Stanislav Konstantinov

Features of teaching New Physics in Universities

Abstract: A new Physics is born at the time of the crisis of theoretical physics and the entire scientific paradigm. The article proposes order to better understand the concept of quantum vacuum (dark matter) in “New Physics” and its participation in all interactions: electromagnetic, gravitational and nuclear interactions. The need to prepare students to participate in modern experiments and theoretical development a new scientific paradigm dictates the emergence of a new course of the nature of dark matter in Universities

Keywords: quantum vacuum, dark matter, electromagnetism, gravity, nuclear forces

1.Introduction

Today in the scientific community there is no unambiguous definition for the concept of “New Physics”. So Academician of the Russian Academy of Sciences, chief researcher at the Institute for Nuclear Research Valery Rubakov, who received Hamburg Prize in Theoretical Physics 2020 believes that despite all efforts, no experimental indications of a “new physics” have yet been received. In his article “Higgs Boson”, he writes: “This is actually already starting to cause concern: is it right we all understand, it’s quite possible, however, that we still haven’t reached the “new physics” in terms of energy and in the amount of data collected. I hope that new, revolutionary discoveries will be associated with of the Large Hadron Collider which, through year begins to work on full energy 13-14 TeV.” To the question: what could be a “new physics”? - V.Rubakov replies: “Theorists have no unity on this subject. One option is the composite nature of scalar fields that provide spontaneous symmetry breaking, which has already been mentioned. Another, also popular possibility is supersymmetry, which we will only talk about that she predicts a whole zoo of new particles with masses in the region of hundreds of GeV - several TeV. Very exotic options are also being discussed, such as additional dimensions of space (say, the so-called M-theory).”[1]. Academician Rubakov wrote these words in June 2012, but even today in 2020 new revolutionary discoveries were not obtained at the LHC, although the energy was reached in the collision of 13 TeV proton beams, which means that theoretical physics, unlike experimental physics, is in a state of crisis and is not even able to comprehend the achievements of experimental physics. Our article will be entirely devoted to the interpretation of the achievements of experimental physics and astrophysics obtained at the beginning of the 21st century. “New Physics”, based on the recognition of quantum vacuum (dark matter and dark energy) as a galactic and intergalactic medium, which, according to the observations of the Planck Space Observatory published in March 2013, makes up 95% of the total mass energy of the observed Universe (the remaining 5% are accounted for by ordinary baryonic matter), these achievements are truly revolutionary [2]. It is correct to write the term “new physics” in quotation marks, since this physics originated earlier than the modern relativistic physics of Albert Einstein and the quantum physics of Niels Bohr, which currently dominates theoretical physics. The foundations of the new physics were laid by the great experimenter Nikola Tesla, whose conceptual ideas were far ahead of his time [3]. If Albert Einstein's General Theory of Relativity was based not only on the phenomenal intuition of the author, but also on the experimental discoveries of Nikola Tesla, today the world would be different and there would be no crisis in theoretical physics.

2. Dark matter and dark energy

Dark matter in astronomy and cosmology, as well as in theoretical physics, is a hypothetical form of matter that does not emit electromagnetic radiation and does not directly interact with it. This property of this matter complicates and, possibly, even makes its direct observation impossible. The conclusion about the existence of dark matter is made on the basis of numerous, consistent with each other, but indirect signs of the behavior of astrophysical objects and the gravitational effects they create. Clarification of the nature of dark matter will help solve the hidden mass problem, which, in particular, consists in the anomalously high rotation speed of the outer regions of galaxies. Of particular interest to astronomers was the Andromeda nebula, in which the speed of stars around its center does not decrease, as celestial mechanics predicts, is inversely proportional to the distance to the center R, but remains almost constant (Figure 1). This may mean that the galaxy along its entire length contains a significant mass of invisible matter (“galactic halo”)

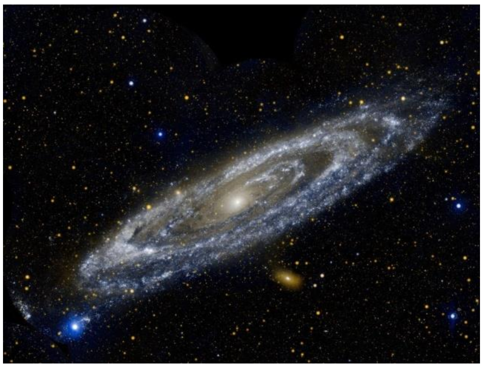

***Figure 1**. The beautiful Andromeda galaxy*

Moreover, the approach of the Andromeda galaxy and our Milky Way galaxy, observed with the help of radio telescopes, can be explained by the existence of the fifth fundamental interaction between dark matter and baryonic matter.

Dark energy in cosmology is a hypothetical form of energy introduced into the mathematical model of the Universe in order to explain its observed expansion with acceleration. Unlike dark matter with gravity, dark energy has something similar to antigravity. In the standard cosmological model, dark energy is a cosmological constant - a constant energy density that uniformly fills the space of the Universe (in other words, non-zero energy and vacuum pressure are postulated). A group of researchers, according to observations using the Habble -HST space telescope in 1998, established the accelerated expansion of galaxies in the visible part of the Universe. In 2011, researchers were awarded the Nobel Prize for this discovery. Cosmological antigravity in the standard ΛCDM (Λ- Cold Dark Matter) model is described by linear force depending on the distance:

$$Fe = (c^2 / 3) \times \Lambda \times R, \qquad (1)$$

where Λ is Einstein’s cosmological constant and R is the distance .

Phase state quantum vacuum characterizing dark energy, are considered in the superfluid cosmological model of quantum vacuum as analogous the superconducting α-phase ^3He-B while assuming that dark matter can be considered as an analog of the spontaneously ferromagnetic β phase ^3He-B, formed in strong gravitational and electromagnetic fields of galaxies and black holes and at the same time acquired gravitational properties [2]. I propose a "natural" mechanism for the generation of dark matter and baryonic matter, based on deep analogies with the behavior of the superfluid medium ^3He-B [2]. The formation of significant masses in dark energy vortices, significantly exceeding the mass of the medium, explains the mechanism of the phase transition of dark energy into dark matter, similar to two phases in superfluid ^3He-B. Dark matter gathers in clumps, is attracted to galaxies and forms halos around them, which extend to several radii of galaxies. These halos predict the observed distribution of dark matter in galaxies and are derived from observations using modern radio telescopes. The conclusion of Academician V.E. Fortov that “any transformation of matter includes the stage of strong compression under the action of gravitational forces and the subsequent strong heating and expansion due to thermonuclear energy release us of the Universe” was not complete. This conclusion in the extreme conditions of the Cosmos must be supplemented by the transformation of baryonic matter up to the formation of the galactic and intergalactic environment. The mechanism for the formation of halos from dark matter, which extend to several radii of galaxies, may be similar to the mechanism that causes the formation of stars from interstellar matter - the gravitational instability of Jeans. J. Jeans (1902) was the first to show that an initially homogeneous gravitating medium with density ρ is unstable with respect to disturbances of low density [2]. If there is condensation in the medium, then the gravitational forces will tend to increase it, and the elastic forces will tend to expand the medium and return it to its original state. Under the action of these oppositely directed forces, the medium will either enter oscillatory motion or experience monotonic motion. The nature of the motion depends on the ratio between the wavelength of the disturbance and some critical scale, called the Jeans scale. This value depends on the parameters of the medium: the speed of acoustic vibrations in the medium (the velocity of the longitudinal wave) cs and its density ρ_0. It determines the minimum scale of perturbation, starting from which the elastic forces of the medium are unable to resist the forces of gravity, which leads to the gravitational instability of the medium [2]. At the same time, small-sized random compaction of the medium grows in time if they cover an area with a linear size greater than jeans length. Disturbances with less than jeans length are acoustic vibrations. The converse statement that dark matter is transformed into ordinary baryonic matter is also valid. This is the circulation of matter in the Universe.

3. Vacuum polarization and Maxwell's real electrodynamics

3.1 Vacuum polarization

Consider the features of the electromagnetic field in a vacuum from the point of view of classical electrodynamics. First of all, this is a medium with absolute dielectric and magnetic permeability's (ε_a, μ_a) equal to the dielectric and magnetic constants (ε_0, μ_0):

$\varepsilon_a = \varepsilon_0 = 1/(36\pi) \times 10^{-9}$ [F×m⁻¹] (2)

$\mu_a = \mu_0 = 4\pi \times 10^{-7}$ [Gn×m⁻¹]

The electric strength of this medium should be infinitely high, due to the lack of charge carriers. This means that the electric field E and the magnetic field H, as well as the electromagnetic energy density determined by them in a vacuum, can be infinitely large. Such a conclusion, obtained from the position of the theory of classical electrodynamics, in the high-energy region, is wrong [4]. In quantum electrodynamics, the instability of vacuum in external fields was experimentally established for electric field strengths $Es = 1.32 \times 10^{16}$[V × cm⁻¹] (Schwinger's characteristic quantum electrodynamic field) and magnetic field strength $H = 10^{16}$ [T], caused by the creation of electron-positron pairs in a vacuum (polarization effect of the vacuum) due to which the vacuum itself becomes unstable. With the polarization of vacuum and its transformation into the matter, the change in vacuum energy w can be represented as the sum:

$$w = w^p + w^{\sigma} \qquad (3)$$

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

w^{σ} is the change in the energy of the substance at the production of particles

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

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 E strength for the given time T ($Es \approx 10^{16}$ [V × cm⁻¹] is the critical Schwinger's field) [5]. For an electromagnetic field, the polarization energy density of quantum vacuum can also be represented as the sum of two terms (6). Where is the first term w^p (w_0) quadratic in the electric and magnetic fields:

$$w_0 = \frac{\left(\mathbf{E}^2 + \mathbf{H}^2\right)}{8\pi} \qquad (5)$$

determines the energy of a non-interacting electromagnetic field before critical values electric strengths Schwinger's field $Es = 1.32 \times 10^{16}$[V × cm⁻¹] and magnetic field strength $H = 10^{16}$ [Gs]. The second term w^{σ} (w_I) describes the interaction of photons due to the production of electron-positron pairs [3]:

$$w_I = 2D\left[3\mathbf{E}^2\mathbf{E}^2 - \mathbf{H}^2\mathbf{H}^2 - \left(\mathbf{E}^2\mathbf{H}^2 + \mathbf{H}^2\mathbf{E}^2\right)\right] + 7D\left[\left(\mathbf{EH}\right)^2 + \left(\mathbf{HE}\right)^2\right] \qquad (6)$$

The constant D can be calculated by the methods of quantum electrodynamics [6] and in Gaussian units $D \equiv \eta\frac{\hbar^3}{m^4c^5}$, where the dimensionless coefficient $\eta \equiv \frac{\alpha^2}{45\times(4\pi)^2} \approx 7.5 \times 10^{-9}$, and $\alpha = e^2/\hbar c \approx 1/137$, α is the fine structure constant, m is the mass of the electron, c is speed of light. It is convenient D to write the coefficient through the Compton wavelength of the electron $D = h/mc$ in the form $D = \eta\frac{D^3}{mc^2}$ [6]. Experiments show that if an external field acts on the vacuum, then due to its energy, the production of real particles is possible [6, 7]. Precisely because the vacuum is not virtual, but a real physical object (dark matter) and has a structure, the polarization of the vacuum leads not to virtual, but real radiation corrections to the laws of quantum electrodynamics [7]. Originally Maxwell endowed the light-carrying environment, in which vortex electric fields and currents of displacement have arisen, necessary for him to derive the famous equations of Electrodynamics, with properties surprisingly close to the properties of a superfluid ^{3}He-B (analogue dark energy and dark matter) [2,8]. Here are these properties:

1) the rotation of the particles of the medium, which, according to the quantum vacuum model, is comparable with the presence of spin in quantum forming the dark matter ;

2) the translational motion of particles of the medium without friction between themselves and without loss of energy, which can be interpreted as the absence of shear viscosity and superfluidity in the dark matter ;

3) the rotation of the particles of the quantum vacuum without slipping, which, essentially, is the rotational viscosity;

4) the formation of vortices during the propagation of electromagnetic waves, which fully coincides with the conclusions of the quantum vacuum model;

5) dielectric properties of the light-carrying environment the quantum vacuum. Maxwell called the component (dE / dt) in his equations “bias current”, bearing in mind that an electric field is created in a luminiferous ether when excited due to the relative motion of its differently charged particles that form a dipole. In quantum electrodynamics (QED), this phenomenon the polarization is characterized by the production of electron and positron pairs in a physical vacuum (dark energy and dark matter) [8] ;

6) the formation of a significant mass in the dipoles, a much larger mass of particles of the medium, which is identical to the property of the vortices in the dark matter.

The last property of the quantum vacuum explains the mechanism of the phase transition of dark energy into dark matter, during the formation of massive domains in the gravitational and magnetic fields of galaxies. The non-invariance of the equations of electrodynamics was associated with the assumption of the reality of the existence of a quantum vacuum (dark matter) and with the existence of the effects of retarded potentials and deformations of the electric field of moving charges in a polarizing environment. Full invariance of the equations of electrodynamics is admissible only in absolutely empty space of Einstein's SRT. The invariance of the equations of electrodynamics is accepted by modern science as an axiom. As a result, Maxwell’s equations have been separated from the original model of the environment in which the conduction currents and displacement played a very definite physical role. Since then, the Electrodynamics of Maxwell lost virtually every opportunity for additions, changes or improvements. Attempts by a number of scientists [9] to point out the obvious contradictions and paradoxes of the classical and Quantum Electrodynamics encounter complete lack of understanding and fierce opposition from the contemporary apologists of the ruling in the Physics of Einstein’s theory. Maxwell made a mistake, applying the Ostrogradsky-Gauss theorem not only for resting charges, but also for moving ones (Gauss's theorem is one of Maxwell's equations). As a result of this arbitrary assumption, the dynamic state of moving electric charges is simply replaced by their static state [9]. The mistake made required a revision and improvement of the theory of electrodynamics, since experiments, including the Aharonov-Bohm effect, indicated the existence, in addition to the transverse magnetic forces of Lorentz, also an electrodynamic longitudinal force [9]. “Since the true theory of electricity is based on the concept of a quantum vacuum (ether), this branch of physics is closed for improvement and modernization in the interests of US national security, and deliberately distorted by deceitful propaganda ...” writes modern American researcher William Line, in his books. William Line, in his book, "Space Aliens from the Pentagon", describes these new technologies in some detail.

3.2 Correction of Maxwell's classical equations of electrodynamics

Correction of Maxwell's classical equations electrodynamics based on the recognition of the additional scalar magnetic field, acting along the direction of the current, which creates a force in addition to the transverse Lorentz forces. The expression for the electromagnetic energy flux density (Poynting vector) has the form [6]:

$$S = (E \times Hr) + (E \times Hp) \qquad (7)$$

Changing the scalar magnetic field equivalent to the formation of electrical charges, which change in turn generates an electric potential field. The longitudinal wave propagates along the axis toroyda in the tokamak plasma column. Based on experimental results, it is proposed to abandon the Lorentz calibration, but instead take the expression for the electromagnetic energy density in the form [9]:

$$S = - \operatorname{div} \bar{A} - \lambda \varepsilon 0 \mu 0 \, d\varphi/dt \qquad (8)$$

Obviously, potentials imposed thus allow great flexibility in the use of Maxwell's equations. In the classical case relies S = 0. When using the calibration (8) at $\lambda = 0$ we obtain the Coulomb gauge, and at λ

= 1 we have the Lorentz gauge. If you do not assume the vanishing of the expression for S, then at $\lambda = 0$ the scalar field acquires the meaning of a longitudinal magnetic field. Further transformations are performed in the standard way, with the result that allows to obtain the following system of equations:

$$
\begin{aligned}
&dE/dt - \mathrm{rot}H - \mathrm{grad}\ S = 0,\\
&dH/dt + \mathrm{rot}E = 0, \qquad (9)\\
&\mathrm{div}\ E - dS/dt = 0,\\
&\mathrm{div}\ H = 0
\end{aligned}
$$

For ease of reference the equations (9) Consider the case of absence of currents and charges and accepted $\varepsilon 0 = \mu 0 = 1$ [10].

For clear separation of the concept of a longitudinal wave in a vacuum, and of the electromagnetic longitudinal waves that exist in material media, in [10] proposed to call the longitudinal electromagnetic E-wave of a wave, in which the magnetic field is zero, and the vector of the electric field is directed along the propagation direction energy flux density. This is a scalar function SE // = αE, where α = α (x, y, z, t). Similarly, is determined by the longitudinal H-wave, generating energy flow SH // = bH. Differential equations for the generalized electromagnetic field can be derived from the concept of the Poynting's vector. Poynting's vector for electromagnetic waves of general view, including both conventional transverse modes and longitudinally polarized modes, can be represented as:

$$S = E \times H + \alpha E + bH \qquad (10)$$

The corresponding energy density of this vector is expressed as:

$$W = 1/2\ (E^2 + H^2) + WE// + WH// \qquad (11),$$

where WE // and WH // - extra energy.

A rigorous derivation of the additional energy and differential equations for generalized electromagnetic field are given in [10].

3.3. Real electrodynamics inside the tokamak

Relatively modest results of years of work (1950-2020) of the collective of the National Research Centre "Kurchatov Institute" in the creation of a fusion reactor based on the tokamak (a closed plasma trap) due to the fact that Maxwell's electrodynamics is very different from the real electrodynamics in a tokamak (Figure 5). Hot plasma particles move in a magnetic trap along the magnetic field lines of an arbitrary topology to the walls of the tokamak and destroy it. For the TM-15 tokamak, which was modernized in 2015, the duration of plasma confinement in the trap was 1 second [9]. The tokamak is a closed toroidal chamber with magnetic coils, designed for magnetic confinement of plasma in order to achieve the conditions necessary for the flow of controlled thermonuclear fusion (Figure 2). To create the magnetic trap uses a combination of magnetic fields: strong toroidal field Bt and a weaker (100 times) poloidal field Bp, as well as the Bi field current I, flowing through the plasma column. It is believed that the plasma is stable in a tokamak if the criterion Shafranov - Kruskal:

$$Bt / Bi > R / \alpha \qquad (12)$$

where R - radius of the circumference of the plasma ring, α - the radius of the cross section of the plasma column.

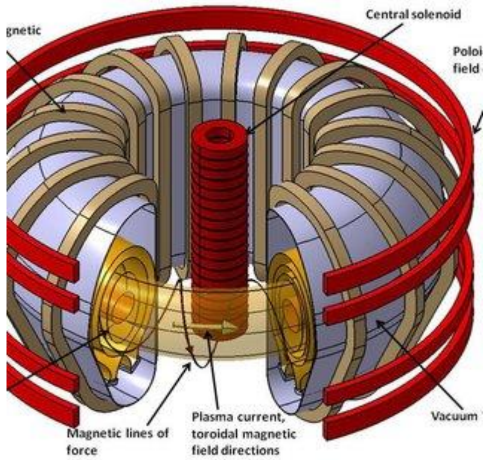

***Figure 2**. Closed plasma trap (tokamak).*

Real electrodynamics inside the tokamak is very different from the calculation [11,12]. Hot plasma particles move along magnetic field lines of arbitrary topology to the walls of the tokamak and destroy it. Due to the effect of self-generation strong toroidal magnetic field Ht and vice versa poloidal magnetic field Hp, hold the plasma in a tokamak a long time is not possible. The more intense toroidal magnetic field generated by the windings of the toroid, and it reaches 3-5Tl in the tokamak, the more intense extra poloidal magnetic field will be created by it. Chief Scientific Officer of the Siberian Branch of the Russian Academy of Sciences, professor V.V.Aksenov experimentally and mathematically substantiated the effect of self-excitation and the uncontrolled growth of magnetic fields. This leads to uncontrolled instabilities of plasma column [11, 12]. Self-excitation process will grow almost instantly due to the mutual generation of the above-mentioned magnetic fields. According to the electrodynamics developed by Professor V.V. Aksenov, the magnetic field inside the tokamak obeys the following equations:

$$\mathbf{H}_T = \nabla^{\times}(Q\mathbf{r}), \qquad \mathbf{H}_p = \nabla^{\times}\nabla^{\times}(Q\mathbf{r}),$$
$$\nabla^{\times}\,\mathbf{H}_T = \mathbf{H}_p \qquad \nabla^{\times}\,\mathbf{H}_p = \chi\mathbf{H}_T \qquad (13)$$

In this case, the effect of self-generation by a strong toroidal magnetic field Hm of the poloidal magnetic field Hp and vice versa is possible only in a conducting medium when the parameter $\chi \neq 0$ [12]. Here Q is a scalar function of three or four variables, if we take into account the time dependence, and r is the radius vector. Vortices of a toroidal magnetic field create a force poloidal magnetic field and vice versa. This is one of the variants of the so-called dynamo excitation of a magnetic field. When the temperature rises inside the tokamak diffusion rate will also increase due to the growth of the resistance (conductivity drop) the plasma column and growth of the poloidal field inside the tokamak. The above approach to describing electrodynamics in a tokamak requires a more thorough analysis using the Boltzmann equation. V.V. Aksenov conducted an estimation of self-excitation in the large model T-15 (Fig. 3a) according to his equations (13) of electrodynamics. The results are as follows [12]. If we assume $\nabla^{\times} \approx 1/L$, where L is the linear dimension of the plasma pinch inside the tokamak, then:

$$(1/L)\cdot\,\mathbf{H}_p \approx (\Upsilon/\eta)\cdot\,\mathbf{H}_T\,, \qquad (1/L)\cdot\,\mathbf{H}_T \approx \mathbf{H}_p \qquad (14)$$

where Υ is the diffusion rate of the field in the torus plasma, η is the magnetic viscosity.

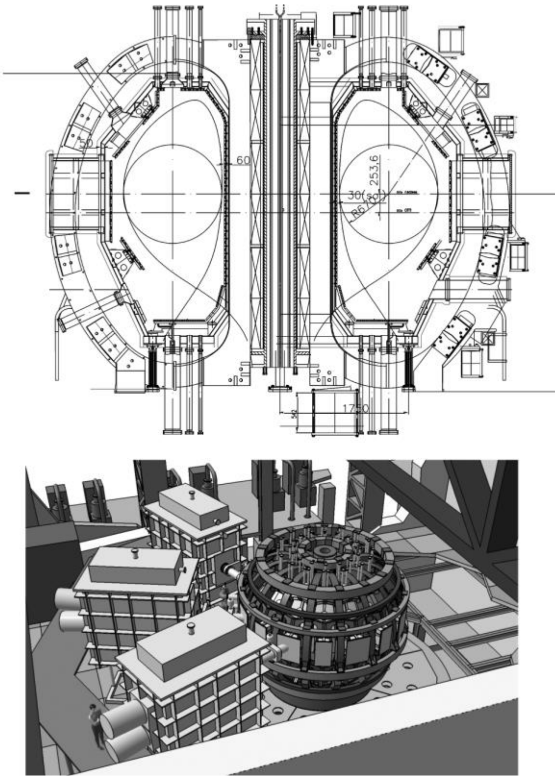

***Figure 3**. The cross section of the Tokamak TM-15 (a)*

Let the small radius of the plasma filament R = 2m, then $L = 2\pi\, R = 4\pi$ m, and the intensity of the toroidal magnetic field $|\,\mathbf{H}_T\,| = 5$Tl. The intensity of the additional poloidal magnetic field excited by the toroidal magnetic field will be of the order of

$$|\,\mathbf{H}_p'| = 5/4\pi \text{ Tl} \sim 0{,}4\text{Tl}. \qquad (15)$$

In this case, the estimate of the diffusion rate with respect to the original magnetic fields is as follows

$$\Upsilon = (\eta/L)(|\mathbf{H}p|/|\mathbf{H}_T|) \qquad (16)$$

The additional toroidal magnetic field will increase by an amount

$$\mathbf{H}_T' = (\eta/L\Upsilon)\, \mathbf{H}p' = (\mathbf{H}_T/\mathbf{H}p)\, \mathbf{H}p' \qquad (17)$$

In conclusion, Professor VVAksenov notes that “the above approach to the description of electrodynamics in a tokamak needs a more thorough analysis involving the Boltzmann equation describing the behavior of plasma particles with increasing temperature in a complex magnetic field different from the toroidal one that arises in a tokamak due to self-generation. At the present time, electrodynamics in a tokamak is described by the well-known classical Maxwell equations.” [12]. In article [11], the mutual generation of force and non-force magnetic fields is formulated by V.Aksenov in strictly mathematical formulas, and the appearance of these fields is determined by the theorem on total electric currents in spherical regions. This points to the inaccuracy of research only magnetic fields and refusing to study electric currents when calculating the electrodynamics of tokamaks.

At the Kurchatov Institute, after 60 years of very costly efforts, they abandoned further attempts at long-term confinement of plasma at a temperature of one hundred million degrees using a closed magnetic tokomak trap using the fusion of light nuclei of deuterium and tritium, the thermonuclear reaction $_1^2H + _1^3H \rightarrow _2^4He + _0^1n + 17.6$ MeV [MeV] in a natural solar reactor, and proceeded to the implementation of a new hybrid tokamak T-15MD, in which at a much lower temperature, nuclear and thermonuclear energy. In the city of Sarov, he is completing the modernization of the T-15 tokamak, a prototype of future hybrid reactors, now thermonuclear scientists are waiting for the key elements of the new T-15MD tokamak: a vacuum chamber with an already assembled magnetic system. Although the project is called modernization, in fact it will be the first new thermonuclear installation in Russia in the last 20 years. The T-15MD hybrid tokamak will run on thorium, which is cheaper and has more reserves than uranium. Its main difference from a fusion reactor is that a hybrid reactor does not need to obtain ultra-high temperatures to generate energy. The physics of the process was explained in an interview with the magazine “In the world of science” Doctor of Technical Sciences, scientific director of the Kurchatov complex of thermonuclear power and plasma technologies of the National Research Center “Kurchatov Institute” Petr Khvostenko: “The tokamak will generate thermonuclear neutrons that irradiate the fuel surrounding the plasma. In this case, after neutron irradiation of thorium-232, which is very abundant in the earth's crust, we get uranium-233, which will be the fuel for nuclear power plants. At the same time, the plasma temperature in the thermonuclear part of the hybrid reactor should be 30-50 million ° C, and not 120-150 million ° C, as in the power reactor. The ignition temperature of nuclear fusion of the excited nuclei is lower, and the scattering cross-section of the excited nuclei is larger.

4. Quantum theory of gravity and the principle of equivalence

The Equivalence Principle (PE) predicts the same acceleration for bodies of different composition in the same gravitational field and allows us to consider gravity as a geometric property of space-time, which leads to the interpretation of gravity from the point of view of general relativity [13]. As a result, A. Einstein's gravitational mass became equal to the inertial mass under any conditions.

Experiments related to the verification of the principle of equivalence are carried out to this day, using the most modern equipment, but no significant deviations have been identified. However, many extensions of the Standard Model containing macroscopic quantum fields predict a violation of the equivalence principle. It turned out that it is possible to reveal a violation of the equivalence principle only in experiments carried out in non-equilibrium systems with irreversible processes. That is why the Nobel Prize Laureate Professor I. Prigogine wrote about this: “In a steady state, the active influence from the outside on the system is insignificant, but it can become very important when the system goes into a nonequilibrium state, while the principle of equivalence is violated” [14]. In the new cosmological model of the Universe, where the rotation of planets, stars and galaxies occurs in a halo of superfluid dark matter, the reason for the violation of the principle of equivalence may be the added (added) mass, the nature of which is associated with the excitation of a field around a moving cluster with a hydrodynamic velocity υ_i (r) and the appearance in connection with this additional kinetic energy. The macroscopic approach, in which the hydrodynamic attachment of mass to spherical bodies of any nature (including charged clusters) into superfluid ^{3}He-B (an analogue of dark matter), was outlined by Stokes back in the century before, was experimentally substantiated by Vladimir Shikin, an employee of the Institute of Solid State Physics, Russian Academy of Sciences, in 2013. We are talking about a complex force F (ω), acting from the side of the liquid on a sphere of radius R, performing periodic oscillations with frequency ω. Within small Reynolds numbers, we have [15]:

$$F(\omega)= 6\pi\eta R\left(1+\frac{R}{\delta(\omega)}\right)V(\omega)+3\pi R^2\sqrt{\frac{2\eta\rho}{\omega}}\left(1+\frac{2}{9}\frac{R}{\delta(\omega)}\right)i\omega V(\omega), \qquad (18)$$

$\delta(\omega) = (2\eta/\rho\omega)^{1/2}$

where ρ - fluid density, η – viscosity, V - velocity amplitude sphere, δ (ω) - the so-called viscous penetration depth, which increases with an increase in viscosity and a decrease of the oscillation frequency.

The real part of the expression (18) is a known Stokes force derived from the movement of fluid in the sphere. Imaginary component (coefficient of iωV) is naturally identified with the effective mass of the cluster added:

$$Meff\,(\omega R) = \frac{2\pi\rho R^3}{3}\left[1+\frac{9}{2}\frac{\delta(\omega)}{R}\right] \qquad (19)$$

Origin added (attached) mass Meff (ωR), depending on the frequency ω and the radius R of the sphere of the cluster associated with the excitation of the field around a moving cluster of hydrodynamic velocity υ_i (r) and the appearance in connection with this additional kinetic energy. In superfluid, additional mass has two components: superfluid and normal [15].

The added inert mass can explain the violation of the equivalence principle for Mercury by Δ (mg / m_i) ~ 10^{-2} when it moves in the halo of superfluid dark matter in its orbit, subject to strong disturbances [16]. The time has come to say that Einstein's mistake, made by him in calculating the perihelion perihelion of the orbit of Mercury, discovered by Academician Hua Di, after a hundred years of the victorious march of general relativity on the planet is not accidental and general relativity is applicable only in equilibrium integrable systems for reversible processes for which there is no violation of the equivalence principle [16]. In 2013, the scientific world was shocked by the article by the Chinese mathematician Academician Hua Di "Einstein's Explanation of Perihelion Motion of Mercury" published in the collection of articles "Unsolved Problems in Special and General Relativity", edited by Florentin Smarandach USA [17]. In his article, Academician Hua Di showed that when calculating the magnitude of the perihelion precession of the orbit of Mercury, Einstein made a gross error in integration [18]. As a result, the result was 71.5´´, and not the expected 43´´. The shock from Hua Di's article was quickly forgotten, five years have passed since the publication of the article, and no one was surprised why, within the framework of the field general relativity equations, the calculation of the perihelion perihelion of Mercury's orbit gives 503.5´´ for 100 years instead of the observed value 575´´. However, the error value ~ 71.63 " was also obtained by direct numerical simulation of the perihelion precession of the orbit of Mercury in the field of the spherical Sun within the framework of general relativity, carried out by Professor N. V. Kupryaev in 2018 [19]. Direct numerical modeling of the precession of the perihelion of the orbit of Mercury taking into account all planets, as well as taking into account the contraction of the Sun, carried out within the framework of the modified Newton's law of universal gravitation with a value of Gm ~ 6.63403 × 10^{-8} [dyn × cm^2 / g^2], obtained by me after taking into account the violation of the principle equivalence in the Mercury-Sun system, allows to estimate the result with an accuracy of ~ 570 "± 5" [20]. This is the most accurate result presented in astrophysics in the entire history of calculating the perihelion precession of Mercury's orbit. The equivalence principle predicts the same acceleration for bodies of different composition in the same gravitational field and allows us to consider gravity as a geometric property of space-time, which leads to the interpretation of gravity from the standpoint of the General Theory of Relativity. In a heliocentric system, the gravitational constant in Einstein's general relativity for all planets must have the same value. However, as shown above, the gravitational constant for each planet can have its own meaning, depending on the nature of the movement of the planet in orbit. Unlike general relativity, Newton's Law of Universal Gravitation allows this:

$$F = G\frac{M\,m}{R^2} \qquad (20)$$

Where G is the gravitational constant for each planet in the solar system;

M is the mass of the Sun;

m is the mass of the planet;

R is distance from the center of the planet to the center of the Sun

The historical role of Mercury in front of science is that violation of the principle of equivalence, when the planet moves in a strongly perturbed orbit, requires a revision of the theoretical constructions of

Einstein's General Theory of Relativity. And the new gravitational constant for Mercury Gm ~ 6.63403 • 10^{-8} dyne • cm² / g² will be in demand in practical astronomy and space navigation. For the Earth, the value of the gravitational constant is equal to or close to the generally accepted value G_0 = 6.67408 • 10^{-8} dyn • cm² / g² [20].

Computer simulation according to developed by three US engineers at NASA can illustrate the special position of Mercury in the solar system. The results of their work are published by Physics Today in 2019. While scientists usually look at the distance between the orbits of the planets, a computer program does calculations differently. It simulates the location of the planets of the solar system over 10.000 years, and therefore can very accurately calculate the average distance between two planets. The results are based on a technique called the dotted circle method - essentially a mathematical equation that takes the orbits of two planets as round, concentric and coplanar, and calculates the average distance between two planets when they rotate around the Sun. Modeling of the orbits of the planets begins to show that Mercury has the smallest average distance from the Earth and most often is the closest neighbor to the Earth. Mercury is closer to us than Venus and Mars (Figure 4. Image Source: Physics Today).

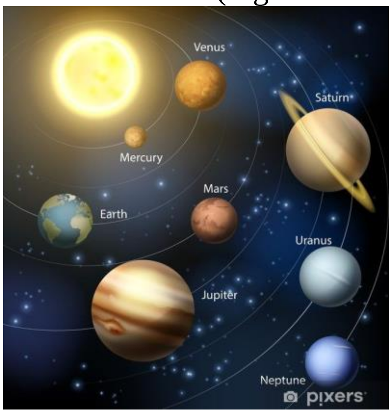

***Figure 4**. Planets in the solar system*

The average distance between the Earth and Venus is 1.14 [AU]. At the same time, the distance between the Earth and Mercury is only 1.04 [AU] (a little bit more 150 million [km]).

5. Quantum vacuum (dark matter) in the Large Hadron Collider

We'll consider experimental discoveries recently made at the Large Hadron Collider (LHC) but have not received an explanation in the Standard Model. The recognition of the polarization of quantum vacuum (dark matter) under the action of ultrarelativistic protons and superpower magnetic and electric fields distorts the spatial patterns in the LHC and allows us to state the presence of the third channel of proton interaction in the LHC, in addition to their mutual collisions [21] .

The New model represents quantum vacuum (dark matter) as the third full participant of proton collisions in the LHC, whose presence the apologists of the dominant 100 years in the physics of Einstein's Special Relativity Theory deny. Until recently, it was believed that the use of such an important connection as the unitarity condition (the assertion that the total probability of all elastic and inelastic processes during proton collisions should be equal to unity) allows us to elucidate the spatial picture in the LHC of the proton interaction region and its evolution with a change in energy [22]. However, the results of recent experiments obtained in the LHC, where the proton collision energy reaches 13 [TeV], make it possible to doubt the reliability of the unitarity condition when two channels of elastic and inelastic proton collisions are rigidly connected to each other in the probability of particle production events [23]. The recognition of the polarization of quantum vacuum (dark matter) under the action of ultrarelativistic protons and superpower magnetic and electric fields leads to the creation of jets of unstable particles in the LHC and distorts the spatial picture of the proton interaction region adopted in the SM, that is, the third channel is added. It can be assumed that the creation of new particles in energy range $W_p \approx$ 10-100 [GeV] is associated with the polarization of a quantum vacuum (dark matter) and are irrelevant to the integrity of the protons. Today scientists at the Large Hadron Collider at CERN think that they may have discovered a new particle, the decay of which gives rise to muon pairs in a narrow peak of the energy of colliding protons strictly defined at 28 GeV. The new result has been published as a preprint on ArXiv and Roger Barlow's article was published as an on November 13, 2018 [24]. The LHC collaborations have very strict internal review procedures, and we can be sure that the authors have done the amounts correctly when they report " 4.2σ standard deviation value". If this particle really exists, then it should be outside the standard model. In most cases, pairs of muons come from different sources from two different events, and not from the decay of a single particle. If you try to calculate the parent mass in such cases, it will spread over a wide range of energies, rather than creating a narrow peak. In the new experiment, the CMS detector detected a large number of pairs of muons and, after analyzing their energies and directions, found that these pairs originate from the decay of one parent particle. This may indicate the instability of quantum vacuum (dark matter) and its polarization both in the Large Hadron Collider and in near-Earth space [24].

The CMS collaboration in the experiment at the Large Hadron Collider in 2019 demonstrated a decrease in the t-quark mass with increasing energy for the first time [25]. They studied the distribution of reaction products in pp collisions with an energy from 1 [TeV] to 13 [TeV]. It was found the decrease in the mass of elementary particles obtained from data up to an energy of 13 [TeV], as well as a decrease in the magnitude of the interaction constants at a confidence level of 95%, depend on the energy at which measurements are made. This effect, explained by vacuum polarization, was indeed observed in experiments in particular, the decrease in the mass of b and c quarks was measured, as well as the decrease in the strong interaction constant [25].

6. Conclusion

The views on New Physics, which I presented to you in the article, arose on an experimental-physical basis. This is their strength. The participation of the quantum vacuum (dark matter) in all interactions causes a rejection of the paradigm of the evolution of a closed system and requires a revision of all conservation and symmetry laws. For decades, we have known about four fundamental forces: gravity, electromagnetism, and strong and weak nuclear interactions. The experimental discovery of the fifth force is associated with the participation of a quantum vacuum (dark matter) in interactions with baryonic matter [26]. The new scalar field may belong to a hypothetical dark matter particle, a protophobic X-boson, which, like the Higgs boson, creates a scalar field responsible for the fifth interaction between dark matter and ordinary (baryonic) matter [26]. Dr. Jonathan Feng of the University of California, Irvine said in a 2017 press release: "For decades, we have known about four fundamental forces: gravity, electromagnetism, and strong and weak nuclear forces. The discovery of a possible fifth force acting between baryonic and dark matter will completely change our understanding of the universe, which will entail the unification of the fifth force and dark matter." [27]. Higher education should keep up with the times and, following the example of the master's program at the Department of Experimental Nuclear Physics and Cosmophysics (Institute of Nuclear Physics and Technologies, MEPhI), introduce a new curriculum on the nature of dark matter. The emergence of such a course is dictated by the need to prepare students to participate in modern experiments to search for hypothetical dark matter particles, which are actively carried out at various facilities on Earth and in space. In addition National Research Nuclear University MEPhI (Moscow Engineering Physics Institute) publishes a journal Physical in Higher Education for students and graduate students, which publishes articles on New Physics and dark matter [28,29].

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