

New longitudinal magnetic interaction (Tokamaks, longitudinal waves and railgun engines)

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Abstract: The article raises the question of revision of Maxwell's electrodynamics and the refusal of the Lorentz calibration. Relatively modest results of years of work of the collective of the National Research Centre "Kurchatov Institute" in the creation of a fusion reactor based on the tokamak due to the fact that Maxwell's electrodynamics is very different from the real electrodynamics in a tokamak. The article examines the nature of longitudinal electromagnetic waves, as well as the possibility of wireless transmission energy. New electrodynamics theory can explain the Aharonov-Bohm effect and the physical nature of the forces in the railgun engines for which, based on the Lorentz transverse forces, could not find the correct explanation.

Keywords: Tokamak (toroidal chamber with magnetic coils for plasma confinement), a toroidal (non-force) magnetic field, poloidal (force) magnetic field, vector potential \mathbf{A} .

1. Introduction

Soon it will be 10 years (2006) the agreement between Russia, EU, USA, Japan, China, Korea and India for the joint construction of the International Thermonuclear Experimental Reactor (ITER) in France based on the tokamak. Prospects for the tokamak as a fusion (14 MeV) neutron source are considered. In June 2016 it was reported to delay completion of the work from 2020 to 2025. Today, we can talk about a complex problem faced by the creators of the ITER project, because for the calculation of electrodynamics in a tokamak currently used classical equations of Maxwell. Real electrodynamics inside the tokamak is very different from the calculation [1]. Hot plasma particles move along magnetic field lines of arbitrary topology to the walls of the tokamak and destroy it.

In the early 20th century it became clear that Maxwell's electrodynamics requires revision and improvement. But it took more than 100 years, and this task is not finished today. Attempts by a number of scientists [1,3,7,8] to point out the obvious contradictions and paradoxes of the classical and quantum electrodynamics encounter complete misunderstanding and fierce opposition from the apologists of the ruling today in the physics of Einstein's SRT and GRT. As a result the Maxwell 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 its additions, changes and improvements. 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, member of the Board of plasma physics at NRC "Kurchatov Institute", E.A.Azizov bypassed this fact with silence, although the plasma confinement in tokamaks T-15 less than 1s. [2].

2. Tokamaks electrodynamics (theory and experiments)

In the 20th century, many scientists including Albert Einstein undertook repeated unsuccessful efforts to unite gravitation and electromagnetism geometrically in the framework of four dimensions of Minkowski continuum, and only T.Kaluza has managed to do it, but in the five-dimensional formal world of four spatial dimensions and one time dimension. Eddington's statement that «a matter particle understood as a population of events is a system the linear extent of which has a time character» allowed him to pass on to the five-dimensional Kaluza theory. Here absolutely implicit physical meaning of the Kaluza fifth coordinate (hidden dimensions) becomes the real pseudo-spatial x5-coordinate. Eddington five-dimensional world absorbed all the advantages of the Kaluza five-dimensional world over the planar four-dimensional Minkowski continuum, allowed to reveal the connection between macrocosm, including space-time vision, and microcosm with the charge and mass of elementary particles, with presence of cosmic environment (uranoid), with the existence of electromagnetic vector and scalar fields. Eddington's uranoid includes electrically neutral environment and equality of particles with opposite charges and the left and right polarization. This fifth component of the velocity of the particle has the physical meaning of the ratio of electric charge q to the mass m of the particle, which is included in the dimensional

coefficient G - Newton's gravitational constant. The fifth equation of a geodesic is constant ratio q / m for the current state of the planets in the solar system (the current time horizon). Justice is even a statement that the momentum of the particles of the fifth coordinate is meaningful electric charge (up to a dimensional constant $c / 2\sqrt{G}$) [10].

Spatial and temporal diversity of different dimensions different properties introduced into these discrete transformations P-space conversion, the conversion time T and C charge conjugation. Eddington found equality in Uranoid particle systems with different properties.

The 5-dimensional manifold instead of the square of the 4-dimensional interval $ds^2 = g_{\alpha\beta} dx^\alpha dx^\beta$ should take $dI^2 = G_{AB} dx^A dx^B$, where the indices A and B have the meanings: 0,1,2,3,5.

G_{AB} values are components of the five-dimensional metric tensor. They form a square matrix having a generally 15 independent components:

$$\begin{matrix}
 & G00 & G01 & G02 & G03 & G05 \\
 & G10 & G11 & G12 & G13 & G15 \\
 G_{AB} = & G20 & G21 & G22 & G23 & G25 \\
 & G30 & G31 & G32 & G33 & G35 \\
 & G50 & G51 & G52 & G53 & G55
 \end{matrix} \quad (1)$$

In the curved Riemannian space-time, operating with the components of five-dimensional metric tensor, one can obtain ten components of metric tensor of the Einstein's general theory of relativity, four components of electromagnetic vector potential A of the Maxwell theory, and one component which theoretically can describe any new scalar field [10].

Tomsk physicist G.Nikolaev, using the single-valued magnitude of physical property of vector potential A and moving charge e , at ($v \ll c$) [3]

$$A = ev/cr, \quad (2)$$

ascertained existence of two types of magnetic fields in the space around it:

$$\text{vector field } H^\perp = \text{rot}A \quad (3)$$

$$\text{scalar field } H_{\parallel} = - \text{div}A \quad (4)$$

It is generally accepted that if the magnetic field H is known, there is no need to refer to "formal" vector potential A . However, the mere fact that the Schrödinger wave equation appears only vector potential was obvious since the inception of this equation. Unsuccessful attempts to replace the vector potential A in the equations of quantum mechanics "physical" magnetic field H is said that the wave function of any moving charge in the field of the vector potential A , should reflect the existence of a quite tangible interaction between a moving charge with this field. This interaction can be characterized by the magnitude of potential A change and the wave function. In 1956. in quantum physics has been demonstrated simple experiment, the result of which is known as the Aharonov -Boma [4]. When an electron moves along the long solenoid with a current, the electron trajectory is changing, although the magnetic field outside the solenoid is zero ($\mathbf{B} = 0$). Aharonov-Bohm effect has several explanations [1,3,4]. Feynman explains the effect of the interaction of the particles with the vector potential A , while Nikolaev and V.Aksenov suggest that the particle interacts with the magnetic field. In electrodynamics Nikolaev particle interacts with a new longitudinal scalar magnetic field H_{\parallel} , in theory, toroidal and poloidal magnetic fields V.Aksenov particle interacts with the non-force toroidal magnetic field H_t . In theory, Nikolaev scalar magnetic field generated by currents of displacement, in theory Aksenov non-force magnetic field is generated by the displacement currents occurring between the plates of the capacitor and conduction currents. The experimentally observed phenomenon of the power of moving electrons interact with the field of the vector potential A in the experiments of the Aharonov-Bohm effect, was confirmed in later experiments by Japanese scientists (1984) [5]. During experiments, it was found change in the phase of the wave function of a moving charge in the absence and presence in the test area of the vector potential field A , the complete absence in this area of the magnetic field H . The positive results of experiments matched only unique value of the vector potential A , is compared with the same parameters unambiguous elemental power. Changing the phase of the wave function of the vector potential A is given by:

$$\Delta\varphi = q / \hbar \int A ds, \quad (5)$$

where the integral is taken along the particle's trajectory.

Experimental discovery of the phenomenon of longitudinal force effect of interaction along the axis of current toroid of electrons with the field of vector potential A in the experiments of Aharonov-Bohm make one revise the well-established view about the transverse magnetic Lorentz forces alone and accept the presence of longitudinal forces of magnetic interaction.

Experiments Solunin A. and A. Kostin [6], confirming longitudinal interaction.

To demonstrate the phenomenon of moving charge interaction with the field vector potential A at the cathode-ray tube 1, at the location of the deflecting plates 2, 3. wearing toroidal coil toroidal winding made of outer and inner layers of wound copper wire of 0.62 mm with a total of 500 turns. the need for a two-layer winding caused by the fact, to prevent the magnetic field of the ring current (one left-winding spiral, the other - the right-helical). The windings are connected so that their magnetic fluxes summed. The electrons are accelerated in the tube potential difference 400V. On the vertical plate was fed a constant deflection voltage to set the on-screen (5-20 mm) of the electron beam of the base offset. The current in the coil was varied 0-5A. The experimental results are plotted. As the current increases in one direction of the electron beam deflection angle increases in magnitude relative to the reference deviation. Increasing the angle of deflection of the electron beam at a constant voltage across the deflection plates is due to a decrease in the electron beam velocity due to their interaction with the field of the vector potential A toroidal winding. When the current in the coil on the back, the electron beam deflection angle decreases its value in relation to its baseline deviation, registering the effect of increasing the speed of the electron beam in their interaction with the field of the vector potential A toroidal winding.

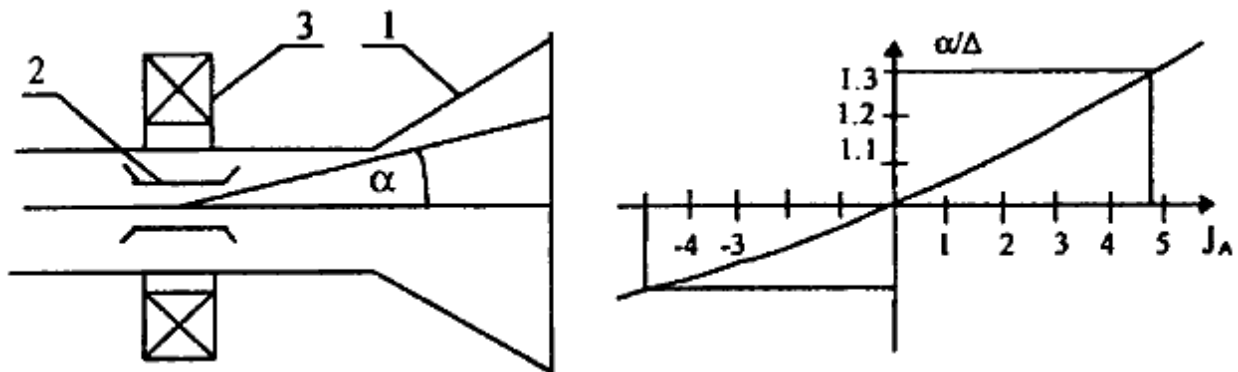


Fig.1

Thus, the results described the experience clearly prove the existence of a conventional classical analogue of the well-known experience of the Aharonov-Bohm and confirm the existence of a previously unknown phenomenon in the science of the longitudinal magnetic interaction.

The main difficulty associated with the management of plasma in tokamak chamber, associated with longitudinal magnetic interaction. Hot plasma particles move along magnetic field lines of arbitrary topology, in contrast to the toroidal field.

Tokamak is a toroidal chamber with magnetic coils, designed for magnetic plasma confinement in order to achieve the conditions necessary for the occurrence of controlled thermonuclear fusion. 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 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:

$$B_t / BI > R / \alpha \quad (6)$$

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

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 intense toroidal magnetic field generated by the windings of the toroid, and it is in the tokamak reaches 3-5Tl, the more intense will be created them extra poloidal magnetic field. In fact, there is self-excitation, and the uncontrolled growth of the magnetic fields of different topologies, different from the toroidal, by itself inside the tokamak magnetic field, when a conductive plasma in it. This leads to uncontrolled instabilities of the plasma column [1]. Today in EAST tokamak Chinese Institute of Plasma Physics succeeded in a record time of plasma confinement during the 3s, and in the ITER project is necessary to achieve the following: inductive mode $P_{fus} = 0,4-0,5$ GWt and $Q > 5V$ and to bring the length of the plasma confinement before 3000S. [2].

In the natural fusion reactor, such as the Sun, regularly observed coronary solar plasma emissions, which indicates the instability of a solar reactor. Such plasma emissions from a fusion reactor could lead to an environmental disaster.

3. Longitudinal waves

The presence of longitudinal waves, both in the near and far space is certain. Numerous terrestrial and satellite measurements confirm the excitement of various kinds of electrodynamic waves over a wide frequency range of up 10^{-3} to 10^7 Hz.

The mechanism of occurrence of a longitudinal wave to be reduced to that of the magnetic field change the scalar electric charges equivalent to the formation, modification of which, in turn, generates an electric potential field. In space, the generation of longitudinal waves enormous intensity must occur during the collapse of stars, their explosive evolution. The same applies to the Sun during the cycles that are accompanied by intense emissions of solar plasma and charged particles flows, including the solar wind. Invading Earth's ionosphere to the plasma, the solar wind disturbs not only the plasma, and magnetic field. It should be noted that usually recorded as the transverse waves of electromagnetic waves in ground conditions, even when the nature of their longitudinal known. It is believed that the longitudinal waves are transformed into cross at various plasma irregularities, its borders or by interactions with other waves and charged particles. It is necessary to design and develop special methods of registration of longitudinal waves. Under laboratory conditions, the radiation of longitudinal waves can be produced by any system that generates a scalar magnetic field. It turns endless scalar current creates a magnetic field while the element current creates a magnetic field vector and scalar magnetic field. In general, the vector potential A can be represented as the sum of the potential and vortex components of $A_t + A_p$. In this current element creates a magnetic field vector

$$H^\perp = \text{rot } A_t, \quad (7)$$

and the inner magnetic field

$$H^\parallel = -\text{div } A_p. \quad (8)$$

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 toroid [7].

Correction of Maxwell's equations of electrodynamics based on the recognition of an additional magnetic field, which creates a force in addition to the transverse Lorentz forces acting along the direction of the current. To this end, a number of authors have suggested [3,7,8] to abandon the calibration and enter Lorentz expression for the electromagnetic energy density in the form of:

$$S = -\text{div } A - \lambda \epsilon_0 \mu_0 \text{d}\phi/\text{d}t \quad (9)$$

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 (9) 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, introduced in Nikolaev. Further

transformations are performed in the standard way, with the result that allows to obtain the following system of equations:

$$\begin{aligned} dE/dt - \text{rot}H - \text{grad} S &= 0, \\ dH/dt + \text{rot}E &= 0, \\ \text{div} E - dS/dt &= 0, \\ \text{div} H &= 0 \end{aligned} \quad (10)$$

For ease of reference the equations (10) Consider the case of absence of currents and charges and accepted $\epsilon_0 = \mu_0$

For clear separation of the concept of a longitudinal wave in a vacuum, and the longitudinal electromagnetic waves that exist in material media, in [7] 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 fluence. This is a scalar function $SE // = \alpha E$, where $\alpha = \alpha(x, y, z, t)$. Similarly, H is determined by the longitudinal wave generating energy flow $SH // = bH$.

Differential equations for the generalized electromagnetic field can be derived from the concept of the Poynting vector. Poynting vector for a general electromagnetic waves, including both conventional fashion transverse and longitudinally polarized modes can be represented as:

$$S = E \times H + \alpha E + bH \quad (11)$$

The corresponding energy density of this vector is expressed as:

$$W = 1/2 (E^2 + H^2) + WE// + WH// \quad (12),$$

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

A rigorous derivation of the additional energy and differential equations for generalized electromagnetic field are given in [7].

The value of [3,7,8] is that the authors proposed a relatively simple experiments for the detection of longitudinal waves.

Longitudinal waves can be applied not only in the medium, but in vacuum like transverse waves without charges and currents. In this generation of longitudinal waves occur when the current element, which gives rise to not only a magnetic vortex field and scalar magnetic field. The mechanism of propagation of longitudinal waves in the dipole polarization medium possessing electric and magnetic perception is different. In a neutral space environment current dipole elements (bias currents) are born as a result of the polarization process. In the Earth efirofere, unlike transverse electromagnetic waves having a rectilinear propagation, the longitudinal waves propagate along a curve that is the shortest path between two points on the surface of the globe and capable as longitudinal seismic wave repeatedly bend around the Earth. Distribution of current "electric fluid" on the surface of the sphere can be described analytically in the theory of steady, two-dimensional, ideal incompressible fluid on a Riemann surface and conduct computer simulations of this process. See Appendix A

Based on the fact of the real existence of bias currents (jb) in the physical environment around a moving charge $jb = 1 / 4\pi \partial E / \partial t$, Nikolaev established a functional relationship of these currents induced by them on the basis of short- range magnetic fields:

$$\begin{aligned} H^\perp &= 1 / C 2jb^\perp / Ro = 1 / C ev / r^2 \sin\varphi, \\ H^\parallel &= 1 / C 2jb^\perp / ho = 1 / C ev / r^2 \cos\varphi, \end{aligned} \quad (13)$$

where:

$$\begin{aligned} jb^\parallel &= \int_{so} jb^\parallel dS, \\ jb^\perp &= \int_{s\sigma} jb^\perp dS, \\ (Jb &= jsm^\parallel + jb^\perp) \end{aligned} \quad (14)$$

The surface SO restrict axial flow of the bias current $j_b \parallel$. On its outer surface is determined by the intensity of the magnetic field vector H^\perp . Surface $S\sigma$ restricts radial flux bias current j_b^\perp . On its outer surface is defined by the inner strength of the magnetic field $H \parallel$ [3].

Considering that on the surface of the Sun is concentrated electric charge $Q \approx 1,7 \cdot 10^2 \text{ }^\circ \text{ Kl}$. and the outer sphere flowing currents, creating a magnetic field $H \approx 80\alpha / \text{m}$ (stained $H \approx 10^5\alpha / \text{m}$), you can imagine the magnitude of the longitudinal forces, forces to move the sun along with the planets of the solar system to its apex at a speed of 330km / s. The result of the new longitudinal force is a collision of galaxies. This process is accompanied by the absorption of smaller galaxies, large galaxies and the formation of powerful gravitational waves. Instead of fading gravitational waves left in the universe after the mythical "Big Bang", the scientists found quite noticeable gravitational waves, born in the collision of galaxies and black holes. Here I would like to point out that even In 1994, when the July 16, 1994. great nucleus of the comet Shoemaker-Levy collided with Jupiter gas sphere, radial oscillations gave rise to the surface gravity waves, instantly resulted in fluctuations in several geodetic satellite command-measuring complex of Russia. Usually geodetic satellites orbit are located inside the tube of about 1 km indiameter. The collision between the diameter of the path of the tube increased by 5 - 8 times. Speed, formed by the collision of a comet with Jupiter, gravitational waves significantly exceeded the velocity of electromagnetic waves (light from Jupiter to Earth is about 1 hour). Thus, the Russian military ahead of American scientists with the discovery of gravitational waves (LIGO project) for 22 years and were even able to roughly estimate their speed of propagation in space.

The term "true conductivity" was first used by Nikola Tesla in conversation with Lord Kelvin, on the theme of wireless transmission of energy in the near-Earth space. Asked Kelvin: "So you mean, do not use the Hertz waves?" - "Of course not, - said Tesla - they are radiations. No energy cannot be transferred to economic benefits in the distance by means of this kind of radiation. The basis of my method is true conductivity, which is carried out on the biggest distance without significant losses. " This conversation took place in the summer of 1897 during a visit to Kelvin lab Tesla in Long Island. So, from the late 19th century to the present day in the 21st century, science remains a mystery, what is the meaning invested in Tesla, the term "true conductivity." Tesla himself, in an interview given to them in 1932, answers this question: "Wireless transmitter produces longitudinal waves in the near-Earth environment, electricity, whose behavior is similar to the behavior of sound waves in the air, except that the great flexibility and very low density This medium (ether) makes their speed equal to the speed of light. "[9].

Nikola Tesla published his article "Wireless transmission of electrical energy," March 5, 1904. in the publication of "The Electrical World and Engineer" and then not once repeated the publication: "The famous scientific errors" in the publication "Electrical Experimenter" in February 1919 and the "world system of wireless transmission of energy" in the edition of the Telegraph and Telephone Age in October 1927. [9].

Unfortunately, the modern physics, which is based on a relativistic theory of relativity of Einstein, with its subjective spatiotemporal representations and quantum mechanics with its vague concept of the physical vacuum, and can not give a scientific explanation of the experiments Tesla. The fact that 100 years ago and realized Tesla the strength and the modern scientist. Wireless transmission of energy promises great economic benefits for the whole of humanity, and can also become a formidable weapon, superior missile technology with nuclear warheads.

4. Railgun engines, guns and accelerators of Nikolaev [3].

4.1. Railgun engines

Under the new theory of electrodynamics, many phenomena have found their explanations, such as motion of U-shaped conductor, an issue of railgun engine and results of Aaronov- Bohm experiments, for which, going from transverse Lorents forces, there has been no correct explanation found.

In September 1991, at the II International Conference on space, time and gravity in St. Petersburg, G.Nikolaev reported opening of a new kind of the magnetic field, and a new theory of electromagnetism, as well as presented a unique electromotor of his own design. Analysis of operation of this type of device has shown that the driving forces there are no potential transverse Lorentz force applied to the radial currents rotating armature and the longitudinal reaction force applied to a supply designs. The physical nature of the rotation axis of the "engine", fortified on two bearings, while passing of current (AC or DC) through the outer ring of the bearing (Figure 2), Nikolaev explained as follows: "In

this experiment, at a constant angular velocity of the rotation axis of the bearings , measures the contour and consequently its inductance L, are not changed. Consequently, the dependence of power circuit:

$$W_L = \frac{Lj^2}{2} \tag{15}$$

from which we can found the force influencing the axle:

$$F = \frac{dWL}{dx} = -\frac{j^2}{2} \frac{dL}{dx}, \tag{16}$$

turns out to be essentially unacceptable.

An analysis of functioning for devices of such type shows that driving forces in them are not potential transverse Lorentz forces applied to radial rotation currents of an anchor, but longitudinal reaction forces applied to currents in supplying rails” [3].

It should be clarified that in the case of a symmetric current input (Figure 2.A), an engine axis starts spinning in any direction after the first push. In case of asymmetric current input (Fig.2B) the axis starts spinning without the prior push. If we now expand the experiment to the planetary scale and to consider as the axis of the motor Globe, which is focused on the surface of a negative electrical charge $5,16 \cdot 10^{14}$ Kl. And on the outer sphere flow currents creating a magnetic field of 50 A / m, the axial rotation of the Earth is due to the same longitudinal forces as in the experiment "railgun". Role of bearings in this case plays a fixed space ether. Asymmetry of the globe achieved spaced on the surface of the magnetic and geographic poles, which eliminates the need to first clean and jerk.

Austrian physicist Stefan Marinov announced his interest in Nikolaev’s papers. He reproduced some G.Nicolaev experiments and built his paradoxical electromotor, functioning against laws of electrodynamics. Stefan Marinov also published a monograph, a main theme of which was a new theory of electrodynamics G. Nikolaev and a principle of operation for the electromotor that he called “SIBERIAN COLIA”

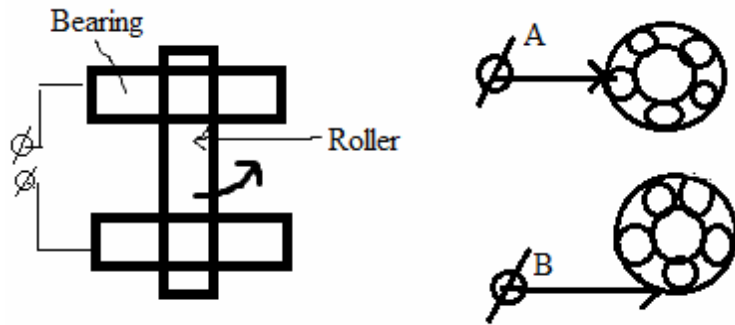


Fig. 2
Motor Nikolaev railgun «SIBERIAN COLIA»

4.2. Railgun and accelerators

So far not found the correct explanation of the forces of reaction and place their applications in devices such as the railgun. Research shows that the forces of reaction are the longitudinal forces F_{\parallel} , and they are attached to the rails along the current direction in which the vicinity of the accelerated current bridge.

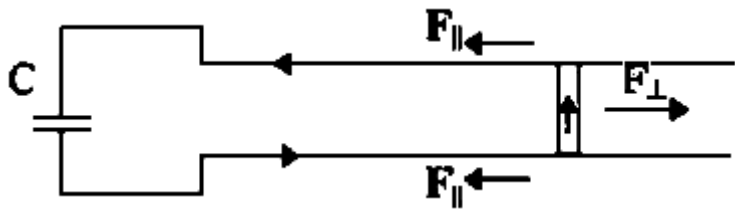


Fig.3

So far not found the correct explanation of the reasons translational and rotational movement of the conductor at constant loop size. Studies show that the devices work force perpendicular magnetic interaction of currents non potential type, the potential energy of the interaction is equal to zero. Reaction forces are longitudinal F_{\parallel} interactions that are applied to the conductors, rails.

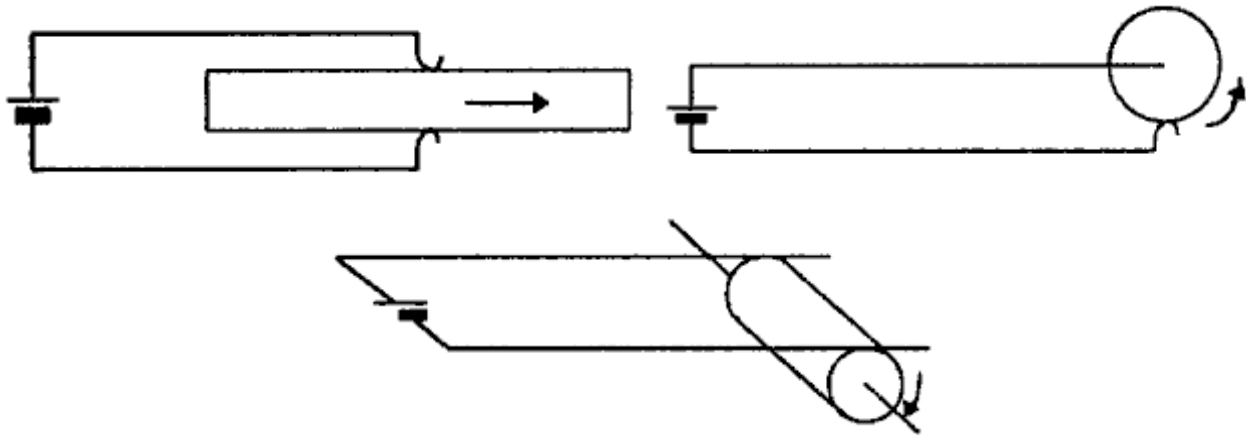


Fig.4

5. Conclusion

Paying tribute to the enormous scientific and technical progress made by mankind in the 20th century, it should be noted that all these achievements have been obtained in the framework of fundamental theoretical century-old plants. To society has evolved and more rapidly, the science necessary to revise such established and successful theory of electrodynamics of Maxwell, Einstein's relativity theory, quantum mechanics, some sections; build a new theory of the physical vacuum (the cosmological theory of ether) and the unified theory of interactions in nature; understand the fundamental concepts such as space, time, energy, mass, space environment. We need a new, revolutionary development paradigm.

Appendix A

Riemann Spaces and Modelling the Globe Electrification Process

As interpreted by Helmholtz-Monastyrsky [11], the theory of analytic functions on the Riemann surface we can present as an issue of physics. We will show that the theory of the stationary two-dimensional ideal incompressible fluid on the surface entirely down to reduces to the theory of analytic functions. Let us consider a stationary fluid flow u on the plane (x, y) . The flow speed at each point has x -component $P(x, y)$ and y -component $Q(x, y)$. Through the cell with sides $\Delta x, \Delta y$ per a time unit the mass of liquid outflows (liquid density is constant and equals to

$$\int_0^{\Delta y} \{P(x + \Delta x, y + h) - P(x, y + h)\} dh + \int_0^{\Delta x} \{Q(x + l, y + \Delta y) - Q(x + l, y)\} dl \quad (A.1)$$

Approximating an arbitrary domain Ω with rectangles and applying the Green's formula, we obtain that the integral (A.1) is equal to :

$$\iint \left(\frac{\partial P}{\partial x} + \frac{\partial Q}{\partial y} \right) dx dy \quad (A.2)$$

Since the fluid is incompressible and nowhere appears and disappears in the Ω domain, it follows that the expression (A.2) is zero. The stronger statement is also reasonable, i.e. flow divergence u is zero:

$$\text{Div } \mathbf{U} = \frac{dP}{dx} + \frac{dQ}{dy} = 0 \quad (\text{A.3})$$

The flow circulation along the curve C is defined as the integral

$$\int Pdx + Qdy.$$

If this integral along any closed curve is zero, then the flow is called irrotational. For any single-bound domain, it follows that statement $Pdx + Qdy$ is a complete differential of the function $u(x, y)$. This function is harmonic.

The function $U(x, y)$ is called the flow speed potential. Helmholtz introduced this concept. Curves $U(x, y) = \text{const}$ are called equipotential lines. A tangent line to the equipotential line forms such an angle α with the axis x , that

$$\text{tg } \alpha = - \frac{dU/dx}{dU/dy}, \text{ if only } \Delta U \neq 0.$$

The flow speed vector makes an angle β with the x axis,

$$\text{tg } \beta = \frac{dU/dy}{dU/dx},$$

i.e. the flow goes orthogonally to equipotential lines in the direction of increasing U function. As we remember, the harmonic function $u(x, y)$ defines the function of

$$f(z) = u + iv$$

where v is a conjugate to the harmonic function u , defined from Cauchy-Riemann equations (A.4).

Essentially, Cauchy solves the following problem, under which conditions for the complex function $f(z)$ the integral $\int f(z) dz$ in a closed loop ℓ is zero. However, he does not speak explicitly of the complex function, but applying pairs of real functions $P(x, y)$ and $Q(x, y)$, gets his main result: the integral $\int f(z) dz$ does not depend on the integration path if such conditions are met:

$$\frac{dP}{dx} = \frac{dQ}{dy}; \frac{dP}{dy} = -dQ/dx \quad (\text{A.4})$$

This condition is a (A.4) - characteristic property of analyticity (holomorphicity) of function of a complex variable. In modern literature, the common name is the Cauchy-Riemann condition. The function $f(z)$ people call the complex potential of the flow.

The tangent line to the curve $v = \text{const}$ makes an angle γ with the x axis and

$$\text{tg } \gamma = - \frac{dv/dx}{dv/dy} = \frac{du/dy}{du/dx} = \text{tg } \beta$$

i.e. the u flow goes along the curve $v = \text{const}$. These curves people call streamlines.

The condition $\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} \neq 0$, equivalent to $f'(z) \neq 0$,

indicates that streamlines are orthogonal to equipotential lines except at points where $f'(z) = 0$

This physical analogy allows us to interpret any properties of analytic functions exceptionally clearly. For example, if the analytic function $f(z)$ has at the point z_0 $f'(z_0) = 0$, then curves $u = \text{const}$ and $v = \text{const}$ do not cross at $z_0 = x_0 + i y_0$ at right angles. Such points are called stationary points, e.g. for the function

$$f(z) = a_0 + a_2 z^2$$

curves $u = \text{const}$ and $v = \text{const}$ intersect at an angle $\pi/4$.

With the same success, we can explore arbitrary features of analytic functions.

Consider the flow with the potential $f(z)$, a derivative $f'(z)$ of which is the rational function, i.e. has only pole specifics $(z-z_0)^{-n}$. Then the function $f(z)$ itself we can represent in the neighbourhood of a specific point in the form of

$$f(z) = A \log(z - z_0) + A_1(z - z_0)^{-1} + \dots + \varphi(z) \quad (\text{A.5})$$

where $\varphi(z)$ - function without specifics

Features of flows defined with the function $f(z)$ are made from specifics of streams made by individual components (A.5).

Let us consider an influence of the logarithmic term. Let us at first assume that A is a real number. Let us choose a circle of the radius r around the point z_0 :

$z = z_0 + re^{i\varphi}$ and assume that $A \log(z - z_0) = u + iv$;
separating the real and imaginary parts, we obtain $A \log r = u$, $A\varphi = v$.

Streamlines $v = \text{const}$ will be radii going from the point z_0 , while equipotential lines $u = \text{const}$ will be circles with a centre in z_0 .

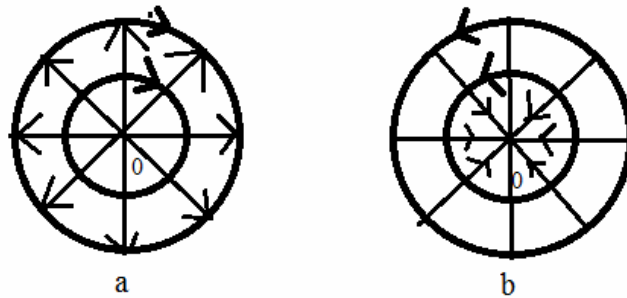


Figure A.1 Divergent flow or drain, source and curls in the near-Earth environment.

Thus, the point z_0 will be either the source (Fig. A.1a) or the fluid outlet (Fig. A.1b), depending on the operator A (the liquid will either outflow, or flow into the point z_0). If A is a purely imaginary value, then we obtain the conjugate stream $A = iB$, $u = -B\varphi$, $v = \log r$. Circles will be streamlines. Such streams are called curls. Direction of motion (clockwise or counter clockwise) depends on the B operator.

We have obtained a great result. All features of the analytic function $f(z)$ on the sphere we can describe in terms of the fluid flow with a defined number of sources, outlets, curls, etc.

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