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The Awake project at CERN and the T-15 MD tokamak in Sarovo (Russia) in the Light of Maxwell's Real Electrodynamics

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Abstract: *The article raises the question of revising the classical Maxwell electrodynamics and abandoning the Lorentz calibration. The authors of the AWAKE projects and the device for thermonuclear fusion of the T-15 tokamak are guided in their calculations by the Maxwell's classical electrodynamics, which differs from real electrodynamics. 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 tokamak trap and proceeded to the implementation of a new hybrid tokamak T-15MD, in which at a much lower temperature, implemented nuclear and thermonuclear energy.*

Keywords: *proton, electron, vector field, scalar field, longitudinal force, tokamak*

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1. Introduction

"Since the true theory of electricity is based on the concept of a quantum vacuum ("ether"), this branch of physics is closed for circulation" in the interests of US national security, "writes the book's author William Line," And deliberately distorted by deceitful propaganda ... "Contemporary American researcher William Line, in his books, for example, Space Aliens from the Pentagon, describes these new technologies in some detail. Scientists are slowly beginning to uncover the true nature of electricity and the AWAKE project may be the first breakthrough in this direction. At CERN, for the first time in the world, it has been experimentally proved that the acceleration of an electron beam in the plasma by means of a proton driver is possible. The team behind the Advanced Proton Driven Plasma Wakefield Acceleration Experiment (AWAKE) at CERN in Geneva has been working since 5 years after CERN approved the project in 2013. In an interview with the project manager AWAKE Edda Gshwendtner "This is the fantastic: the new method of particle acceleration works " explains the essence of the experiment "In the classical scheme, the electron beam in the collider accelerates under the influence of the electromagnetic field. In our experiment, a beam of protons flies in the plasma it creates a wave and thereby ensures the acceleration of the electron beam that follows. The beam of electrons with an the energy of 19 MeV flew in the plasma ten meters and increased energy to 2 GeV, that is, more than 100 times. This means that the average acceleration rate was 200 MeV / m." [1]. The experiment was carried out by the AWAKE collaboration and scientists from the Budker Institute of Nuclear Physics, Siberian Branch of the RAS (INP SB RAS). Traditional accelerators use what are known as radio-frequency (RF) cavities to kick the particle beams to higher energies. This involves alternating the electrical polarity of positively and negatively charged zones within the RF cavity, with the combination of attraction and repulsion accelerating the particles within the cavity. By contrast, in Wakefield accelerators, the particles get accelerated by "surfing" on top of the plasma wave (or Wakefield) that contains similar zones of positive and negative charges. Allen Caldwell, spokesperson of the AWAKE collaboration said, "Wakefield accelerators have two different beams: the beam of particles that is the target for the acceleration is known as a 'witness beam', while the beam that generates the Wakefield itself is known as the 'drive beam'. AWAKE is the first experiment to use protons for the drive beam, and CERN provides the perfect opportunity to try the concept. Drive beams of protons penetrate deeper into the plasma than drive beams of electrons and lasers. Therefore, Wakefield accelerators relying on protons for their drive beams can accelerate their witness beams for a greater distance, consequently allowing them to attain higher energies." However, the use of charged protons as a driver for electron acceleration, in comparison with photons, has one more advantage. It consists in the appearance of an electrodynamics longitudinal force that effectively accelerates the flow of electrons during the motion of the proton beam. This force electromagnetic interaction can be characterized by the magnitude of the potential change $\bar{\mathbf{A}}$ and the wave function of the particle. The interaction was discovered in 1959 in the experiments of Aronov-Bohm.When an electron moves near a long solenoid with a current, the trajectory of the electron changes, although the magnetic field outside the solenoid is zero (**H** = 0), when there is no current in the solenoid, the trajectory of the electron remains unchanged . Professor R. Feynman explains this effect by the interaction of a particle with a vector potential $\bar{\mathbf{A}}$ [2]. The experimentally discovered phenomenon of the force interaction of moving electrons with the field of vector potential A in the experiments of Aharonov-Bohm was also confirmed in later experiments of Japanese scientists in 1986 [3]. In the course of the experiments, a change in the phase of the wave function of a moving charge was found in the absence and presence in the investigated space of the field of the vector potential $\bar{\mathbf{A}}$, in the complete absence of the magnetic field **H** in this space. Positive experimental results corresponded only to the single-valued value of the vector potential current. The change in the phase of the wave function by the vector potential $\bar{\mathbf{A}}$ is determined by the expression:

$$\Delta\varphi = q / \hbar \int \bar{\mathbf{A}} ds, \qquad (1)$$

where the integral is taken along the trajectory of the particle. The Aharonov-Bohm experiment forces us to reconsider the well-established ideas about some transverse magnetic forces of Lawrence and recognize the presence of longitudinal forces of magnetic interaction. The existence of an electrodynamic longitudinal force is confirmed not only by the Aharonov-Bohm effect, but also by the wakefield acceleration of the electron flux in the collider by a beam of relativistic protons. The mechanism of this wakefield acceleration by a charged proton beam differs from the wakefield acceleration of electrons by laser radiation. To explain the nature of the electrodynamic longitudinal force, it is necessary to revise the equations of Maxwell's electrodynamics. Maxwell mistakenly applied 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. Coulomb's law is valid only for stationary charges [4]. The non-invariance of the equations of electrodynamics is associated with the assumption of the reality of the existence of a quantum vacuum (dark matter) and with the existence of effects of retarded potentials and deformations of the electric field of moving charges in a polarization medium. The complete invariance of the equations of electrodynamics is admissible only in the absolutely empty space of Einstein's STR.

2. Paradoxes and Contradictions in Maxwell's Electrodynamics

1) Of paradoxical role of the bias currents in the induction of the magnetic field of the moving charge. In the modern electrodynamics is dominated by the belief that the magnetic field is generated only by the transfer currents **j**t(r) # 0:

$$\mathrm{rot}\mathbf{H} = 4\pi / c\ \mathbf{j}t, \qquad \mathrm{div}\mathbf{H} = 0 \qquad (2)$$

What is "bias currents"? Maxwell called component **j**b=1/4π (d**E** /dt) in their equations "bias current", meaning that the electric field is created in the medium (dark matter) due to the relative motion of its constituent oppositely charged particles that form the dipole polarization. On the one hand the bias currents are a physical reality, because without them it is impossible to understand the workings of a simple capacitor, on the other the displacement currents are of mathematical formality, with which it is possible to make the symmetrical Maxwell's equations. On one side of the magnetic properties of bias currents are taken to be of equivalent magnetic "transfer currents " properties, on the other hand only the transfer currents generated moving magnetic fields are determined for some reason, as if the bias currents are absent.

2) Based on the fact of the real existence of displacement currents jcm in a physical medium near a moving charge jb = 1 / 4π ∂E / ∂t, an employee of Tomsk Polytechnic University G.V. Nikolaev, established the functional relationship of these currents with the magnetic fields they induce:

$$H^{\perp} = 1/C\ \ 2j_{cм}^{\parallel}/r_0 = 1/C\ \ ev/r^2\ \sin\varphi ,$$

$$H^{\parallel} = 1/C\ \ 2j_{cм}^{\perp}/x_0 = 1/C\ \ ev/r^2\ \cos\varphi, \qquad (3)$$

Where

$jb\| = \int_{so} jc_M\| \, dS$,

$jb^{\perp} = \int_{s\sigma} jc_M^{\perp} \, dS$, (4)

$(jb = jb\| + jb^{\perp})$

Surface S_0 limits the axial displacement current flux $jb\|$. On its outer surface, the magnetic field strength $H^{\perp}$ is determined.

The surface Sσ limits the radial displacement current flux $jb^{\perp}$. On its outer surface, the magnetic field strength $H\|$ is determined [5];

The formalism of the vector potential field **Ā** turns out to be well applicable to describe the phenomenon of electromagnetic induction of current in a conductor outside the transformer core, because outside the core, under the condition dH / dt = 0, the condition d**A** / dt ≠ 0 is realized. G.V. Nikolaev , using the single-valued magnitude of physical property of vector potential **Ā** moving charge e_o at v < c ascertained existence of two types of magnetic fields in the space around moving charge [5]:

vector field $Hr = H^{\perp} = \text{rot}\bar{\mathbf{A}}$ (5)

scalar field $Hp = H\| = -\,\text{div}\bar{\mathbf{A}}$ (6)

and the longitudinal force of the magnetic interaction, which is different from the transverse Lorentz forces.

3) Maxwell himself pointed out the difficulties with his the equations when unclosed electric currents and the individual elements of the current. These difficulties lie in the fact that for the open currents alone, non-zero spatial derivative rot**Ā** = **H** of vector potential Ā cannot determine it completely. It revealed the existence of yet another non-zero spatial derivative div**Ā** ≠ 0 of the vector potential **Ā**. In general, the vector potential **Ā** can be represented as the sum of the potential and the vortex components of **Ā**r + **Ā**p. This current element creates:

vector magnetic field $\mathbf{H}t = \text{rot}\,\bar{\mathbf{A}}t$, (7)

scalar magnetic field $\mathbf{H}p = -\text{div}\,\bar{\mathbf{A}}p$. (8)

It turns out that an infinitely long current conductor generates only a magnetic field **H**t, but the current conductor of limited length creates a the vector magnetic field **H**t and the scalar magnetic field **H**p. Since isolated current element is hard to imagine, since this requires the source and drain of charges, the field configuration is of interest in case of a real closed currents, in particular for this purpose may be a used the toroid, or used of the tokamak rings [6].

4) 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 (ε0, μ0) 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. The physicist-inventor Andrey Melnichenko used this effect to create his "transgenerator" with an efficiency> 100%, which works contrary to all the laws of both classical Maxwell's electrodynamics and quantum electrodynamics. In the article "And yet it shines" A. Melnichenko describes a simple experiment with two light bulbs clearly and visibly showing that "the energy of the secondary magnetic field removed from one or several secondary circuits with ferrite cores separated from the primary winding by a dielectric gives a significant an increase in electricity received from the current source"[5]. When the primary circuit is closed, a light comes on in it, exactly the same light comes on in the secondary circuit, separated from the primary circuit by a small gap, but it burns without any expenditure of energy from the primary circuit. Andrey Melnichenko explains the additional "free" energy in the "transgenerator" by the disturbances of the medium in the

space between the ferromagnetic cores with windings separated by relatively small gaps of the dielectric (2-3mm.). Ferrite cores placed in this field enhance the electromagnetic characteristics of the medium (ε, μ) due to the resonant spin polarization of the domains. 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 strongly depends 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 edge effects in which vacuum (dark matter) plays a decisive role. Here we see a connection with the Casimir effect, but the effect of separating magnetic fields and generating 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 influence of the magnetic moment exceeds the polarization of the vacuum under the influence of the electric one. In [6], the following relationship was obtained between the influence of magnetic ($Fm = 2I^2 / c^2 r$) and electrical ($Fd = Fc$) forces on vacuum polarization:

$$\frac{Fm}{Fc} \approx \frac{8e^2 r^3}{3\mu^2{}_\beta v^2} 10^{-24} \approx 10^2 \,, \tag{9}$$

$Fm > Fc$ at $r^3 / v^2 < 10^{-24} m \cdot s^2$, where ν is the speed of the electron.

This effect, partially described by Michael Faraday two hundred years ago, in our time can serve as an impetus for the creation of a fundamentally new electrical engineering based on the work of the Russian physicist Andrey Melnichenko (Fig. 1) [7].

5) Paradoxically, in classical electrodynamics particle can move with a constant acceleration, generating energy from nowhere. It is known that in the case of charged particle movement in plane condenser with the constant tension to be applied classical uniformly accelerated motion $x = \alpha t^2$ appears. If during acceleration of a charge one takes into account force acting on a charge itself, then the braking due to radiation arises. In different works this effect is called in different way: Lorenz frictional force or Plank's radiant friction. That force is proportional to third derivative of coordinate x relative to time and was experimentally proved many years ago. If we write the equations of motion for the charge moving in space free from external fields impact and if the only force acting on the charge is the "Plank's radiant friction", then we would obtain following equation:

$$m\frac{d^2x}{dt^2} = \frac{2e^2}{3c^3}\frac{d^3x}{dt^3} \tag{10}$$

It is evident that equation in addition to trivial particular solution v=dx/dt=Const has general solution where particle acceleration is equal:

$$\alpha = \frac{d^2x}{dt^2} = C\exp\left[\frac{3mc^3t}{2e^2}\right] \tag{11}$$

i.e. is not only unequal to zero, but more over it unrestrictedly exponentially increases in time for no reason whatever!!! [8]. L.Landau and E.Lifshits in their classical work "Theory of the field" wrote apropos of this: "A question may arise how electrodynamics satisfying energy conservation law is able to give rise to such an absurd result in accordance to which a particle was able to unrestrictedly increase its energy. The background of that trouble is, actually, in infinite electromagnetic "eigen mass" of elementary particles."[9]. I will allow myself to disagree with the classics. In new physics, the recognition of the quantum vacuum (dark matter) in the theories of quantum electrodynamics (QED) and quantum chromodynamics (QCD) leads to the violation of symmetries, conservation laws and prohibitions in the Standard Model [10].

3. 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]:

$$\mathbf{S} = (\mathbf{E} \times \mathbf{H}r) + (\mathbf{E} \times \mathbf{H}p) \tag{12}$$

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 [11]:

$$\mathbf{S} = - \operatorname{div} \bar{\mathbf{A}} - \lambda\varepsilon0\mu0\, d\varphi/dt \quad (13)$$

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 (13) at $\lambda = 0$ we obtain the Coulomb gauge, and at $\lambda = 1$ 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:

$$d\mathbf{E}/dt - \mathrm{rot}\mathbf{H} - \mathrm{grad}\,\mathbf{S} = 0,$$

$$d\mathbf{H}/dt + \mathrm{rot}\mathbf{E} = 0, \quad (14)$$

$$\mathrm{div}\,\mathbf{E} - d\mathbf{S}/dt = 0,$$

$$\mathrm{div}\,\mathbf{H} = 0$$

For ease of reference the equations (14) Consider the case of absence of currents and charges and accepted $\varepsilon0 = \mu0 = 1$ [6].

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 [6] 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:

$$S = E \times H + \alpha E + bH \quad (15)$$

The corresponding energy density of this vector is expressed as:

$$W = 1/2\,(E^2 + H^2) + WE// + WH// \quad (16),$$

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

A rigorous derivation of the additional energy and differential equations for generalized electromagnetic field are given in [6].

4. REAL ELECTRODYNAMICS INSIDE THE TOKAMAK

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 1). To create the magnetic trap uses a combination of magnetic fields: strong toroidal field **B**t and a weaker (100 times) poloidal field **B**p, as well as the **B**i field current I, flowing through the plasma column. It is believed that the plasma is stable in a tokamak if the criterion Shafranov - Kruskal:

$$\mathbf{B}t / \mathbf{B}i > R / \alpha \quad (17)$$

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

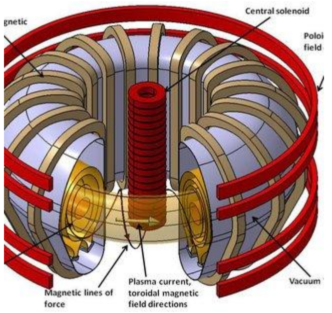
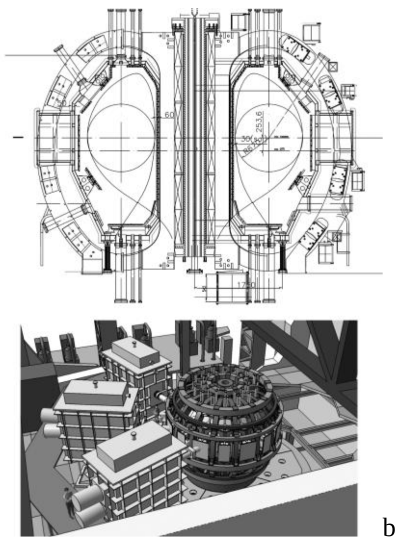


Figure1. *Closed plasma trap (tokamak).*

Real electrodynamics inside the tokamak is very different from the calculation [12,13]. Hot plasma particles move along magnetic field lines of arbitrary topology to the walls of the tokamak and destroy it. Not to recognize this fact is becoming more difficult, but the author of the article "Tokamaks: from A.D.Sakharov to nowadays (the 60 year tokamak history)" Professor, NRC "Kurchatov Institute", E.A.Azizov bypassed this fact with silence, although the plasma confinement in tokamaks T-15 less 1s [14].

a



b

Figure2. *The cross section of the Tokamak TM-15 (a) up, in the lower part the TM-15 (b)*

However, due to the effect of self-generation strong toroidal magnetic field **H**t poloidal magnetic field **H**p, and vice versa, 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 [12, 13]. 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:

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

$$\nabla^\times \mathbf{H}_T = \mathbf{H}_p \qquad \nabla^\times \mathbf{H}_p = \chi\mathbf{H}_T \tag{18}$$

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 $\chi \neq 0$ [13]. 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. 2a) according to his equations (18) of electrodynamics. The results are as follows [13]. If we assume $\nabla^{\times} \approx 1/L$, where L is the linear dimension of the plasma pinch inside the tokamak, then:

$$(1/L)\cdot \mathbf{H}_P \approx (\Upsilon/\eta)\cdot \mathbf{H}_T , \qquad (1/L)\cdot \mathbf{H}_T \approx \mathbf{H}_P \qquad (19)$$

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

Let the small radius of the plasma filament R = 2m, then L = 2π R = 4π 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

$$|\mathbf{H}_P'| = 5/4\pi \text{ Tl} \sim 0{,}4\text{Tl}. \qquad (20)$$

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

$$\Upsilon = (\eta/L)(|\mathbf{H}_P|/|\mathbf{H}_T|) \qquad (21)$$

The additional toroidal magnetic field will increase by an amount

$$\mathbf{H}_T' = (\eta/L\Upsilon)\, \mathbf{H}_P' = (\mathbf{H}_T/\mathbf{H}_P)\, \mathbf{H}_P' \qquad (22)$$

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." [13]. In article [12], 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. In this case, the Lawson criterion can easily be realized." How in this case Lawson's criterion can be implemented remains a mystery? The intention to obtain neutrons from deuterium means that it will be a hybrid reactor, in which neutrons are also formed due to decay, in this case, deuterium, and not at all due to the synthesis of deuterium and tritium, as in the reactor Velikhov's. A fusion reactor blanket is a fusion reactor device located behind a fusion reaction area designed to utilize neutrons generated from fusion. It consists of two zones. In the first zone - fissile substances (uranium or thorium), in the second - lithium-containing substances for reproduction of tritium burnt in plasma. That is, such reactors can be used for the production of tritium for a thermonuclear reactor and the production of nuclear fuel for thermal and fast reactors (plutonium-239 and uranium-233), for transmutation. Tritium is radioactive and the reaction creates neutron irradiation of thorium-232. According to the technical description, the T-15MD installation will have an elongated plasma column configuration with an aspect ratio of 2.2, a plasma current of 2 MA in a toroidal magnetic field of 2 T, with a quasi-stationary additional heating system with a total power of up to 20 MW. The installation is designed for a pulse duration of up to 30 seconds, in contrast to the modernized TM-15 tokamak, in which in 2015 the plasma confinement time in a stationary mode was less than 1 s. (The project included a time of 5-10 s). The new T-15MD will be "warm": 16 of its magnets do not use superconductivity and do not require cooling, their coils are wound from a conventional copper conductor with the addition of less than 1% silver. This "alloying" did not impair the electrical conductivity, but made the conductor as strong as steel. If earlier, during the operation of a cold tokamak, there was a rapid destruction of the magnets, now "warm" magnets made of silver-containing copper are able to create and withstand a sufficiently high magnetic field of 2 Tesla. A hybrid thermonuclear reactor receives energy both from the decay of an atom (like a conventional nuclear power plant) and from fusion, that is, it combines the principles of nuclear and thermonuclear energy. Currently, work on the modernization of the T-15MD unit is entering the phase of preparation for the physical start-up of the tokamak. At the same time, by National Research Council of Science & Technology dezember 24, 2020 reports that the Korean superconducting thermonuclear device Tokamak Advanced Research (KSTAR), also known as the Korean artificial sun, set a new world record as it managed to maintain a high-temperature plasma for 20 seconds with an ion temperature of more than 100 million degrees Celsius. Director Si-Woo Yoon of the KSTAR Research Center at the KFE explained, "The technologies required for long operations of 100 million-plasma are the key to the realization of fusion energy, and the KSTAR's success in maintaining the high-temperature plasma for 20 seconds will be an important turning point in the race for securing the technologies for the long high-performance plasma operation, a critical component of a commercial nuclear fusion reactor in the future." The ultimate goal of KSTAR is to achieve success in continuous operation for 300 seconds with ion temperatures above 100 million degrees by 2025. What decision will be made for the ITER International Thermonuclear Experimental Reactor in France, whether it will be a hybrid reactor based on the RussianT-15MD tokamak, or a tokamak based on the Korean KSTAR tokamak or a Chinese version of the Tokmak "HL2M", it's a question of time. In July 2020, French President Emmanuel Macron solemnly opened the start of work on the installation of the reactor (ITER). In the ITER project, the duration of plasma confinement is planned to be increased to 3000 seconds.

5. CONCLUSION

Today, physicists are faced with the question of which scientific and technical projects they should choose for new colliders that allow them to reduce its size and cost, and at the same time realize the necessary energy for flows of elementary particles or tokamaks intended for magnetic confinement of plasma in order to achieve the conditions necessary for the flow of controlled thermonuclear fusion. The facts presented in the article indicate that a reasonable approach can only be realized if the modern scientific paradigm is updated.

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