive environments ($\varepsilon 0$, $\mu 0$) for any point in space near of the coil primary circuit magnetization is easy of install by placing this space winding magnetizing the second closed circuit. As a result of the magnetic interaction with the primary field in the secondary circuit generates energy, which can be registered. This effect can be used to create a generator with an efficiency of > 100%, working against all the laws of classical Maxwell electrodynamics. Of generates "gratuitous" energy in the generator can be explained by disturbances in the environment between the ferromagnetic cores with windings separated by a relatively small gap of a dielectric material (1-3 mm.). A soliton (quantum vortex) can move along the vacuum transition. It carries a quantum of magnetic flux, which can be associated with the magneton, a quantum of a magnetic field, named above. Ferrite cores are placed in the field to strengthen the electromagnetic characteristics of the medium ($\varepsilon$, $\mu$). Replacing the ferrite cores with steel cores can enhance the effect in the secondary circuit in the dozens of times, as in the ferrite cores electromagnetic induction reaches a maximum of 0.4 - 0.5 Tl, and in the electrical steel magnetic flux density is 1.5 -2 Tl and more. In addition, the value of the secondary magnetic field energy depends strongly on the size of the gap between the cores and the shape of the core itself, since it is associated with the outer layer of the core and the edge effects in which the vacuum (dark matter) plays a decisive role. Here we see a connection with the Casimir's effect, but the effect of the separation of magnetic fields and the generation of energy with the participation of the quantum vacuum model has not been fully investigated. The distance between the plates, on which the influence of the Casimir force is noticeable, is $r \approx 10^{-9}$ m. , and the distance at which the separated magnetic fields interact is $r \approx 10^{-3}$m. This indicates that the polarization of the vacuum under the action of the magnetic moment exceeds the polarization of the vacuum under the action of an electric one. In paper [17] obtain the following relation between the influence of magnetic ($Fm=2I^2/c^2r$) and electric ($Fd=Fc$) forces on the vacuum polarization:

$$\frac{Fm}{Fc} \approx \frac{8e^2 r^3}{3\mu^2_\beta \nu^2} \approx 10^2, \quad (10)$$

$Fm > Fc$ at $r^3/v^2 < 10^{-24}$ ms$^2$ , where $v$ is the electron velocity

This effect, partially described by Michael Faraday two hundred years ago, in our time can serve as an impetus for creating fundamentally new electrical engineering on the basis of the works of the Russian physicist Andrei Melnichenko [18].

Above presented effects combine to show that vacuum (dark matter) has a complex structure that is able not only to transmit any interaction, but also to participate in all interactions known in nature.

## The Einstein-De Haas Effect and the London's Effect

Model of the superfluid quantum vacuum , significantly expanded the analogies between the properties of superfluid $^3$He-B and the cosmic medium (dark matter), mainly due to the inclusion of the properties of vortices: spin and electric polarization of the medium in vortices, inertia properties vortices and superfluid spin currents between them [17]. Experiments on magnetic resonance made it possible to establish that in the case of superfluid $^3$He-B, the Einstein-de Haas effect takes place: this is the rotation of the volume of the liquid upon magnetization. Since the magnetization of the atoms $^3$He does signify their spin polarization, then the Einstein-de Haas effect is the rotation of the volume of the liquid at dS / dt, where S is the total spin of the extracted volume of the liquid. It can be assumed that many polarization physical phenomena in baryonic matter and quantum vacuum must have the same nature and proceed identically. During experiments with artificial satellites of the earth equipped with magnetometers it was possible to detect in the near-Earth environment the moving vortex formations - quantum spinors. The velocity of the satellite relative to the spinors was determined from the intensity of the magnetic field in the magnetometer. These magnetic vortices have the form of tangential cylinders, with axes parallel to the axis of rotation of the Earth. It can be argued that in the near-Earth environment the polarization of a quantum vacuum by the Earth's magnetic field leads to the Einstein-de Haas effect. Consider the Einstein-de Haas experiment, in which the rotation of a ferromagnet placed in a constant magnetic field is demonstrated. The traditional mechanics of continuous media, postulating the symmetric stress tensor, is applicable only to processes without an internal distribution of moments, when the moment's equations are fulfilled identically. At the same time, in the polarization medium, under the action of a magnetic field, internal moments can arise, that create tangential stresses with an asymmetric tensor. This effect is explained in that the spins of ferromagnets initially oriented arbitrarily under the action of a magnetic field acquire a predominant orientation in the direction of the field. If in the initial state, the total angular momentum of all the spins is zero, then in a magnetic field it acquires a definite value. By the angular momentum theorem, this will lead to a rotation of the crystal lattice in the opposite direction to the spins. In addition, the internal torque of the spins causes a tangential stress, leading to torsional deformation of the ferromagnet. Fluctuations were first localized in a small part of the system, and then spread and led to a new macroscopic state. The Einstein-de Haas experience clearly shows how microscopic processes, studied only by quantum mechanics, manifest themselves in macroscopic processes. This situation radically changes the traditional notion of the relationship between the microscopic level described in terms of particles and the macroscopic level described in terms of concentrations, densities and volumes.

**The London's effect** is that a rotating superconductor generates a magnetic field exactly aligned with the axis of rotation, with a magnetic moment called the "London's moment". The effect can be explained in the following way: when the superconductor rotates, the inverted particles also rotate with it. This orbital rotation of charged particles creates an electric current, which in turn generates a magnetic field. It is interesting that magnetic spinors of in the form of tangential cylinders with axes parallel to the axis of rotation of the Earth are found not only in near-earth space, but also in the molten magma of the earth's core [19].

## The Meissner's Effect

The Meissner effect is that the superconductor pushes out the magnetic flux, that is: rot **B**=0. For the first time the nature of the Meissner effect was explained by F.London , who installed the connection between the current and the magnetic field in the superconductor. F.London formulated the equation [20]:

$$\frac{4\pi\lambda^2}{c}\,\mathrm{rot}\,\mathbf{J} + \mathbf{B} = 0 \qquad (11)$$

where **J** is the current density;

**B** is magnetic induction;

$\lambda$ is penetration depth of magnetic field, $\lambda^2 = mc^2/(4\pi nq^2)$

m, q is mass and charge of superconducting current carriers;n is carrier density

The London equation allows us to understand the nature of the superconducting ordered vacuum structure. Introducing the vector potential **A**, where rot **A** = **B** and using the collation div**A** = 0, we arrive at the London equation for the superconductor in the form:

$$\frac{4\pi\lambda^2}{c}\,\mathbf{J} + \mathbf{A} = 0 \qquad (12)$$

In the presence of a vector potential, the generalized momentum of a charged particle is given by:

$$P = \sum p = 2\sum \left(mv + \frac{q\mathbf{A}}{c}\right) \qquad (13)$$

The average momentum per particle can be written as:

$$P = \frac{q}{c}\left(\frac{4\pi\lambda^2}{c}\,\mathbf{J} + \mathbf{A}\right) = 0 \qquad (14)$$

Consequently, the superconducting order in a vacuum is due to the condensation of vacuum quanta (current carriers) in the state with the smallest possible momentum. From the point of view of superconductivity, the vacuum, by definition, is in the lowest energy state. Structurally, the vacuum (dark matter) consists, like any other field from vacuum quanta. These quanta are not particles of matter, but they are subject to physical laws and can be described in space-time characteristics. That is, the vacuum quantum can have a length, shape, lifetime, and can also vary with time. Changes in shape over time impart a property of elasticity to the vacuum quantum. Together, physical quantities describing the state of vacuum show that in the superconducting state there vacuum as a whole and not one quantum of vacuum. An analysis of the above effects allows us to state that such a vacuum state is violated if the external field exceeds the critical value. In particular, this occurs near the surfaces of the plates in the Casimir's effect. The field of conduction electrons acts externally with respect to the vacuum quantum and breaks the superconducting state of vacuum quanta. In this regard, the vacuum quantum ceases to squeeze out the external magnetic field (Meissner's effect) and begins to participate in the transmission of electromagnetic effects on the plates. As soon as the perturbation has disappeared, that is, the effect of the external field has ceased, the quantum of vacuum returns to the superconducting state. All these moments create conditions for the existence of surface currents in combination with magnetism and the realization of the rotational effect (the London's moment) and the formation of isolated magnetic vortices (solitons) in the Josephson's effect.

## CONCLUSION

In conclusion, it should be noted that the world of virtual particles, which operate in modern quantum field theory, survives the last days. With the accumulation of knowledge about the microcosm, virtual particles give way to real particles. This can be confirmed by the experiments cited in this article, which say that when a vacuum enters a strong external field, the vacuum quanta are restructured and the real pairs of elementary particles are generated (vacuum polarization). The concept of "Vacuum" in the sense of empty space in the twentieth century was transformed into the concept of "Physical vacuum", filled with virtual particles that appeared for a brief moment as a result of vacuum fluctuations, and in the XXI st century it was supplemented by non-baryonic dark matter of the galactic medium and dark energy of the intergalactic medium. However, the short-term existence of virtual particles (not violating the energy conservation law) within the quantum uncertainty $\delta t \sim \hbar / \delta E$, includes the description of the virtual event by real quantities-time, Planck's constant and energy. In this connection, the question arises as to how this real description becomes virtual. Modern quantum field theory is not ready to describe nonlinear processes of production of real particles in a vacuum under the influence of external fields. In quantum electrodynamics, the electromagnetic field is quantized in the same way as the harmonic oscillator in quantum mechanics. For some of these fields, it is possible to construct the corresponding quantum theory of the Dirac field, but on the whole there are insurmountable difficulties connected with the creation of electron-positron pairs from the vacuum leading to nonlinear many-particle problems [21]. Today, more than ever, the improvement of quantum field theory in describing the phenomenon of polarization the vacuum becomes urgent in the advanced fields of physics, beginning with cosmology and astrophysics (dark matter, dark energy) and ending with of accelerators and colliders. The creation of unstable particles in the Large Hadron Collider (LHC) at proton energies of the order of 10-100 GeV is indeed observed [22, Fig. 2], as is the production of electron-positron pairs in the cosmic AMS-02 detector [8, Fig. 16], but this effect can be explained by the polarization of the quantum vacuum (dark matter), which is the third full participant in collisions of protons in the LHC and whose presence the apologists of the dominant 100 years in the physics of the Einstein's Special Relativity Theory (SRT) deny. It may turn out that the number of resonances identified as newly generated unstable particles in the polarization of a quantum vacuum, under the action of peak electric and magnetic fields or relativistic protons in the LHC is so great that it will be necessary to create special tables analogous to the tables published by the collaboration Particle Data Group (PDG ), which describes all the properties of resonances associated with the presence of quantum levels in the particles. It's time to revise and expand the scope of the Standard Model.

## REFERENCES


[1] Adornov T.K., Gavrilov S.P., Gitman D.M., Ferreira R., *Peculiarities of the production of particle pairs in a peak electric field,* - M: Russian Physics Journal, Vol. 60, N3, (2017)

[2] Quantum-electrodynamic cascades with ionization of atoms - Physics - Uspekhi, Vol.60, No.11, p.1271, (2017)

[3] Narozhniy NB, Fedotov AM *Quantum-electrodynamic cascades in an intense laser field* - Physics - Uspekhi, Vol.58, No.1, pp.103-108, (2015)

[4] Feynman R. *Strange theory of light and matter,* Moscow: Nauka, 1988

[5] Dikusar V.V., Tyunyaev A.A. Vacuum. *The concept, structure, properties* - M.: VTS, of the Russian Academy of Sciences (2013).

[6] Hunting the mysterious dark photon: the NA64 experiment (CERN)

[7] Mikhailov V.V. and others., *Secondary electrons and positrons in the near Earth space in the PAMELA experiment,* - M .: Bulletin of the Russian Academy of Sciences: Physics, ISSN 1062-8738, Vol.81, No.2, pp. 222-224, (2017)

[8] Galaktionov Yu. V., *Search for antimatter and dark matter, precision studies of the cosmic rays fluxes on the international space station. AMS experiment. Results of four year exposure*. – Physics – Uspekhi, Vol.60, No.1, pp. 45-64, (2017)

[9] Kornienko VN, Cherepenin VA, *Dynamics of the flow of backward electrons in many-wave Cherenkov generators,* - M.: Bulletin of the Russian Academy of Sciences: Physics, ISSN 1062-8738, Vol.81, No.1, pp. 38-40, (2017).

[10] Harold White, Paul March, James Lawrence, Jerry Vera, Andre Sylvester, David Brady and Paul Bailey. *Measurement of Impulsive Thrust from a Closed Radio-Frequency Cavity in*

*Vacuum*, - NASA Johnson Space Center, Houston, Texas 77058, Journal of Propulsion and Power, (2016).

[11] Konstantinov S.I., *The cosmological constant and dark energy: theory, experiments and computer simulations*,- Global Journals Inc. (US) GJSFR-A, Volume 16, Issue 5, 2016.

[12] Grib AA, Mamaev SG, Mostepanenko VM. *Vacuum quantum effects in strong fields*. - Moscow: Energoatomizdat, (1988).

[13] Lamoreaux S.K. *Demonstration of the Casimir Force in the 0,6 to 6 μm Range* – Physical Review Letters 78 pp.5-8 (1997).

[14] Capasso F., Munday J.N. and Parsegian V.A. *Measured long – range repulsive Gasimir – Lifshitz forces* – Nature 457 pp. 170-173 (2009).

[15] Parsel M. *Electricity and Magnetism, Berkeley Course of Physics*, Volume 2 - Moscow: Nauka (1975).

[16] Uehling E.A. , Physical Reviev , 48, 55, (1935)

[17] Boldyreva L.B. *What does physics granting physical vacuum properties of superfluid $^3$He-B?* - Moscow: URSS, (2011).

[18] Andrei Melnichenko, *And yet it glows* - Moscow: Technique-Youth No. 10 (2015)

[19] Litasov K.D., Shatskiy A.F. *Composition and constitution of the Earth's core* – Novosibirsk Publishing House of the Siberian Branch of the Russian Academy Sciences, (2016), p.90

[20] London F. *Superfluids* – Vol.1, Wiley, Nev York (1950)

[21] Gitman D.M., Gavrilov S.P., *Description of processes in strong external fields within the framework of quantum field theory.* – M.: Russian Physics Journal, Vol. 59, N11, (2016).

[22] Dremin I.M. *Some new discoveries at colliders* – Physics-Uspekhi, **61**, (4) (2018).

**Citation:** *Stanislav Konstantinov, " Polarization of Vacuum", Open Access Journal of Physics, vol. 2, no. 3, pp. 15-24, 2018.*