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# Strange traces of a "strange" radiation

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*Abstract:* **A review of the main works on the study of "strange" radiation is presented – an intense glow that occurs above the explosion chamber during an electric discharge of metal foils in water in it. Photographs of the most diverse structures of tracks-traces of "strange" radiation are presented. Existing hypotheses of particles that leave such traces are outlined: Lochak's magnetic monopole hypothesis, the magneto-toro-electron radiation hypothesis, the tachyon hypothesis, the hypothesis of an intermediate quasi-molecular state of paired electrons, and the "dark" hydrogen hypothesis. Numerical estimates of all discussed hypotheses are given with an explanation of the mechanism of trace formation. The hypothesis of miniature ball lightnings – multiply charged clusters – spherical clusters with a radius of $2.14 \cdot 10^{-6}$ m, having a charge of $4.5 \cdot 10^{-12}$ C is presented. The electric field strength on the surface of such clusters can reach up to $10^{10}$ V/m, which is comparable to the electric field strength in an atom. When such a cluster is introduced into the crystal lattice, a strong polarization of the substance is possible, which can facilitate the conditions for the approach of protons and nuclei of elements. This forces us to consider the possibility of nuclear reactions proceeding through the process of overcoming the potential barrier, which lasts for a time that is many orders of magnitude longer than the nuclear collision time in a conventional nuclear process.**

*Keywords:* **type of traces of "strange" radiation, hypotheses of the structure of "strange" particles, model of a multiply charged cluster, explanation of the mechanism of traces formation**

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**Contents**

## 1. INTRODUCTION

More than a quarter of a century ago, in experiments on the study of the electric explosion of metal foils in water, initiated by wide practical applications, an intense glow was noted that occurs above the explosion chamber, which received the name "strange" radiation accompanying the studied electric discharge in further studies. The registration of this radiation with various photographic materials revealed the presence on photographic materials of many micro- and macroeffects - tracks, traces in the form of lines, and imprints of round objects tens of microns in size [1,2]. Interest in such traces increased after the experiments of Urutskoev L.I. et al., who found that the appearance of traces on the films turned out to be somehow related to a change in the isotopic composition of materials that were in contact with the particles of this "strange" radiation [3,4]. It was found that these particles, flying parallel to the film at a speed of 20–40 m/s, are able to create traces in the photographic emulsion, the formation of which requires an energy of $10^{10}$ eV. They deflected in a magnetic field. Their footprints looked like solid or dotted lines with complex relief. The most interesting was the discovery of "twin tracks", when a large number of absolutely identical tracks were observed on an area of about 1 cm$^2$. Sometimes these traces had chiral symmetry. In subsequent experiments, it was found that these traces appear not only in film emulsions, but also on the surfaces of any objects - on glass, mica, plastic [5,6].

This paper presents a review of the main studies of these tracks and a hypothesis about the object that leaves these strange tracks.

## 2. TYPE OF TRACES OF "STRANGE" PARTICLES

The result of the work of many researchers of this phenomenon was the determination of a fairly complete set of typical tracks of "strange" particles. The search for an explanation of the reasons for the formation of these tracks can become the basis for clarifying the nature of these objects.

It was found that the average speed of the "strange" particles was 20-40 m/s. However, the energy of the particles, determined from the blackening area of the photographic film

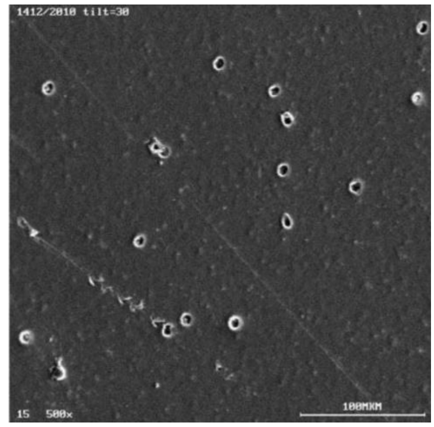


**Fig. 1**. *Type of traces of "strange" particles* [5,6].

under the assumption of Coulomb deceleration of charges, turned out to be greater than 700 MeV. **Fig. 1** shows the cavities left by such particles, and **Fig. 2** – section of such a cavity [5,6]. Let us assume that during the formation of the cavity, the detector material (polycarbonate) was heated to the melting point. The cavity volume is $V_c = 4.3\cdot10^{-20}$ m$^3$, and the mass of the melted material is $5\cdot10^{-17}$ kg. The energy required to heat the material, is $E = 10^{-11}$ J = 75 MeV. The traces were located inside the photographic emulsion layer, which allowed us to conclude that the source of the blackening of the film flew parallel to the emulsion plane. Particles, moving along the surface of solid objects or photographic film, left continuous or intermittent traces on them (**Fig. 3**) [7]. Sometimes the solid line turned into a dotted line (or vice versa) (**Fig. 4**) [5,6]. These traces had a complex shape in the form

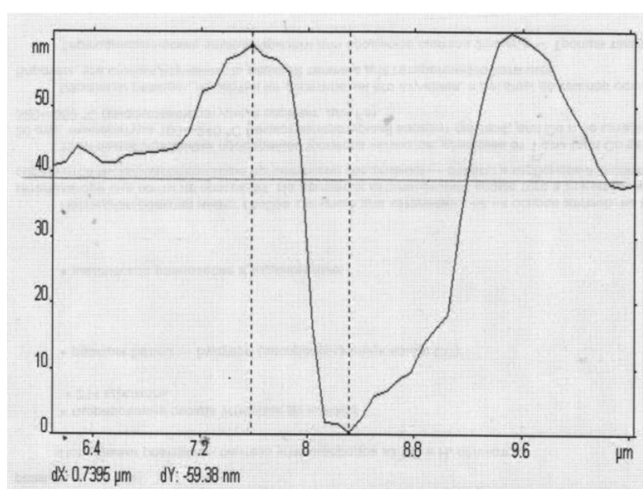


**Fig. 2**. *Section of a cavity formed when a particle hits the surface of a polycarbonate disk* [5,6].

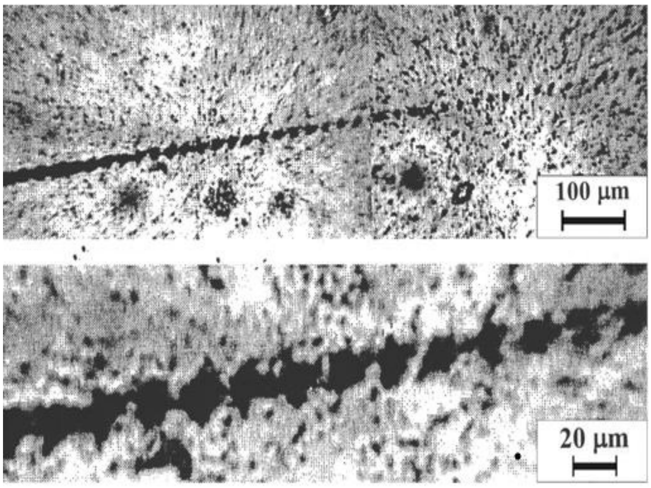


**Fig. 3**. *Discontinuous trace of a "strange" particle on a photographic film* [7].

of a periodically repeating pattern (**Fig. 5**) [8,9]. Both straight and curved trails were observed, and frequently the flying particle abruptly changed its direction of motion (**Fig. 6**) [8,9]. In a magnetic field directed perpendicular to the film surface, traces in the form of parabolas were observed on it (**Fig. 7**) [8,9]. Chaotic movement of particles that left traces was often observed (**Fig. 8**) [8,9]. Along with this, "twin tracks" were found when there were several identical copies of the track in an area of several square centimeters (**Fig. 9**) [5,6,8,9]. When their images were superimposed on each other, they almost completely coincided (**Fig. 10**) [8,9]. Moreover, the identity of the details of the traces was preserved when the image of

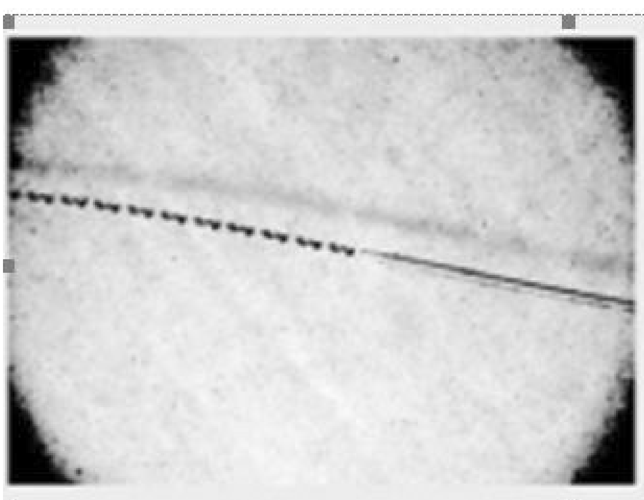

**Fig. 4.** *Transition of a discontinuous trace to a continuous one* [6].

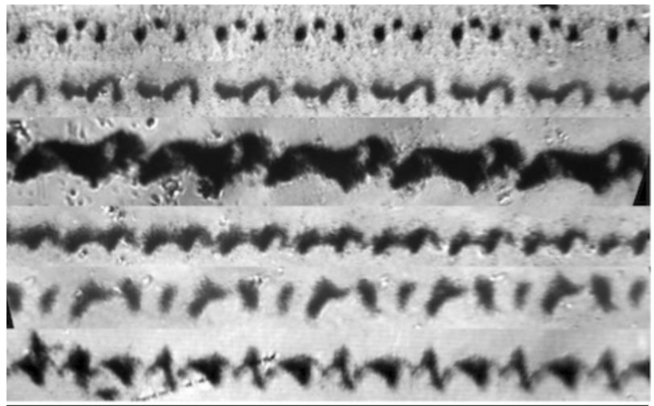

**Fig. 5.** *Types of traces of "strange" particles* [8,9].

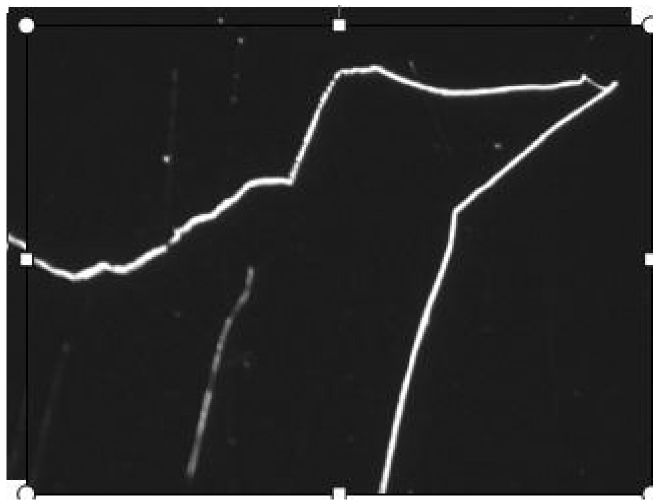

**Fig. 6**. *Trajectories of "strange" particles* [8,9].

the trace was magnified using a microscope (**Fig. 11**) [5,6]. "Chirally"-symmetric tracks were also found, traced by particles moving "in antiphase" (**Fig. 12**) [10,11].

Bogdanovich et al. studied results of action of current pulses of 15 kA with a voltage of 6 kV on a water jet. In these experiments,

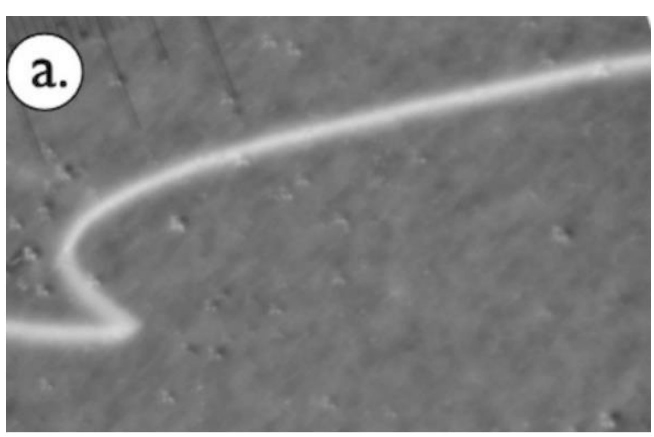


**Fig. 7.** *Trail left by a particle moving in a magnetic field with an induction of 1 T* [9].

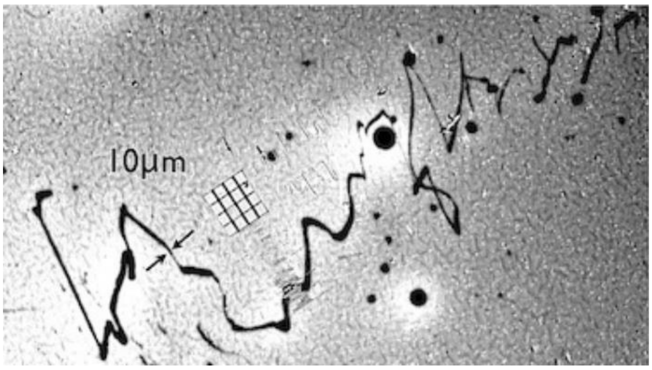


**Fig. 8**. *Chaotic motion of particles* [9].

particles were found that can penetrate into solid materials [12]. In this case, the titanium surface was hardened, and copper crumbled into a fine powder. Sections of copper plates were pierced with channels: sometimes straight, sometimes curved, sometimes helical. The copper plates after exposure to current retained the "activity" for a long time. Video filming in the dark showed that moving luminous spots appeared on the plate for tens of seconds [13].

Since the "strange" traces were discovered by nuclear scientists, most their models were based on the assumption that the "objects" are like elementary particles with high kinetic energy. The following were proposed: Lochak's magnetic monopole hypothesis [3,4,10,11,14-16], the Magneto-Toro-Electric radiation hypothesis [17,18], the tachyon hypothesis [8,9], the hypothesis of the Intermediate Quasimolecular State of paired

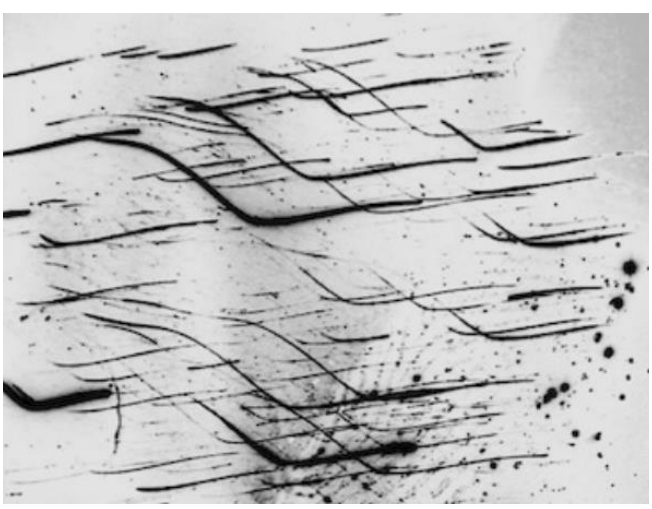

**Fig. 9.** *Traces "twins"* [8,9].

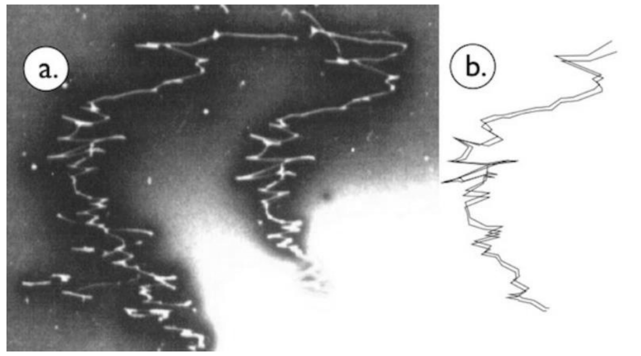


**Fig. 10.** *Comparison of the type of traces of "twins": a) parallel tracks, b) the result of overlaying footprint images* [9].

electrons [19], hypothesis of "dark" hydrogen [20]. We assumed that "strange" traces were left by miniature ball lightnings – "multiply charged clusters" [21-23]. In the following sections, we will present a description of the main ideas of the proposed hypotheses and discuss how they explain the appearance of the various traces of "strange" particles presented above.

## 3. MODELS OF THE ARRANGEMENT OF "STRANGE" PARTICLES

### 3.1. Magnetic monopole

Urutskoev L.I. et al. [3,4] suggested that these "objects" are particles with a magnetic charge – magnetic monopoles. Based on the fact that particle tracks in a magnetic field broadened and took the form of a "comet", they concluded that the particles do not have an electric charge, but they have a magnetic charge. Based on the

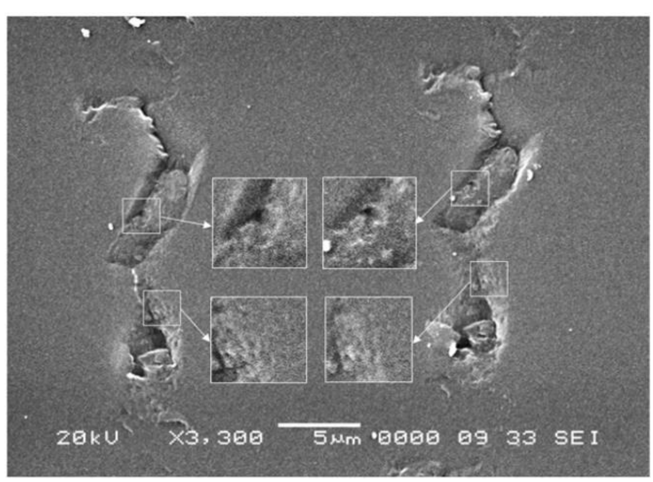


**Fig. 11.** *Enlarged image of two parallel traces* [5,6].

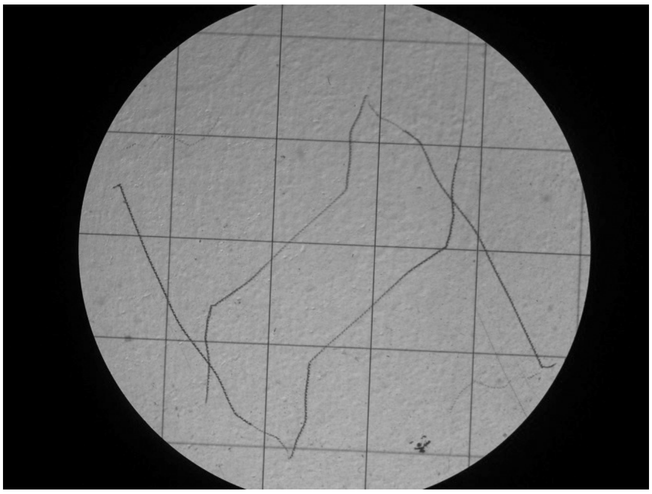

**Fig. 12.** *"Chiral"-symmetric traces left by particles that simultaneously moved in the opposite direction. Square: 1mm × 1mm* [10,11].

results of observations, let's try to compile a list of properties of a magnetically charged particle that leaves traces in a photographic emulsion. This particle has no electric charge and interacts only with a magnetic field. Some of them move in the direction of the magnetic field vector, and some in the opposite direction. According to Ivoilov's observation [10,11], when a particle hits a photographic emulsion of a film, the direction of particle motion changes by 90º – it begins to move in the plane of the photographic emulsion under the action of a magnetic field whose vector is parallel to the plane of the photographic film. At this moment, the magnetic field perpendicular to the plane of the film ceases to act on the particle. Since the change in the direction of the particle's motion occurs almost instantly, it is assumed that the mass of the particle is zero or very small. The role of such particles is best suited to neutrino in an excited magnetic state, a particle theoretically predicted by Lochak [14]. Moving inside a photographic emulsion or other solid material, the particle periodically "emerges" and plunges into it again, melting the tunnel. The kinetic energy of the particle is clearly not enough to form such a tunnel. It does this by initiating exothermic nuclear reactions in the material. Fine details of track formation are not discussed in this case. The physical reason for the sharp change in the properties of neutrinos under the action of a magnetic field is not discussed: the neutrino, which in the ground state freely passes through the thickness of the globe, after excitation begins to slow down in an emulsion layer several microns thick.

In Kyiv, in the Proton-21 laboratory, experimental evidence was obtained of the nuclear transformation of metal under the influence of coherent electron beams [15,16]. Tracks of magnetically charged particles in a multilayer MIS structure (metal-insulator-semiconductor) were studied. It was found that the particles behave like a needle in the shuttle of a sewing machine - they periodically pierce through the aluminum layer with a constant pitch (60 μm), leaving a melted winding hollow tunnel about 1 μm wide. An estimate of the energy release was made in [16]; it turned out to be about $10^6$ GeV/cm. A hypothesis was proposed for the existence of a magnetically charged particle moving through a layer of a paramagnet. The authors drew attention to the fact that simple deceleration of particles is unable to generate such an amount of energy at a practically undecreasing particle velocity in the track. Therefore, they suggested that such particles are capable of initiating magnetic catalysis of energy-favorable nuclear reactions. This happens because magnetic monopoles, moving in matter, very strongly distort the electron shells of atoms which they come across on their way and thereby increase the probability of nuclear tunneling and their fusion. Getting into aluminum (paramagnet) as into a potential well, a magnetically charged particle stimulates nuclear reactions with the release of energy. Melting through the aluminum layer, the particle changes its magnetic properties (it becomes a diamagnet) and, as a result, it tends to "emerge" from this layer. After leaving the aluminum and passing some distance along the surface, the particle is again attracted by the potential well of the paramagnet, and the whole process is repeated. The authors suggest that an external magnetic field is essential for this behavior of particles. An estimate of the speed of the monopoles showed that it is larger than 200 km/s: the particle must fly so fast that the magnetic field does not change during its flight. Indeed, the step on the track remains constant throughout the entire trace and, therefore, the entire track (2 mm long) must be created in a time significantly less than 30-50 ns (this is how long the current pulse lasts).

### 3.2. Magneto-toro-electric radiation

In 2010, Shishkin et al. [17,18] suggested that traces appear as a result of interaction with the film of MTER vortex solitons – Magneto-Toro-Electric radiation. Traces are obtained from the explosive unpacking of solitons, in each of which more than $10^{11}$ electrons and at least $10^{5}$ ions are "packed". During the explosion of such a soliton, a significant part of the electrons acquires kinetic energy of 6-10 keV.

The authors of this hypothesis believe that "the physical vacuum is filled with the smallest material particles with a high penetrating power. This "hidden" matter consists of background "cold" neutrinos (BCN) (axions) coupled to each other through weak topological nontrivial bonds, which form a background neutrino (or axion) condensate. In the near field in the vicinity of the atoms, this neutrino condensate thickens, forming "field" shells of BCN, which, due to the interaction with the electrons of the atom, tending to "escape" from the nucleus, become extremely dense. The nucleus of an atom is a mini-neutron hole that absorbs very "compressed" vacuum background cold neutrinos (BCNs). Due to this mechanism of compaction, the shells made of BCN acquire a very high potential energy. As a result, a "concentrated" neutrino condensate is formed near the nucleus, which is in equilibrium with nuclear forces, and its residual potential, called the long-range Coulomb field of the nucleus, attracts electrons. But at a close distance from the nucleus, a repulsive "short-range" magnetic field begins to act on electrons, the power of which near the nucleus exceeds the Coulomb forces by an order of magnitude. Due to repulsion, an electron with a large acceleration relative to the incident (electron) flies away from the nucleus. As a result of interaction with the magnetic field of the nucleus, the parameters of the electron change in such a way that the shell, consisting of BCN, becomes impenetrable for it. As a result, the electron begins to condense the shell, pushing the BCN from the nucleus to its periphery. At the Bohr radius from the nucleus, the electron loses energy, transferring it through the compacted shell of an atom to the BCN, external to the shell. After the transfer of part of its energy through the shell by the external BCN, the electron is again attracted by the Coulomb forces to the nucleus. The process is repeated. Thus, the nucleus receives energy, which, in turn, the electron transfers through the shell to the "vacuum" BCN. The "shell" of an atom, built by its nucleus, is a soliton, that is, a closed vortex structure of BCN dipoles. Based on this model, the shell has a "torus-like" structure similar to a "bun" with an extremely small central region. In this case, the nucleus of the atom hangs, as it were, on the "absorbing" and "radiating" vortices. When the shell is hit (mechanically, by a strong electric field, thermal or light radiation), with a certain probability, one of the "vortices" can break away from the core for a short time, as a result of which the core "falls out" of the shell. The shell also leaves the electrons that have lost their energy supply from the nucleus. An empty "field shell", being closed on itself, is a soliton. It has a high penetrating power and carries the characteristics of a "mother" nucleus. The shell flying away from the nucleus unpacks into a string-vortex soliton (SVS). The diameter of the head part of the string is 0.98 nm, the length of the SVS can reach 700 m, and a gimlet no longer than 0.1 μm and with a diameter of $d = 0.078420533 \cdot A$ "runs" along the SVS string, where $A$ is the atomic weight of the "mother" nucleus. When interacting with a material object, the gimlet drills a cavity on the surface of the object. When colliding with the shells of atoms, the string-vortex soliton loses energy and eventually collapses into the original torus-like structure. A large number of "empty" shells behave like "neutrino" – cluster radiation, called magneto-toro-electric radiation (MTER). A separate shell is called a magneto-toro-electric cluster (MTEC)."

The hypothesis was stated that "strange" traces "appear during the destruction of MTER clusters that release energy up to $10^{17}$ eV (according to the analysis of traces of strange radiation on $X$-ray detectors). Unlike the massless quantum of ordinary electromagnetic radiation (photon), the new formation (in fact, an empty "field" shell of an atom) - voluminous, but not heavy - carries a huge amount of energy. It occupies an intermediate place between corpuscular radiation and gamma radiation. The collapse of the cluster into separate vortices is possible – this is recorded on photodetectors in the form of black drops. On the basis of experiments, it was assumed that the diameter ($d$) of the microcrater is proportional to the atomic mass of the atom ($A$) that generated the corresponding MTER cluster, $d = k \cdot A$, where $k = 0.078$ ($d$ is in μm). Starting from a certain atomic number, the MTER cluster is not able to "gnaw out" a large crater, but is able to ionize a zone corresponding to the cluster diameter. Hence the conclusion follows: the cluster, passing through the material, acquires the properties of this material."

### 3.3. Tachyons

Fredericks [8,9] used sensitized photographic film to register "strange" marks that appear when fingers are applied to it. The appearance of these traces was the same as that of traces obtained by other methods. Solid lines, traces in the form of a dotted line of repeating figures, paired traces, traces with sharp breaks were observed. In the field of a permanent magnet applied to the film, traces in the form of parabolas were found (Fig. 7). Processing such traces, and assuming that they were left by particles with a magnetic charge, Fredericks found the average value of the particle moment $p = 20$ eV/$c$ ($c$ is the speed of light). The kinetic energy of the particles was determined by taking into account the energy losses due to the formation of silver grains in the photographic emulsion. It was believed that for the formation of one grain it is necessary to expend energy of 750 eV. The kinetic energy of the particles turned out to be $10^8$-$10^9$ eV. The resulting figures were plotted on a plot of kinetic energy versus momentum. For particles with a momentum of 20 eV/$c$, which speed is less than or equal to the speed of light, the kinetic energy cannot be greater than 1 eV. The found values of kinetic energy exceeded this figure by several orders of magnitude. Such a ratio of energy and momentum values can only belong to tachyons - particles moving faster than light. Tachyons have an imaginary mass. For them, unlike ordinary particles, the kinetic energy increases with decreasing momentum.

### 3.4. Compact pairs of electrons

Kashchenko [19] believes that the repulsive force of the nuclei of chemical elements can be reduced by placing a negative charge in the space between them. "Such a charge can be created by two electrons located at a distance of 1 fm = $10^{-15}$ m from each other ($(ee)$-pair). Such electrons are bound by a force that exceeds the force of the Coulomb repulsion of charges. According to the uncertainty relation, the minimum kinetic energy of an electron pair should be about $10^3$ MeV. This is three orders of magnitude higher than the rest energy of an electron pair. The presence of such energy determines the relativistic nature of the motion of electrons in a bound pair. The natural form of motion of a bound pair is rotation around a common center of mass. Let us choose the size of the pair $d$ equal to the diameter of the circular orbit and take into account that on the scale $d \sim 1$ fm the stability of the pair is ensured by the contact interaction. An orbit with a small radius $r = d/2 = 0.5$ fm is possible at a speed close to the speed of light, $v \rightarrow c = 3 \cdot 10^8$ m/s. In this case, the minimum value of rotational motion energy of the pair is $E^*_{min} = 2mc^2$ (where $m$ is the relativistic mass of the electron). The value of $m$ can be found based on the minimum value of the angular momentum of electrons $L = \hbar = h/2\pi = 1.054 \cdot 10^{-34}$ J·s. Angular moment $L = 2mvr = 2mcr = \hbar$. Hence $m = m_e[(1 - (v/c)^2]^{-1/2} = \hbar/2cr$. Energy of relativistic rotation of a pair of electrons is $E^*_{min} = \hbar c/r$. Substituting $L = \hbar$, $r = 0.5$ fm and $v = c$, we find $E^*_{min} = 375$ MeV." The author assumes the possibility of the existence of "*IQS* – an intermediate quasi-molecular state in the form of an annular electron current of radius *R*, flowing in the plane of the ring, orthogonal to a line connecting a pair of nuclei with equal charges. In the annular orbit, there are electrons in the form of bound pairs with opposite spins. The electrons are attracted to positively charged nuclei. The component of the force in the plane of the orbit is the centripetal force that holds the bound pairs in orbit. The nuclei are affected by the force of attraction in the direction of the electric field created by the electrons and the force of mutual repulsion. *IQS* model leads to the conclusion about the possibility of forming an ensemble of stable catalysts for low-temperature nuclear reactions under the conditions of electron flows."

"The synthesis of atoms with increasing charge and mass numbers corresponds to catalyzing ring orbits with an increasing number of (*ee*)-pairs. Ring orbits are capable of strongly polarizing the electron shells of atoms between which they are localized, reducing the shielding effect of atomic shells on the Coulomb field of nuclei. As a result, the radius of the catalyzed orbit rapidly decreases, which corresponds to an increase in the value of the effective negative charge at a point on the line connecting the centers of the nuclei. These (*ee*)-pairs remain stable if the energy of the quantum of action on them is small compared to the energy of the pair. This means that neither thermal vibrations of the lattice, nor photons, nor electron beams should destroy pairs."

According to the author of the *IQS* idea, the formation of traces on the surface of a detector (film, DVD, etc.) occurs as follows. "There is an electrically neutral complex consisting of a catalytic ring of (*ee*)-pairs and an ionic component of a pair of approached nuclei (or already merged nuclei) with distorted and incompletely filled electron shells (called a *KK*-activator). Upon collision with the detector, the complex decomposes into a positively charged ionic component, which remains in the detector material, and a free *KK*-activator, which rapidly expands due to the repulsion of (*ee*)-pairs. The *KK*-activator contains rotating (*ee*)-pairs and has a mechanical moment *L* and a magnetic moment *M*. The propagation of *KK*-activators is responsible for the formation of tracks. 1) If the plane of the *KK*-activator is parallel to the plane of the detector, and the translational velocity of the center of inertia of the *KK*-activator is perpendicular to the plane of the detector, a trace appears in the form of a crater. 2) If the plane of the *KK*-activator is orthogonal to the plane of the detector, and the translational velocity of the center of inertia of the *KK*-activator is parallel to the plane of the detector, a wide straight line appears. A trace with discrete periodic point illumination of the detector surface is constructed on the basis of matching the translational and rotational motion of (*ee*)-pairs along helical trajectories. A track is a discrete set of intersection points of (*ee*)-pair trajectories with the detector surface. Smooth tracks are described by the movement of a ring with a plane sliding over the detector surface. The width of the track is equal to the diameter of the ring. The reason for the deviation of the shape of smooth lines from a straight line is due to ions in the detector material, which bend the trajectories of *KK*-activators."

The model proposed by the author for catalysis of the fusion of nuclei by rings of rotating pairs of electrons requires further analysis. It is unclear how the ring plane is localized exactly in the middle between the merging nuclei. In the absence of a mechanism that maintains the equality of distances between the ring and two nuclei, symmetry breaking and "attraction" of the ring to one of the nuclei is inevitable. It is also unclear how a ring of (*ee*)-pairs which has collided with the detector and lost its "positively charged ionic component" (that is, the nuclei that the ring was "working" to bring together) can exist. But they were these nuclei that created the centripetal force which kept the (*ee*)-pairs in orbit. With the disappearance of this force, the electrons will fly away tangentially to the orbit.

### 3.5. Dark hydrogen

The idea of the existence of pairs of magnetically bounded electrons located at a distance of several femtometers (1 fm = $10^{-15}$ m) was used by Baranov and Zatelepin [20] in developing the concept of "dark hydrogen". Hydrogen is called "dark" because its spectrum lies in the *X*-ray region, and it cannot be detected by absorbing light in the optical range. According to this hypothesis, the existence of a compact atom with a nucleus of a pair of closely bounded electrons is possible. These electrons rotate in an orbit with a diameter of $2R = 62\cdot10^{-15}$ m. Around them a pair of protons rotates in an orbit with diameter of $2R_p = 65\cdot10^{-15}$ m. In "dark hydrogen", the electron attraction force is determined by several types of interaction. These are: *SS* – spin-spin interaction between intrinsic magnetic moments, *SO* – spin-orbit interaction between intrinsic magnetic moment and orbital moment of two electrons, *OO* – interaction of orbital magnetic moments of electrons, *K* – Coulomb repulsion of electrons. Interaction with protons can be neglected, since they are located in outer orbits, which dampens their electric fields, and the intrinsic magnetic moments of protons are three orders of magnitude smaller than those of electrons. The main contribution to the total *SS* + *SO* + *OO* + *K* – interaction comes from the *SO*-interaction. Accounting for *SS-OO-K* gives a correction of 50%. The speed of electrons is close to the speed of light *c*. The portable acceleration in the rotating system generates the centrifugal force $F_c = \gamma m_0 c^2/R$. (Here $\gamma = (1 - v^2/c^2)^{-1/2}$, $m_0 = 9.1\cdot10^{-31}$ kg, $R$ is radius of the orbital motion of electrons). Force $F_{SO} = 6\mu p^2/4\pi R^4$, $\mu = 4\pi\cdot10^{-7}$ H/m is the magnetic constant, $p = 0.927\cdot10^{-23}$ J/T is the Bohr magneton. Although the electron becomes $\gamma$ times heavier, which reduces its magnetic moment, there is a $\gamma$ times concentration of magnetic and electrical forces in the direction perpendicular to the electron's motion. These processes cancel each other out. We set $F_C = F_{SO}$. Electron orbit quantization rule: $\gamma m_0 cR = \hbar$. Here the unknowns are $\gamma$ and $R$. Substituting constants, we find $R = 4.3\cdot10^{-14}$ m, $\gamma = 8.8$. Using these values, we get $F_C = F_{SO} = 16.8$ N and $\gamma m_0 = 8\cdot10^{-30}$ kg.

Dark hydrogen, when interacting with ordinary matter ("Bohr" atom), participates in three processes: 1) Oxidation of the "Bohr" atom (that is, the removal of an electron from it). 2) Creation of a molecule consisting of dark hydrogen and a "Bohr" atom. Creation of huge structures from millions of such joint molecules. 3) Transmutation of the nuclei of "Bohr" atoms. The first two processes proceed with the rearrangement of the electronic system of the "Bohr" atoms, that is, these are chemical processes. The third process is the change in the nucleus of the "Bohr" atom. This is not a chemical, but a nuclear process. Since there is no electric field outside the "atom" of dark hydrogen, a free electron or an ordinary atom can approach the relativistic electron pair at a distance of $10^{-13}$ m. Here the magnetic forces are greater than the Colombian, and the electron pair attracts a new electron. A new electron will "sit" in the orbit of an electron pair with a quantum number increased by one, which will increase the orbital magnetic moment of dark hydrogen. As a result, dark hydrogen will again be ready to accept the next electron, and its oxidizing properties increase, something like a chain reaction takes place. Track formation is a chemical process of oxidative destruction of the "Bohr" substance. After oxidation, the "Bohr"substance acquires a positive charge. Dark hydrogen and the ion of the "Bohr" substance create a molecule due to the Coulomb interaction. The process of formation of a molecule, like the oxidation process, is exothermic with energy of several keV. The process of formation a molecule of the "Bohr"substance and dark hydrogen formation does not end there, since the formed molecule is able to continue oxidation due to magnetic forces. With each act of molecule enlargement, energy is released due to interaction with a new "Bohr" atom. During the oxidation reaction of dark hydrogen, not only the magnetic momentum increases, but also the mechanical momentum. Due to its small size, dark hydrogen has the ability to approach the nucleus of the "Bohr" atom at nuclear distances, this creates conditions for the tunneling of dark hydrogen protons into the "Bohr" nucleus (and vice versa, from the "Bohr" nucleus to the dark hydrogen proton), which changes the number of the nucleus. It is possible that dark hydrogen atoms can interact with each other. In this case a structure, resembling helium-4, is created.

To explain the appearance of mirror tracks, we can assume the possibility of the formation of associations of two dark hydrogen atoms located at a great distance from each other. In this case, something like a Cooper pair is obtained, but not from two electrons in the lattice, but from two dark hydrogen atoms on the surface of the detector.

## 4. MULTIPLE CHARGED CLUSTERS

We assumed that "strange" particles are multiple charged clusters, the structure of which is similar to the structure of ball lightning [21-23]. According to the electrodynamic model [24-33], ball lightning consists of a unipolar charged core and a dielectric shell (for example, water). In the electric field created by the charge of the core, the shell material is polarized and a force arises that make the shell to move towards the center of the sphere. The magnitude of this force is proportional to the first power of the charge of the nucleus $F_a \sim Q$. The force that stretches the shell due to the Coulomb repulsion of charges is $F_r \sim Q^2$. In the range of charge values from $Q = 0$ to $Q_{max}$, the force $F_a$ turns out to be greater than $F_r$, and at $F_a = F_r$, the existence of a stable structure is possible. Due to the continuous charge leakage, the lifetime of such a structure is limited. When a multiple charged cluster approaches the conductor, the charge flows down towards the conductor. The mechanical impulse acquired by the carriers of the stacked charge when they move in the field of the main charge is transferred to the initial multiple charged cluster. This causes it to push off from the conductor. After some time, the multiple charged cluster will begin to approach the conductor, and the process of transferring part of the charge to it will be repeated. In the presence of an electric field whose vector is parallel to the plane of the conductor, a multiple charged cluster will move along the surface of the conductor (or photographic film) and leave a chain of discontinuous traces on it. If the velocity of the cluster along the surface is low, the points may merge into a solid line.

### 4.1. Forces acting in charged clusters

Thus, it can be assumed that "strange" particles are multiple charged clusters, similar to microscopic ball lightnings, which are a certain amount of ions located inside a shell of water molecules. In the electric field of the charge located inside the shell, the dipole water molecules are oriented towards the center of the sphere, and a force arises that compresses the shell. At the same time, the molecules in the shell tend to push their "neighbors" out of it, which leads to a decrease in the compression force of the shell. The calculation showed that the force $F_p$ of expulsion of water molecules from the shell of such a cluster is described by the formula [21,22]:

$$F_p = 2.69 \cdot 10^{-9} (R - R_0)^{-1.3} (H), \quad (1)$$

where $R$ (inner radius of the sphere) is in angstroms ($10^{-10}$ m), and $R_0 = -4.5$. Let us assume that there is one elementary charge inside the shell. Let us compare the force $F_p$ with the force $F_a$ of attraction of a water molecule (a dipole with moment $p_w = 6.327 \cdot 10^{-30}$ C·m) to the central charge $q = 1.6\cdot10^{-19}$ C. $F_a = p_w\cdot\mathrm{grad}E$, where $E$ is the strength of the electric field created by the charge $q$:

$$F_a = p_w grad(q/4\pi\varepsilon_0 R^2) = -2p_w q/4\pi\varepsilon_0 R^3. \quad (2)$$

The force $F_a$ is directed towards the center of the cluster and falls more steeply with increasing $R$ than $F_p(R)$. At $R = 4\cdot10^{-10}$ m $F_a = 2.84\cdot10^{-10}$ N, which is 1.65 times greater than $F_p$, but already at $R = 6\cdot10^{-10}$ m $F_a = 0.843\cdot10^{-10}$ N, which is less than $F_p$ ($1.27\cdot10^{-10}$ N).

Another reason that hinders the formation of an ordered cluster structure due to the action of the electric field of the ion is the thermal motion of molecules. According to the Langevin formula [34], the noticeable effect of the electric field on the dipole orientation with the momentum $p_w$ stops at the strength $E_{min} = 3k_B T/p_w$ (here $k_B = 1.38\cdot10^{-23}$ J/K is the Boltzmann constant, and $T$ is the absolute temperature). At $p_w = 6.327\cdot10^{-30}$ C·m and $T = 300$ K, the value of $E_{min} = 2\cdot10^9$ V/m. The electric field of the ion takes this value at a distance $R = 8\cdot10^{-10}$ m, that is, at the location of the second layer of water molecules in the cluster. Thus, we come to the conclusion that a cluster with $R = 4\cdot10^{-10}$ m can be formed in the electric field of a unit charge, however, further growth of the cluster, apparently, will occur without significant participation of the electric field of the central charge. This explains the conclusion obtained by calculation that when a water cluster grows in an electric field of an ion, the latter is always "pushed out" to the periphery of the cluster [35,36].

Let us discuss whether it is possible to keep a large number of ions inside the water cluster shell. Hope for the realization of this possibility is given by the fact that the force of attraction of a water molecule to the charge $F_a$ can be increased due to an increase in the total charge of ions $Q$, and the magnitude of the force $F_p$ does not depend on the charge (although the magnitude of the charge must be greater than a certain critical value determined by the requirement of complete polarization of molecules in the shell). To accommodate a large number of ions, the size of the inner cavity of the cluster must be increased in comparison with the case of a singly charged cluster (the radius $R$ must be increased). This should simultaneously reduce the magnitude of the force $F_p$.

Let us consider what a cluster with a total ion charge $Q_1 = 4.5\cdot10^{-12}$ C can look like. For example, $n = 2.8\cdot10^7$ hydroxyl $(OH)^-$ ions have such a charge. Let the ion diameter be equal to $4\cdot10^{-10}$ m, the area occupied by one ion, $s = 16\cdot10^{-20}$ m$^2$, and the ions are placed on the surface of a sphere of radius $r$. The surface area of the sphere $S = 4\pi r^2 = s\cdot n$, hence $r = (s\cdot n/4\pi)^{1/2} = 6\cdot10^{-7}$ m. The electric field created by the charge $Q = 4.5\cdot10^{-12}$ C at a distance $r = 6\cdot10^{-7}$ m, $E = Q/4\pi\varepsilon_0 r^2 = 10^{11}$ V/m, which is greater than $E_{min} = 2\cdot10^9$ V/m determined by the Langevin criterion. This means that the water molecules in the shell are completely polarized. The ions stretch the shell with the force $F_Q = Q^2/8\pi\varepsilon_0 r^2 = 2.53\cdot10^{-1}$ N. The water molecule is attracted to the charge placed in the center of the sphere with the force $F_a = p_w Q/2\pi\varepsilon_0 r^3 = 2.37\cdot10^{-12}$ N. At the same time, it is pushed out of the shell by neighboring molecules with the force $F_p = 2.69\cdot10^{-9}\cdot(6004.5)^{-1.3} = 3.3\cdot10^{-14}$ N. The resulting force acting on the molecule is $F_t = F_a - F_p = 2.337\cdot10^{-12}$ N. On the surface of the shell with radius $r = 6\cdot10^{-7}$ m can fit $n_w = 2.82\cdot10^7$ water molecules (we consider a molecule as a ball with a diameter of $4\cdot10^{-10}$ m). The shell compression force by one layer of water molecules $F_\Sigma = F_t\cdot n_w = 6.59\cdot10^{-5}$ N. This force is 3840 times less than the force $F_Q$. The force $F_Q$ can be compensated if the number of layers of water molecules in the shell is 3840, and its thickness is $a = 4\cdot10^{-10}\times3840 = 1.54\cdot10^{-6}$ m. As a result, we got a cluster with a cavity radius $r = 6\cdot10^{-7}$ m and outer radius $R = r + a = 2.14\cdot10^{-6}$ m. The mass of the cluster $M_1$ is equal to the mass of the shell. Its volume is $V_{sh} = 4\pi[(r + a)^3 - r^3]/3 = 4\cdot10^{-17}$ m$^3$, and its mass is $M_{sh} = \varrho_w V_{sh} = 4\cdot10^{-14}$ kg (here $\varrho_w = 10^3$ kg/m$^3$ is the density of water). Carrying out similar calculations for a cluster with a cavity radius $r_2 = 6\cdot10^{-6}$ m, inside which there are ions with a total charge $Q_2 = 4.5\cdot10^{-11}$ C, we find its radius $R_2 = 3.75\cdot10^{-6}$ m and mass $M_2 = 8.62\cdot10^{-13}$ kg.

Fig. 2 shows a section of a "pit" that appeared as a result of the action of a "strange" particle on the surface of a polycarbonate disk [5,6]. Let us assume that this pit was formed due to the melting of the material and its ejection to the edges of the pit. The well depth is $h_p$ = 38 nm, and the average radius is $r_p$ = 0.6 μm. The volume of ejected material is $v_p = \pi r_p^2 h_p = 4.3\cdot10^{-20}$ m$^3$, and its mass $m_{pc} = \varrho_{pc}\cdot v_p = 5\cdot10^{-17}$ kg (here $\varrho_{pc} = 1.2\cdot10^3$ kg/m$^3$ is density of polycarbonate). Heat capacity of polycarbonate $C_{pc} = 1.21\cdot10^3$ J/kg·K. To heat $5\cdot10^{-17}$ kg of material to a softening temperature of 220°C, energy $E = 1.2\cdot10^{-11}$ J = 75 MeV is required. Let us assume that the same amount of energy is spent on the formation of a hole in the dotted track left by the "strange" particle on the surface of a polycarbonate disk. The number of these holes can reach up to 1000, therefore, the energy required for their formation can be $10^{-8}$ J = $6\cdot10^{10}$ eV.

Let us assume that this energy is drawn from the energy of the electric field of a multiple charged cluster. Consider a cluster in the form of a sphere with a radius of $r = 6\cdot10^{-7}$ m, completely covered with ions with a total charge $Q = 4.5\cdot10^{-12}$ *C*. The expansion of ions is prevented by a spherical shell of water molecules. This cluster can be considered as a spherical capacitor with an inner electrode with a radius $r = 6\cdot10^{-7}$ m and an outer electrode with $R = \infty$. The electric capacitance of such a capacitor is $C = 4\pi\varepsilon_0 r$, and the energy of the electric field is $W_e = Q^2/2C = 1.57\cdot10^{-7}$J = $10^{12}$ eV. This energy is quite sufficient for the formation of tracks on different materials.

### 4.2. The process of traces formation on photographic film

Let us consider a possible scenario for the formation of traces on photographic films. Let us assume that a cluster with radius $R_1 = 2.14\cdot10^{-6}$ m, with charge $Q_1 = 4.5\cdot10^{-12}$ C and mass $M_1 = 4\cdot10^{-14}$ kg moves towards the film. When the edge of the cluster is at a distance $L = 15\cdot10^{-6}$ m from the film surface, a small cluster with charge $q_1 = 4.5\cdot10^{-14}$ C and mass $m_1 = 4\cdot10^{-16}$ kg separates from it and starts moving towards the film. This cluster moves under the action of the force $F_{q1} = Q_1q_1/4\pi\varepsilon_0(R_1 + x)^2$, where $x$ changes from 0 to $L$. Having passed the path $L$, the small cluster will acquire the energy $W_{q1} = (Q_1q_1/4\pi\varepsilon_0)\cdot[1/R_1 - 1/(R_1 + L)] = 7.447\cdot10^{-10}$ J = $4.65\cdot10^9$ eV. Its speed $v_1 = (2W_{q1}/m_1)^{1/2} = 1.929\cdot10^3$ m/s, and moment of momentum is $m_1\cdot v_1 = 7.7184\cdot10^{-13}$ kg·m/s. A large cluster acquires the same momentum, it starts moving upwards from the film with a velocity $V_1 = (m_1\cdot v_1)/M_1 = 19.296$ m/s and acquires an energy $W_{Q1} = M_1V_1^2/2 = 7.447\cdot10^{-12}$ J. Calculation for an ion with $R_2 = 7.5\cdot10^{-6}$ m, $Q_2 = 4.5\cdot10^{-11}$ C, $M_2 = 8.62\cdot10^{-13}$ kg, from which a small cluster with a charge $q_2 = 4.5\cdot10^{-13}$ C and mass $m_2 = 8.62\cdot10^{-15}$ kg separates at a height $L = 15\cdot10^{-6}$ m, leads to the following results: $W_{q2} = 1.619\cdot10^{-8}$ J = $1.012\cdot10^{11}$ eV, $v_2 = 1.938\cdot10^3$ m/s, $V_2 = 19.379$ m/s, $W_{Q2} = 1.619\cdot10^{-10}$ J.

A cluster with a charge $Q_1 = 4.5\cdot10^{-12}$ C creates an electric field $E_1 = Q_1/4\pi\varepsilon_0L^2 = 1.8\cdot10^8$ V/m at a distance $L = 15\cdot10^{-6}$ m, and a cluster with a charge $Q_2 = 4.5\cdot10^{-11}$ C at the same distance creates a field $E_2 = 1.8\cdot10^9$ V/m. Such fields are comparable in magnitude with the intensity $E_{min} = 2\cdot10^9$ V/m, determined by the Langevin criterion. Therefore, we can assume that polarization of the film material will occur, and a force will act on the cluster, which will slow down its movement. When the work of this force becomes equal to the kinetic energy of the cluster, it will stop and begin to "fall" onto the film. The force acting on the cluster from the side of the polarized film is $F_d = P_1Q_1/2\pi\varepsilon_0R^3$ (see formula 2), where $P_1$ is dipole moment of the polarized section of the film, and $R$ is the distance between the charge center and the film. The work of this force on the section of the trajectory $dR$ is equal to $dA = F_d dR$, and the total work until the cluster stops is:

$$A = \int_{R_0}^{R} F_a dR = \\ = -\frac{P_1Q_1}{4\pi\varepsilon_0}\cdot\frac{1}{R^2}\Big|_{R_0}^{R} = \frac{P_1Q_1}{4\pi\varepsilon_0}\left[\frac{1}{R_0^2} - \frac{1}{(R_0+\Delta R)^2}\right]. \quad (3)$$

Here $R_0$ is the height of the cluster above the film surface at the moment it begins to move upward, and $R = (R_0 + \varDelta R)$ is the height it will reach. In this problem, the unknown parameter is the value of the film dipole moment $P_1$ induced by the charge $Q_1$. To estimate its value, we assume that the cluster, starting from a height $R_0 = L = 15 \cdot 10^{-6}$ m, could rise to a height $(R_0 + \varDelta R) = 25 \cdot 10^{-6}$ m. Equating the kinetic energy of the cluster with the charge $Q_1 = 4.5 \cdot 10^{-12}$ C ($W_{Q1} = 7.447 \cdot 10^{-1}2$ J) in work $A$, from formula (3) we find $P_1 = 7.3 \cdot 10^{-21}$ C·m. The specific polarization of the medium $P_V$ (C·m/m$^3$) is related to the field strength $E$ by the relation $P_V = \varepsilon_0(\varsigma - 1)$E [34]. Assuming for the film material the value of dielectric constant $\varsigma = 2.6$, at the field strength $E_{min} = 2 \cdot 10^9$ V/m we obtain $P_V = 2.83 \cdot 10^{-2}$ C·m/m$^3$. The dipole moment $P_1 = 7.3 \cdot 10^{-21}$ C·m can be created by a grain with a volume $V_f = P_1/P_V = 0.26 \cdot 10^{-18}$ m$^3$ sized 0.64 μm.

**Fig. 13** shows the result of numerical calculation of the change in the cluster height above the level of separation of a small cluster from it $L = 15 \cdot 10^{-6}$ m. The parameters of the cluster are accepted as $Q_1 = 4.5 \cdot 10^{-12}$ C, $M_1 = 4 \cdot 10^{-14}$ kg and diameter $D_1 = 4.28 \cdot 10^{-6}$ m. It is believed that for a separated small cluster, the charge $q_1 = Q_1/100 = 4.5 \cdot 10^{-14}$ C and the mass $m_1 = M_1/100 = 4 \cdot 10^{-16}$ kg are one percent of the initial values of the charge and masses of the main cluster, and these quantities remain unchanged despite the fact that $Q_1$ and $M_1$ decrease with each "jump". For the dipole moment of the polarized film, the value $P_1(t) = Q_1(t) \times 2 \cdot 10^{-8}$ C·m was taken (the decrease in the charge $Q_1$ with each act of separating a small cluster was taken into account). It is assumed that at $t = 0$ the lower edge of the cluster was at a distance $1.5 \cdot 10^{-6}$ m from the emission height of a small cluster and its velocity was zero. It can be seen that after five "jumps", the system switches to the mode of alternating short (0.5 μs in duration) and long (1.4 μs in duration) "jumps" with an average period of 1.86 μs. The height of the "jump" and the duration of the "flight" grow with time (see Fig. 13). This can be explained by a gradual decrease in the charge of the large cluster and the magnitude of the induced dipole momentum of the film. The reason for the alternation of long (high) and short (low) "jumps" is as follows. When a cluster "falls" from a great height, it acquires a greater speed. To stop the cluster and change the direction of its velocity vector to the opposite, it is necessary to spend a significant part of the momentum acquired by it during the emission of a small cluster. As a result, the cluster begins to move upwards at a low speed and, accordingly, "falls" also at a low speed. The next pulse of interaction between the charges of a large and small cluster "tosses" it to a greater height. If a charged cluster has a velocity component directed along the plane of the film, it will leave a chain of double spots on it, separated by large intervals. These spots can merge due to charge spreading and form complex traces of the type shown in Fig. 5.

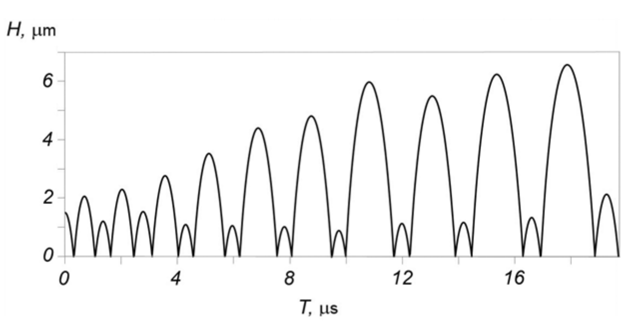


**Fig. 13**. *Change in the rise height of the charged cluster above the level* L = *15 μm, at which a small charge was separated from it (calculation result)* [21-23].

### 4.3. Action on a cluster of a magnetic field

Fredericks [8,9] observed the curvature of particle tracks on photographic film when he applied a permanent magnet to it (Fig. 7). The magnetic field was perpendicular to the film surface. Instead of the expected movement of magnetic monopoles along the magnetic field lines (that is, perpendicular to the plane of the film), they moved perpendicular to the lines of force parallel to the film surface, leaving traces in the form of parabolas on it. Let us discuss how this behavior of "strange" particles can be explained.

Let us assume that a multiple charged cluster with charge $Q$ and mass $m$ flies with velocity $V$ into the region of action of a constant magnetic field with induction $B$. The value of this velocity is determined by the equality of the force of the external electric field $E_x$ acting on the charge and the friction force of the cluster on air. Let the velocity $V$ be perpendicular to the induction vector $B$. In this case, the force $F_m = QVB$ will act on the charge perpendicular to the velocity vectors $V$ and induction $B$. Due to the low speed of the lateral displacement, let us assume that the friction force of the particle on the air is small and can be neglected. The particle's lateral displacement acceleration due to this force is $a = F_m/m$, and the displacement in time $t$ is $S = at^2/2 = (QVB/2m)\cdot t^2$. Let's take $Q = 4.5\cdot10^{-12}$ C, $V = 5$ m/s, $m = 4\cdot10^{-14}$ kg. The time of passage of the track length $L = 10^{-2}$ m is equal to $t = 2\cdot10^{-3}$ s. During this time, the track deviated to a distance $S = 10^{-3}$ m. Substituting numerical values into the expression for $S$, we find $B = 2mS/QVt^2 = 0.89$ T. The line drawn during the passage of a particle of distance $L$, accompanied by a lateral displacement $S$, has the shape of a parabola.

### 4.4. Magnetic momentum of a rotating cluster

The momentum of inertia of a ball of radius $R$ is $I_b = (2/5)mR^2$. The mass of the ball is $m = (4/3)\pi R^3\varrho$ ($\varrho$ is the density of the material of the ball), hence the momentum of inertia of the solid ball is $I = (8/15)\pi\varrho R^5$. For a cluster in the form of a hollow sphere with outer radius $R = 2.12\cdot10^{-6}$ m and inner radius $R_{in} = 0.6\cdot10^{-6}$ m momentum of inertia $I = (8/15)\pi\varrho(R^5 - R_{in}^5) = 71.58\cdot10^{-27}$ kg·m$^2$ (we took $\varrho = 10^3$ kg/m$^3$ equal to the density of water). Let's replace the cluster with a weight $m_e$ rotating on a circle of radius $R$. For it $I = m_eR^2$ and $m_e = 15.927\cdot10^{-15}$ kg. The momentum of rotation of the load is equal to $l = m_evR$ ($v$ is the speed of the movement of the load). For a cluster $l = 3.376\cdot10^{-20}v$. If the load rotates with a frequency of $n_r$ revolutions per second, then its speed is $v = 2\pi Rn_r$ m/s and $l = 4.49\cdot10^{-25}\cdot n_r$ kg·m$^2$/s. Let us estimate the cluster rotation frequency. Let us take the kinetic energy of the load $m_ev^2/2$ equal to $k_BT = 1.38\cdot10^{-23}$ J/K×300 K $= 4.14\cdot10^{-21}$ J. With $m_e = 15.927\cdot10^{-15}$ kg the velocity $v = 0.72\cdot10^{-3}$ m/s and $n_r = v/2\pi R = 54$ s$^{-1}$.

When the cluster rotates around an axis passing through its center, its inner sphere with a radius $R_{in} = 0.6\cdot10^{-6}$ m also rotates, on which there are ions with a total charge $Q = 2\cdot10^{-12}$ C. If the charges are uniformly distributed over the sphere, their surface density is $\sigma = Q/4\pi R_{in}^2 = 0.44$ C/m$^2$. The rotation of the charge is equivalent to the formation of a ring with current, which creates a magnetic moment, the vector of which is directed along the axis of rotation of the cluster. **Fig. 14** shows a cross section of such a cluster. The radius of the current ring is $r = R\cos\alpha$, where $R$ is the radius of the sphere, and $\alpha$ is the angle between the plane of the equator and the line of intersection of the current ring with the sphere. Current ring area $s = 2\pi rR\cdot d\alpha = 2\pi R^2\cos\alpha d\alpha$. Current ring charge $q = s\cdot\sigma = (Q/2)\cos\alpha d\alpha$. If the sphere makes $n_r$ revolutions per second, then the current $i_r = q\cdot n_r = (Q/2)n_r\cos\alpha d\alpha$ flows through the ring of radius $r$. The magnetic momentum of this current is $dp_m = i_r\cdot\pi r^2 = (Q/2)n_rR^2\cos^3\alpha d\alpha$. Total magnetic flux of the rotating sphere is $p_m = Qn_r\pi R^2\int_0^{\pi/2}\cos^3\alpha d\alpha = (2/3)Qn_r\pi R^2$. At $Q = 4.5\cdot10^{-12}$ C and $R = 0.6\cdot10^{-6}$ m $p_m = 3.39\cdot10^{-24}n_r$ (C·m$^2$/s). We found above that due to thermal perturbations, the cluster can rotate at a frequency of about 100 revolutions per second. Suppose that for some reason the rotational speed has become 1000 revolutions per second. Then $p_m = 3.39\cdot10^{-21}$ C·m$^2$/s. In an inhomogeneous magnetic field, a force proportional to the magnetic induction gradient acts on the magnetic dipole, forcing the dipole to move in the direction of increasing magnetic field strength. This force is $F_m = p_m\cdot\mathrm{grad}B$. Let

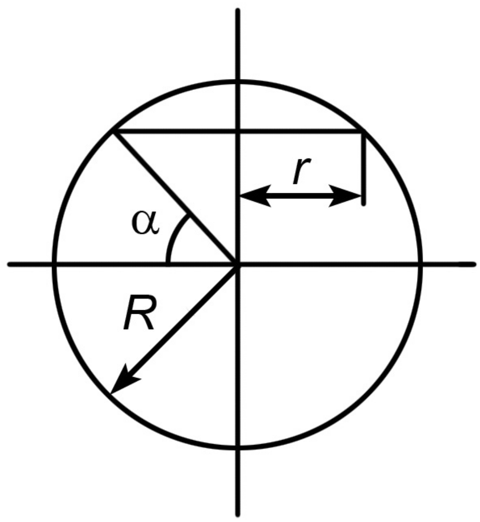


**Fig. 14.** *Section of a rotating cluster.*

grad$B$ = $10^2$ T/m near the pole of a strong magnet, then $F_m = 3.39\cdot10^{-19}$ N. This force is much less than the force of the weak electric field on the cluster charge (at $Q = 4.5\cdot10^{-12}$ C and $E$ = 10 V/m force $F_e = QE = 4.5\cdot10^{-11}$ N). Thus, the magnetic field can only act on a moving charged cluster (due to the Lorentz force). The "gyromagnetic" ratio for the cluster is $p_m/I = 33.9\cdot10^{-25}n_r/4.49\cdot10^{-25}n_r = 7.55$ C/kg (for an electron $p_m/I = 1.76\cdot10^{11}$ C/kg).

### 4.5. Curls of the trajectory

Characteristic feature of traces left by "strange" particles are sharp breaks in their trajectories (Fig. 6, Fig. 8). This gave a reason to some researchers [10,11] to believe that the traces were left by particles with a very small mass (magnetic monopoles or magnetically excited neutrinos) [3,4,10,11]. Let us discuss whether this behavior of particles can be explained if we consider them as charged spheres with a certain size and nonzero mass. Let us have a cluster with inner sphere radius $r = 6\cdot10^{-7}$ m, having charge $Q = 4.5\cdot10^{-12}$ C. The thickness of the water shell of such a cluster is $a = 1.54\cdot10^{-6}$ m, and its outer radius is $R = r + a = 21.4\cdot10^{-7}$ m. The volume of the shell is $V_{sh} = 4\pi[(r + a)^3 - r^3]/3 = 4\cdot10^{-17}$ m$^3$, and the mass of the shell, equal to the mass of the cluster, $M_{sh} = 4\cdot10^{-14}$ kg. In an electric field $E_x$, the cluster is affected by the force $F_e = QE_x$, which makes it move with velocity $v$ in the direction of the field strength vector. The air resistance force $F_D = (\pi C_D \varrho_m R^2 v^2)/2$ acts opposite to the $F_e$ force, where $C_D = 5.8$ is the medium resistance coefficient, and $\varrho_m = 1.205$ kg/m$^3$ is the air density. For $F_e = F_D$, the cluster moves at a constant speed. Let this speed be 10 m/s. In this case, the kinetic energy of the cluster $W_k = M_{sh}v^2/2 = 2\cdot10^{-12}$ J, and the force $F_D = 5\cdot10^{-9}$ N. Suppose that at some moment action of the force $F_e$ is ceased and the cluster, slowing down under the action of the force $F_D$, will stop after passing a certain distance $x$. The magnitude of the force $F_D$ will decrease with decreasing speed, but we will neglect this and assume that it is equal to its maximum value. The distance $x = W_k/F_D = 0.4$ mm, that is, in order to stop the movement and change the trajectory, the cluster must describe an arc with a radius of about 0.25 mm. In fact, according to observations, the radius of this arc is 1000 times smaller. The reason for this discrepancy lies in the fact that we assumed that the cluster flies freely over the film surface without interacting with it. This is not true. According to Fig. 13 the cluster, moving along the film surface, oscillates in the direction perpendicular to the film plane. At some point, it is attracted to the film. This means that when the trajectory is bent, it makes a turn around a certain point lying on the surface of the film, and not a turn in free space. This situation is similar to what you might encounter when you are descending a steep mountain. You are moving fast, visibility is limited due to the fog. And suddenly you see that you are on the edge of the abyss and you no longer have time to turn sideways. You are saved by a tree that happened to be in your way. You grab at its trunk and turn sharply.

### 4.6. Symmetric tracks

The movement of a spherical cluster occurs due to the action of two forces. The first is the action of the electric field $E$ on the charge $Q$: $F_e = QE$.

Opposite to this force, a sphere of radius $R$ moving at a speed $v$ is affected by the air friction force [37]

$$F_D = (\pi C_D \rho_m R^2 v^2)/2, \quad (4)$$

where $\rho_m = 1.205$ kg/m$^3$ is the air density, and the drag coefficient of the medium at a speed $v$ = 10-20 m/s can be set equal to $C_D = 5.8$. At $F_e = F_D$, the cluster velocity is:

$$v = \left(\frac{2QE}{\pi C_D \rho_m R^2}\right)^{1/2} = A\left(\frac{QE}{R^2}\right)^{1/2}. \quad (5)$$

In the images of traces of "strange" particles, symmetrical traces ("twin tracks") are sometimes observed (Fig. 9, Fig. 10, Fig. 11). It can be assumed that the particles that left them flew in the same direction, simultaneously making bends in the trajectory. According to our model, this was due to the fact that the particles had a charge and moved due to the action of electric fields on them, which changed direction at some points in time. In rare cases, "chiral" traces were observed when the particles that left them simultaneously moved in the opposite direction (Fig. 12). This can be explained by the fact that the pair of particles had charges of the opposite sign. An analysis of the lengths of the sections of the trajectory of two particles showed that the lengths of the straight segments are the same, that is, both of these particles moved at the same speed. In principle, this could happen if both particles had the same charge (modulo) and the same size. However, this is highly unlikely. It would be more realistic to assume that the particles had different charges and sizes, however, the size of particles with a smaller charge was smaller and therefore the force of their friction against air was also smaller. Ideally, one would expect particles that have the same ratio of charge $Q$ to the square of radius $R^2$ to move in a constant electric field at the same speed.

Let us discuss whether there can be clusters for which the ratio $Q/R^2$ = const. In Section 4.1, we described the procedure for calculating the parameters of a cluster holding inside a shell with a thickness $a = 1.54 \cdot 10^{-6}$ m an electric charge $Q = 4.5 \cdot 10^{-12}$ C. The cluster radius turned out to be equal to $R = 2.12 \cdot 10^{-6}$ m. Calculating parameters of other clusters on described scheme we find that the cluster with a charge $Q = 4.5 \cdot 10^{-14}$ C has a radius $R = 2.11 \cdot 10^{-7}$ m, the cluster with $Q = 4.5 \cdot 10^{-13}$ C has a radius $R = 6.7 \cdot 10^{-7}$ m, and a cluster with $Q = 4.5 \cdot 10^{-11}$ C has $R = 6.55 \cdot 10^{-6}$ m. The results of calculation of cluster parameters are presented in the **Table.**

As you can see, the value of the $Q/R^2$ parameter is equal to one. This value is close to the value $\sigma = 1$ C/m$^2$, which is the surface charge density of dipoles of water molecules placed as a monolayer on the shell of ball lightning [24-33]. In twin tracks, there is synchronization of two orders. The first is external. On continuous tracks, it is seen that the particles change their trajectory simultaneously under the influence of a change in the external field. The second is internal order. On Fig. 11 it can be seen that the particles "draw" the strokes in a coordinated way, that is, they "reset" the charges at the same time. Perhaps the reason for this correlation is the exchange of pulses of electromagnetic radiation during each discharge. The appearance of multiple charged clusters with different polarity during electric discharges seems to be quite natural. In some cases, they are formed near the anode, and in others, near the cathode.

### 4.7. "Strange" particles and nuclear transmutation

The idea was repeatedly expressed that the registered changes in the isotopic composition of elements during electric discharges can be somehow connected with the appearance of "strange" particles. Even the question of what is primary – the appearance of particles

**Table**

Cluster radius R as a function of its charge Q.

| Q, C | R, m | $R^2$, m$^2$ | $Q/R^2$, C/m$^2$ |
|---|---|---|---|
| $4.5 \cdot 10^{-14}$ | $2.11 \cdot 10^{-7}$ | $4.45 \cdot 10^{-14}$ | 1.01 |
| $4.5 \cdot 10^{-13}$ | $6.70 \cdot 10^{-7}$ | $44.89 \cdot 10^{-14}$ | 1.00 |
| $4.5 \cdot 10^{-12}$ | $2.14 \cdot 10^{-6}$ | $4.58 \cdot 10^{-12}$ | 0.98 |
| $4.5 \cdot 10^{-11}$ | $6.55 \cdot 10^{-6}$ | $42.90 \cdot 10^{-12}$ | 1.05 |

and the subsequent reaction of a change in the composition of nuclei, or vice versa [5,6], was even discussed. Let's assume that the first version is correct. Experiments have shown that "strange" particles can penetrate solids and then be emitting by them for a long time [12,13]. A multiple charged cluster embedded in a crystal lattice creates an electric field in the region around it, the strength of which is comparable to the strength of the electric field at the location of an electron in a hydrogen atom. If the cluster has a negative charge, this will lead to the repulsion of the electron cloud of the lattice atom, and the nucleus will be "bare", as it were. It is impossible to predict in advance what can happen in the region between the outer surface of the cluster shell and the "bare" nuclei during the time the cluster stays inside the crystal lattice (up to several days). For a thermonuclear reaction in deuterium-tritium plasma, there is the Lawson criterion, according to which the probability of a reaction is determined by the product of the plasma density and the time of its confinement. It is possible that the time parameter is also important in determining the probability of nuclear transformations in strong electric fields. Another aspect is important. In the search for the mechanism of nuclear transformations, it is always implicitly assumed that the reaction occurs in the form of a single act, the implementation of which requires energy of several mega-electronvolts. But processes also occur in nature when a "mega-transformation" occurs through a cascade of "small" steps. The most striking example of this is the absorption of two "red" quanta by plant chlorophyll. A polyatomic molecule (for example, $SF_6$) can be excited to the dissociation level ($E_d = 2$ eV) due to the absorption of $CO_2$ laser radiation quanta ($\lambda = 10.6$ μm, $E_l = 0.11$ eV) [38]. A person cannot jump more than two meters, but can climb stairs to the 20th floor of a house. It is possible that such a process of step-by-step overcoming of the barrier may play some role in the reactions of "cold fusion" of elements.

## 5. CONCLUSION

Based on the above, the following conclusions can be drawn:

1. Particles of "strange" radiation are not elementary particles or atomic nuclei, for which the only reservoir of action on matter is their kinetic energy. It is also unlikely that these particles serve as a catalyst for exothermic nuclear reactions in ordinary matter. It is more realistic to consider that these are macroscopic particles with a large internal potential energy reserve.
2. The appearance of traces of "strange" particles is naturally explained under the assumption that they are left by particles with an electric charge exceeding the elementary charge by more than 1000 times.
3. The charge of these particles can be both positive and negative.
4. Charged particles move due to the action of random electric fields on them (the "fair weather" field strength near the earth's surface is about 100 V/m). This field changes chaotically in time.
5. The properties of "strange" particles are similar to the properties of ball lightning. They, like ball lightnings, are able to move along the surface of a solid body, make jumps, leave holes in the material when rebounding, and divide into parts. This makes it possible to identify them with miniature ball lightnings.
6. Like ball lightning, these particles are able to penetrate into a solid body. The estimate shows that a spherical cluster with a radius of $2.14 \cdot 10^{-6}$ m and a charge of $4.5 \cdot 10^{-12}$ C presses on the surface with a force of $10^{10}$ N/m$^2$.
7. The electric field strength on the surface of such a cluster can reach up to $10^{10}$ V/m. This is comparable to the strength of the electric field in an atom ($5 \cdot 10^{11}$ V/m). In the crystal lattice near the intercalated cluster, a strong polarization of the substance will occur, which can facilitate the conditions for the approach of protons and nuclei of elements.

8. This forces us to consider the possibility of nuclear reactions proceeding through the process of overcoming the potential barrier, which lasts for a time many orders of magnitude greater than the time of nuclear collision in a conventional nuclear process.

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