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Strange radiation and LENR: what's the relation?

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Abstract: **A review of studies showing the phenomenon of "strange radiation" is given. The issues of relation of this phenomenon with low energy nuclear reactions (LENR) are discussed. The results of our own experiments, revealing such a relation, are presented on the example of two LENR reactors. Based on the developed technique for assessing the intensity of tracks on sensitive materials, it is shown that tracks of strange radiation with high intensity appear only in the near zone of reactors (up to 20 cm). The aftereffect is described, when the tracks appear after the reactor is turned off. The large variability of the intensity of the tracks makes it difficult to use them as a marker of LENR. The paradoxical properties of strange radiation are discussed.**

Keywords: **strange radiation, low-energy nuclear reactions, LENR**

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Contents

1. INTRODUCTION

Low-energy nuclear reactions (LENR) as the research topic have a long pre-history, 30-year "new" history (since 1989) and a promising future. Despite the rich experimental material and many theories claiming to explain this phenomenon, so far it is just a phenomenon, without a generally accepted theory that would satisfy the scientific community.

Another less known phenomenon is also without a satisfactory explanation, called "strange radiation", and which has been studied for 20 years. Twenty years for research on a certain phenomenon is a long time. For 20 years, nuclear physics was formed and the structure of the atom became clear at the beginning of the 20th century. During the same first 20 years of the last century, two scientific revolutions took place that turned our ideas about the world upside down. Why didn't this happen with LENR and strange radiation? The fact that for many years there has been no progress in finding the mechanisms of low-energy nuclear reactions could be explained by the inapplicability of traditional approaches of nuclear physics to work with this phenomenon. However, the history of physics and steady progress in experimental technology say that if a phenomenon exists and physicists are willing to investigate it, progress will sooner or later follow. Another thing is that this progress may require a new scientific revolution. Is physics ready for it? However, the social reasons for the inhibition of some areas of research are not the subject of this article.

If there is a suspicion that the price of progress is a rethinking of the scientific picture of the world, then it makes sense to pay attention to the strangest features of the studied phenomena, if, of course, they are reliably fixed. Many researchers, working in the field of LENR, are familiar with strange radiation tracks. This is definitely a rather strange phenomenon. But is there a relation between this phenomenon and LENR? What is this relation? Can we use strange radiation as reliable marker of low energy nuclear reactions like well-known nuclear radiation is an unmistakable marker of conventional nuclear reactions?

This article attempts to answer these questions. The first part of the article is a review of key publications that investigate the phenomenon of strange radiation. The second part presents the results of experiments carried out in the KIT laboratory in 2017-2019 to answer the question whether the operation of LENR reactors is associated with the appearance of tracks of strange radiation.

2. OVERVIEW

The first work in which the term "strange radiation" was introduced into scientific use was an article by L.I. Urutskoyev and colleagues [1]. In it, "strange" tracks on photographic emulsions were a concomitant factor for anomalous processes occurring during the electric explosion of titanium foil in water. The consequences of such processes were excess energy release, the appearance of new elements after an electric explosion, and a distortion of the natural isotopic composition of Ti (**Fig. 1**).

The accompanying radiation was indeed strange. It did not resemble any known type of radioactivity, it was biologically active (see below), and it generated tracks of a certain shape on the photoemulsion (**Fig. 2**).

These tracks are reminiscent of a tractor track - they have often periodic shape. In Urutskoyev's experiments, the tracks went in a plane perpendicular to the direction to the foil explosion site (in this case, apparently, they "slid" strictly in the plane of the emulsion).

Another interesting property of this radiation was its ability to accumulate in matter. During one of the experiments after the explosion of the foil,

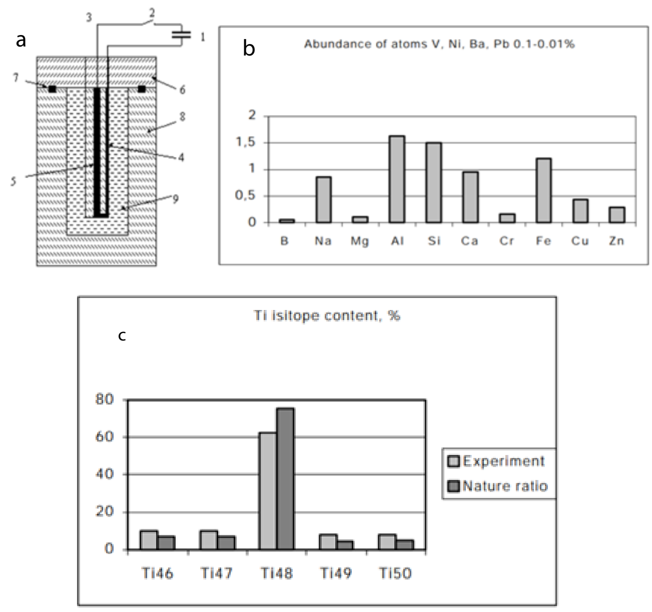


Fig. 1. *(a) Urutskoyev's explosive cell, (b) the appearance of new elements, (c) distortion of the isotopic composition* [1].

water and the remains of the foil were poured into a Petri dish and a photographic film was placed at a distance of 10 cm. After an 18-hour exposure on the film, the same tracks were observed as from the electric explosion itself (**Fig. 3**).

The magnetic field affected the tracks - a form of tracks in a magnetic field is obtained comet-shaped. This made Urutskoyev assume that these tracks belong to electrically neutral particles with a magnetic charge (magnetic monopoles). Light monopoles were predicted by the French theorist George Lochak back in the 1980s as a development of Dirac's ideas about the magnetic monopole. According to Lochak's theory, a magnetic monopole is a massless magnetically excited neutrino. To test this hypothesis, traps made of a ^{57}Fe isotope foil

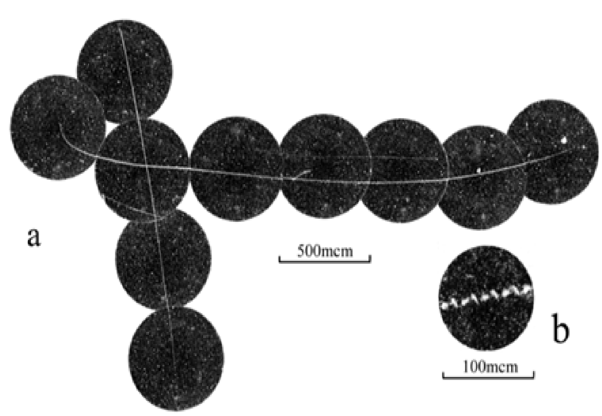


Fig. 2. *Tracks on photographic film from an electric explosion in the experiments of Urutskoyev* [1].

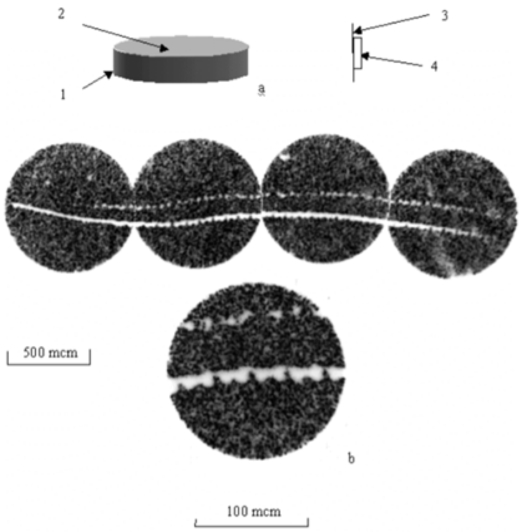


Fig. 3. *Experiment with "aftereffect": (a) - placement of photographic material; (b) - tracks on the photographic emulsion* [1].

placed at the S and N poles of a magnet were used [2]. The experiment showed that when the foils were exposed to "strange radiation", the foil at the S-pole showed a Mössbauer deviation in the spectrum in one direction, and at the N-pole in the other:

"*The results of the measurements showed that in the foils placed at the N-pole, the absolute value of the hyperfine magnetic field increased by 0.24 kG. On the other foil (S), it decreased by about the same value 0.29 kG. Measurement error 0.012 kG.*"

The authors explain this by the bound state of the Lochak's monopoles with the iron nucleus.

Urutskoev conducted many other experiments to study this phenomenon, in particular, when testing high-voltage industrial electrical equipment in an abnormal short circuit mode [3]. It was shown that, in this case, the tracks of monopoles are also recorded (**Fig. 4**). Moreover, as in the case of electric explosion of foils in water, the isotopic composition of titanium in varistors was distorted. The conditions for the experiment were as follows: "*A short circuit on the buses in a complete switchgear (KRU) is carried out by installing jumpers from a wire of any metal with a diameter of no more than 0.5 mm on the current-carrying buses, the main task of the wire being installed is to initiate an arc, which is then maintained by the power of the source for a given period of time. The value of the supplied short-circuit current has a range from 1 to 40 kA, the voltage of the no-load circuit is 8-10 kV. A characteristic feature of the traces is that they are mainly located in the surface layer of the photoemulsion of the detectors. Traces differ markedly from each other in size. Transverse dimensions 5-30 microns, length from 100 microns to several millimeters. As a result of experiments, it was found that the further from the test site is the detector, the narrower the track width. So, traces with transverse dimensions 30 microns are observed on detectors located at a distance L: 0.5 m < L <1 m, and tracks with dimensions of 5-10 microns - at a distance L > 2 m from the test site. If the tests were carried out at currents I ~ 1-2 kA, then no traces were found on the detectors. On the contrary, if the tests were carried out at a current of I ~ 40 kA, then many different traces were recorded. When testing vacuum interrupters, not a single trace of "radiation" was recorded, although 15 experiments were carried out, in which more than 20 photodetectors were installed. This confirms the results of laboratory studies, in which the tracks were observed only in an electric discharge in a medium*".

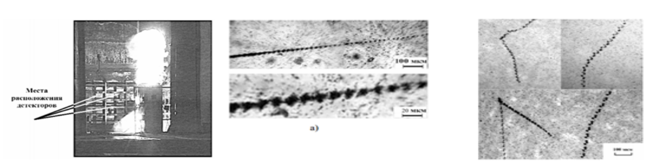


Fig. 4. *Tests of electrical equipment (current ~ 40 kA) and tracks on photodetectors* [3].

N.G. Ivoilov (Kazan University) in [2] together with L.I. Urutskoev studied the Mössbauer spectra of an iron foil exposed to "strange radiation".

Further Ivoilov's experiments were devoted to the study of the properties of particles that form "strange" tracks, and their interaction with matter [4]. Double-sided photographic films were used as detectors, and the author made "sandwiches" from photographic film and various materials, and also used an external magnetic field. The work can be roughly divided into two parts. In the first, experiments are carried out with radiation from a spark discharge in a liquid with graphite electrodes (**Fig. 5**). The

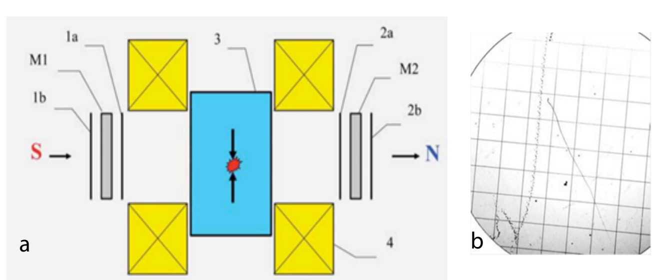


Fig. 5. *(a) - Scheme of the Ivoilov setup: 1 and 2 –X-ray photoplates, M1 and M2 –the material ivestigated. 3 –the thin wall plastic vessel, 4 – Helmholtz induction coils. S →N – direction of magnetic field; (b) - example of tracks, step is 1 mm* [4].

current did not exceed 40 A , the voltage was about 80 V. As a result, in addition to confirming the results of Urutskoyev, very interesting new results were obtained. Ivoilov was able to detect paired tracks of monopoles with mirror symmetry when the recording film was placed close to the reflecting material. Mirror tracks were obtained from different sides of the film - one from the side of the radiation source, the other from the side of the reflecting material (**Fig. 6**). Ivoilov assumes that mirror pairs are S and N monopoles.

As for the interaction with matter, it turned out that magnetic particles are completely absorbed by ferromagnets (Fe and Ni films were used), aluminum shows itself as a weakly reflecting and weakly absorbing substance, and glass and single-crystal germanium and silicon turned out to be well reflecting materials.

In passing to the second part, the author uses a beta-radioactive source in a strong magnetic field to test the new hypothesis, i.e. abandons the original method of obtaining monopoles in a spark discharge. What is this hypothesis? Ivoilov suggests that, since the Lochak monopole is a magnetically excited neutrino, then it should arise from the cosmic neutrino component, as well as from the neutrino component of beta decay of local sources in the presence of a magnetic field. The experimental results support this hypothesis. Here is what the author writes: "*When working with photographic films, as a rule, together with the irradiated films, control films were processed that passed all stages of preparation, except for irradiation. As the control films in this experiment, we used photographic films that were kept during the supposed time of the experiment (10 min) in a constant magnetic field with strength of 20 kOe. After developing in control films are detected the same characteristic tracks which occur during the combustion of the electric arc in the fluid. These tracks we called the background. In the case of the films location near the source in the absence of a magnetic field background is not detected. When a neutrino source (^{90}Sr) was introduced into the magnetic field, the number of tracks recorded during the same time almost doubled in comparison with the background, and some of the tracks had a clearly radial direction from the center where the radioactive source was located. A similar result was obtained with the ^{137}Cs source.*"

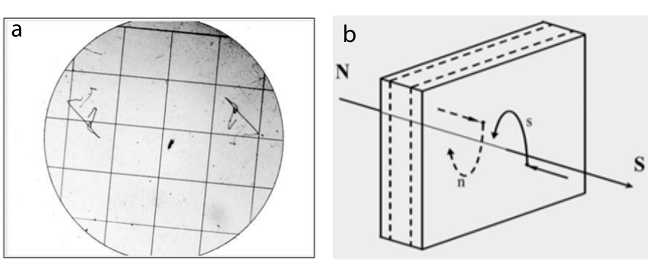


Fig. 6. *(a) - Paired tracks in Ivoilov's experiments, (b) - behaviour of particles flying in opposite directions along radial fluctuating magnetic field* [4].

The author writes in his conclusions: "*1) During an electric explosion and an electric discharge in a liquid, the flowing current, compacted by the liquid, is a source of large magnetic fields, in which magnetically excited neutrinos (magnetic monopoles) are born during the beta decay of cosmic particles. 2) The component of cosmic radiation, which has not yet been clarified, is a necessary factor in the production of magnetic monopoles in the beta decay of unstable nuclei in a magnetic field. 3) S- and N-magnetic monopoles are born in pairs.*"

As we can see, in the works of Urutskoyev and Ivoilov, the relation between the tracks of strange radiation and nuclear transformations is considered from different positions.

The LENR topic has been actively studied by the Proton-21 laboratory in Kiev. There, under the leadership of S.V. Adamenko obtained experimental evidence of the nuclear transformation of a metal under the influence of coherent electron beams [5,6]. Since 2000, thousands of experiments ("shots") have been carried out on cylindrical targets of small (about a millimeter) diameter. The inner part of the target explodes, and the explosion products contain almost the entire stable part of the periodic table in macroscopic quantities, as well as superheavy stable elements.

What is the Adamenko installation? Experimenters call it a high-current vacuum diode. The target itself is the anode - as a rule, it is a copper wire with a diameter of about half a millimeter with a rounded end. The electron beam from the cathode strikes its surface coaxially, as a result of which the central part of the anode explodes (**Fig. 7**). Explosion products are deposited on storage screens (disks about 10 mm in diameter with a hole in the center), made, as a rule, of the same material as the target. The widest range of methods available in a modern laboratory is used to study explosion products.

If we briefly describe the processes occurring with the substance in the target, then, according to the researchers from Proton-21, there is a process of

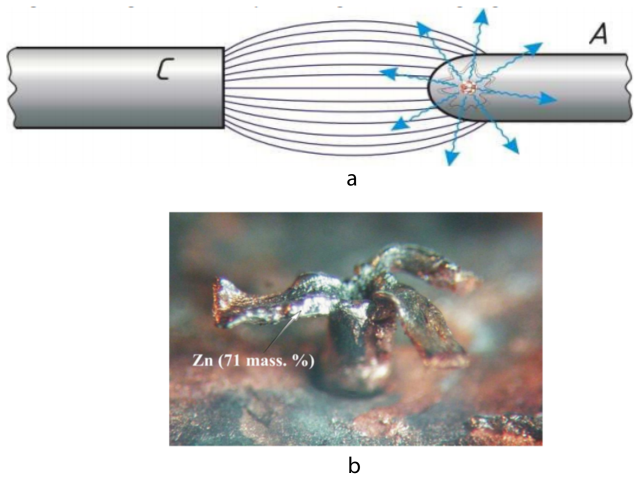


Fig. 7. *(a) - Schematic of self- focusing of an electron beam on the surface of the concentrator anode, which excites a soliton-like density pulse in its near-surface layer converging to the axis of symmetry (illustration from* [5]*). (b) - copper target after the experiment with traces of solidified silver-white "lava" on its petals, pouring out from the center of the exploded target (illustration from* [5]).

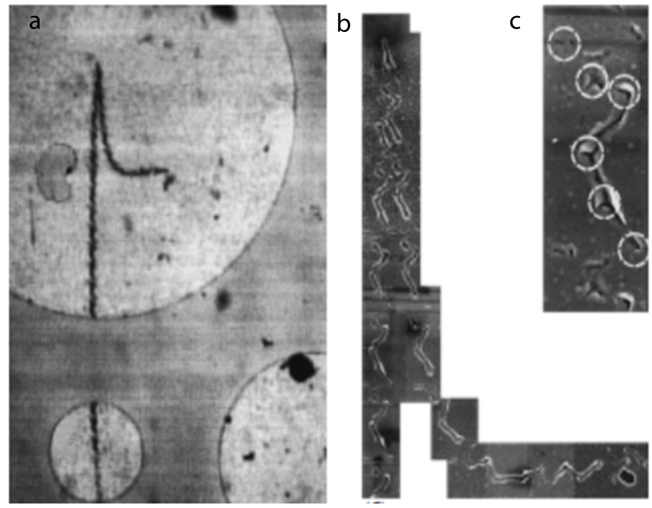


Fig. 8. *(a) - general view of the MIR-structure with a track; (b) - a fragment of the track panorama containing all types of repeating elements; (c) - highlighted zones demonstrate silicon emissions onto the aluminum surface (illustration from* [7]).

collapse of the substance, triggered by the impact of an electron beam on the surface of the metal anode, and leading to the formation of a "nucleon plasma", followed by the creation from it of the widest range of elements, as well as superheavy elements, with atomic masses of thousands of AU. This process is similar to supernova explosions, and the spectrum of X-ray radiation is very strongly correlated with the spectra of cosmic *X*-ray and gamma-ray bursts. The known elements resulting from the explosion are stable, i.e. the reaction products are non-radioactive. In addition, experiments with explosion radioactive targets (^{60}Co) show a substantial decrease of their radioactivity. About 30% of the original target material undergoes nuclear transformation. The amount of released energy is orders of magnitude greater than the amount of energy supplied.

The same team, while studying the properties of hot spot radiation at the facility of the Proton-21 laboratory, investigated some related phenomena. One of them is the tracks of magnetically charged particles in a multilayer MOS structure (metal-oxide-semiconductor). In the structure, which usually serves as the basis for the production of microcircuits, "layered cake" Al-SiO_2-Si, tracks were found that appear when such a structure is exposed under the influence of explosion [7] . Such particles behave like a needle in a sewing machine shuttle - they periodically pierce through a layer of aluminum with a small constant pitch (60 μm), leaving a fused, winding hollow tunnel about one micron wide in its path (**Fig. 8**).

In the work "Experimental detection and modeling of the orientational motion of hypothetical magnetically charged particles on a multilayer surface" [7], the authors V.I. Vysotsky and S.V. Adamenko give an estimate of the energy release during the passage of such particles through a metal - it turns out to be about 10^6 GeV/cm. These tracks run perpendicular to the direction from the hot spot, parallel to the surface of the MOS structure. The authors calculated that the most plausible hypothesis explaining this behavior of the particle is the hypothesis of a magnetically charged particle, which moves through the paramagnetic layer in an external magnetic field (which is directed approximately parallel to the surface).

Further, the authors point out that simple deceleration of particles is not capable of generating such a volume of energy at a practically nondecreasing particle velocity in the track, and they assume that such particles are capable of magnetic catalysis of energetically beneficial nuclear reactions. Monopoles should stimulate nuclear reactions due to the fact that when they move, they greatly distort the electronic shells of atoms that they come across along the way, and thereby increase the likelihood of nuclear tunneling and their fusion. Getting into aluminum (paramagnet) as in a potential well, a magnetically charged particle stimulates nuclear reactions with the release of energy. By melting the aluminum layer , the particle changes its magnetic properties (it becomes a diamagnet) and, as a result, tends to "jump" out of this layer. Coming out of the aluminum, and passing a certain 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 the external magnetic field is essential for this behavior of the particle. An estimate of the velocity of the observed monopoles, which was calculated on the basis of their trajectory and experimental conditions, shows that this velocity should be more than 200 km/s - just so fast the particle should fly so that the magnetic field does not have time to change significantly during its flight. This is important for the hypothesis explaining the behavior of a magnetic particle, since the step on the tracks remains constant throughout the entire track, and, therefore, the entire track (2 mm long) should be produced in a time significantly less than 30-50 ns (this is how long the current pulse lasts).

M.I. Solin (Yekaterinburg) obtained results back in the 1980s that also indicate the joint occurrence of LENR reactions and the manifestation of strange radiation.

Reactor of M.I. Solin is a vacuum melting furnace where zirconium was melted by an electron beam with an accelerating voltage of 30 kV [8]. At a certain mass of liquid metal, reactions began, which were accompanied by anomalous electromagnetic effects, the release of energy exceeding the supplied one, and after analyzing samples of the newly solidified metal, “foreign” chemical elements and strange structural formations were found there. The author writes: “*In the melting zone, long-range propagating volumetric forces appear, which significantly affect the distribution of the pressure force vectors in the liquid phase, change the shape of its free surface and cause the transition of the substance mass from the state of stable equilibrium of the system to the state of ordered and accelerated motion. In the center of liquid mass, although the input of the energy of the magnetic field by the known methods was not performed, the formation of dynamic perturbations in the form of wave ripples on its surface occurs, and then spontaneous curvature and displacement of the interface between the liquid phase surface and the vacuum space of the melting chamber. The relatively large mass of the liquid phase in this process regularly accumulates in the area of exposure to an electron beam and accelerates upward in the form of a traveling solitary wave, acquiring the shape of a cone and a bright white glow, which is clearly distinguished by its shade from the glow of liquid zirconium* (**Fig. 9**)".

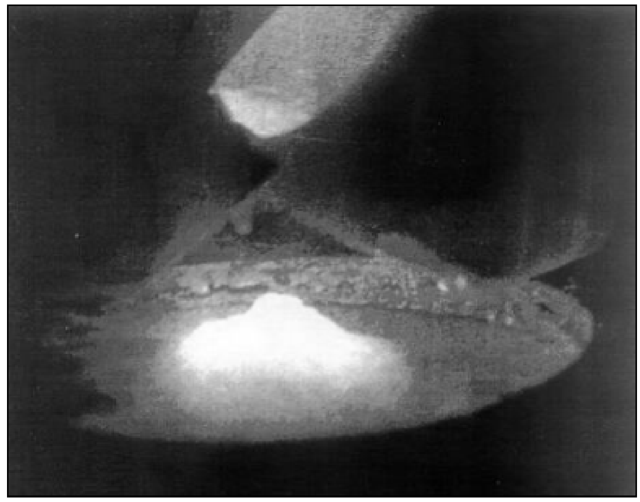


Fig. 9. *A solitary wave in zirconium during the formation of a bulge (illustration from* [8]).

As a result of some strange phenomena, the molten metal begins to behave like Lem’s Solaris, periodically blowing up, forming pits, ripples and standing waves. Vortexes are formed in the liquid, as well as solitary stable waves (solitons). In some modes, these processes are accelerated, and the amount of released energy becomes so great that it is necessary to stop the process by turning off the electron beam: "*According to estimated calculations, taking into account the above-described anomalous hydrodynamic, shock-sound and explosive effects occurring in the volume of a liquid phase with a large mass, the total amount of energy released in it is 1000 or more times greater than the initial input energy of the electron beam.*"

The usual process of melting metal billets has nothing to do with such processes: usually the liquid remains calm, with a smooth horizontal surface, with a visible trace of an electron beam. This is exactly how the melt behaves at the beginning of melting, until the critical mass of liquid zirconium is reached. And the fact of excessive energy release is checked extremely simply - by a sharp increase in the melting rate of the billets. After the liquid mass set solid, anomalous formations are observed in it - hollow spheres and cylinders, winding "wormholes", nugget inclusions, and the structure of the metal itself differs significantly from the structure of ordinary zirconium. “*One group of defects is represented by extended tubular channels of various configurations. They show the*

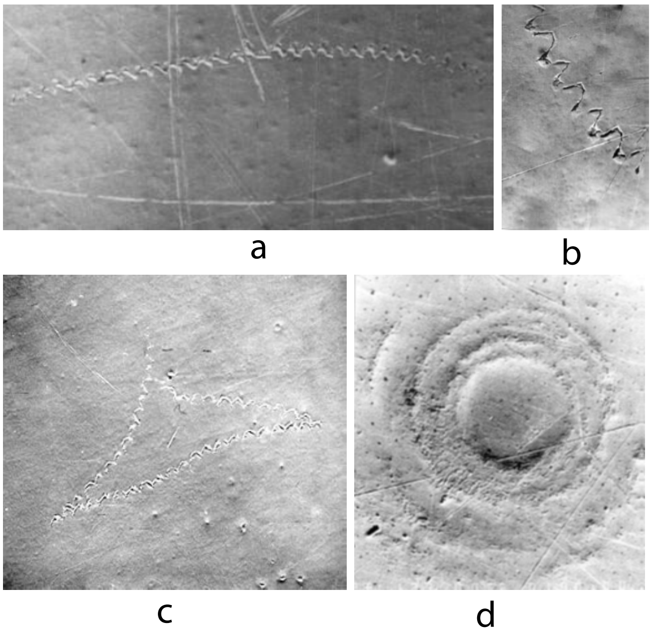


Fig. 10. *Tubular channels in a zirconium ingot: (a) and (b) - in the form of sinusoidal holes, (c) - in the form of a hollow triangular wave loop, (d) - in the form of concentric annular holes (illustration from* [8]).

appearance of cavities in the solidified metal in the form of interconnected sinusoidal wave and rectilinear holes, a hollow triangular wave loop-chain, consisting of regularly repeating semicircular links. These channels are also concentric annular holes. In addition, their configuration contains elements of a meander shape and regularly repeating symmetrical geometric shapes (**Fig. 10**)".

"*Studies by the method of secondary ion mass spectrometry showed the presence of lithium, beryllium, boron, barium and elements of a number of lanthanides in the discovered products-nuggets. These elements are not present in the starting material (in the remelted zirconium). As shown by the results of the analysis of the chemical composition, in the products found in nuggets, in contrast to the initial zirconium is significantly higher (by 2-3 orders of magnitude) of sodium, magnesium, aluminum, silicon, potassium, calcium, titanium, chromium, manganese and iron. By means of X-ray spectral microanalysis and Auger spectrometry, the enrichment of the above-named chemical elements, as well as carbon, nitrogen and oxygen, of the material of cylindrical and spherical shells and the above-mentioned products has been established.*"

Experiments with the generation of radiation leaving the same recognizable tracks and possessing biological activity were carried out by I.M. Shakhparonov (**Fig. 11**). After the action of an electromagnetic pulse generator [9] on diamagnetic materials (including graphite, polymers, glass, ceramics), they acquired paramagnetic properties [10,11]. The author points out that substances with the highest oxygen content, which is a paramagnet, lend themselves to the greatest magnetization. Shakhparonov called the stream from the emitter of his design "Kozyrev-Dirac radiation". The results of the effect of this radiation on radioactive isotopes show an increase in the rate of the beta decay process (in the patent "Method for the decontamination of radioactive materials" experimental confirmation for ^{131}I is mentioned [12]). The impact of radiation on oil samples showed a complex picture of change in the content of various elements depending on the time of irradiation [13].

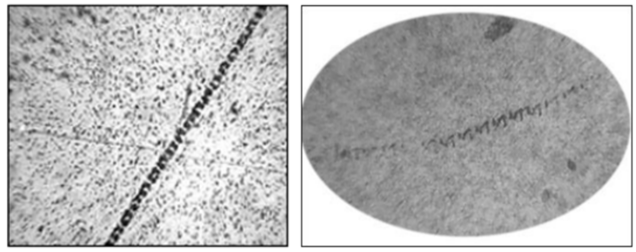


Fig. 11. *Tracks of strange radiation from the Shakhparonov's installation.*

Biological studies of radiation (in mice) show that it is biologically active, reduces blood clotting, leads to a decrease in blood glucose, at the same time, it can increase immunity, as well as increase resistance to gamma radiation [14].

Similar results on biological effects were obtained by E.A. Pryakhin and coworkers (Chelyabinsk). They investigated the biological effects on laboratory mice of "strange radiation" from Urutskoyev's setup [15]. They showed that radiation enhances cell division in bone tissue. In experiments where mice were exposed to "strange radiation" (at a distance of 1 meter from the installation) before exposure to hard gamma radiation, an increased resistance to gamma radiation was noted. The authors suggested that this radiation can affect human health.

Recently, studies of the biological effect of strange radiation from an electric explosion were continued by E.A. Pryakhin and colleagues [16]. The influence of the factors of electric explosion of a tungsten wire in a vacuum on damage to nuclear DNA in leukocytes of human peripheral blood, the frequency of chromosomal aberrations in dividing cells of onion root, the growth rate of green unicellular algae, germination and growth rate

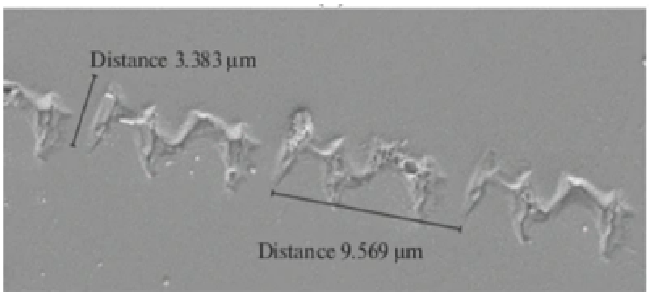


Fig. 12. *Tracks from electric explosion of a tungsten wire in vacuum in the study* [16].

of plant seeds was studied (**Fig. 12**). The authors separated the effects from various factors of electric explosion: strange radiation, light exposure, pulsed magnetic field. Among the results is a reduction in the level of DNA damage caused by strange radiation. It also turned out that the biological effect of strange radiation depends on the material through which this radiation passes: "*The level of damage to nuclear DNA increased depending on the atomic mass of the shielding material with a coefficient of 0.557 ± 0.031 per atomic mass unit.*"

A.L. Shishkin et al. investigated the radiation called "magnetotoroelectric" (in other publications, the authors call the radiation "neutrino-cluster") [17,18]. In addition to extended tracks, microcraters on the surface of an X-ray photographic film with a diameter of up to several microns were studied, and formations of the order of millimeters in size - blackening in the form of "birds" were also observed (**Fig. 13**). The effects of the following processes were studied: water treatment in a cavitation device, rotation of cones made of various materials, irradiation of materials with a gamma source, a high-voltage pulse in a flat capacitor. The study included measuring the diameters of many microcraters and finding patterns in the appearance of microcraters of different diameters. The authors argue that the diameter of the microcraters is proportional to the atomic weight of the elements through which the radiation passes. For example, a diameter of 0.9 µm corresponds to carbon (atomic weight 12), 1.1 µm to nitrogen (atomic weight 14), 1.3 µm to oxygen (atomic weight 16). Aluminum (atomic weight 27) corresponds to a crater diameter of 2.4 µm etc. [17].

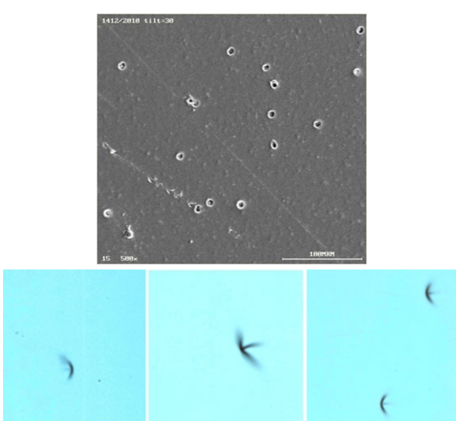


Fig. 13. *Traces of strange radiation on photographic film in Shishkin's experiments* [17].

Similar structures ("birds", spots) on photographic films were observed in the studies of V.V. Evmenenko et al [19]. The scheme for obtaining strange radiation from this group was as follows: water was placed in a magnetic field of ~ 0.5 T, then, after removing the magnetic field, this water was shone through with a low-power laser. A photographic material with protection from the optical component of the laser was placed in the path of the laser. In addition to traces on photographic films (**Fig. 14**), this method of producing strange radiation was accompanied by other phenomena: a change in the weight of ampoules with water, "reactive" effects from such ampoules, when a light raft with an ampoule of water through which a laser was shone through, began to move towards laser, magnetization of non-magnetic materials. These results are described in the review [20].

In this review, it is impossible to describe in detail all the results of studies of strange radiation. Let us briefly mention the results of B.U. Rodionov and I.B. Savvatimova (**Fig. 15**) - the appearance of tracks during a glow discharge. The tracks were formed both on the surface of the electrodes inside the chamber and on photographic films outside the discharge chamber [21]. D.S. Baranov, V.N. Zatelepin et al. investigated tracks on CD-disks from various

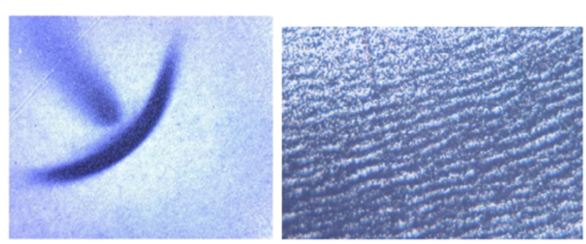


Fig. 14. *"Bird" on photographic film and its "fine structure" in the experiments of V.V. Evmenenko and others* [19].

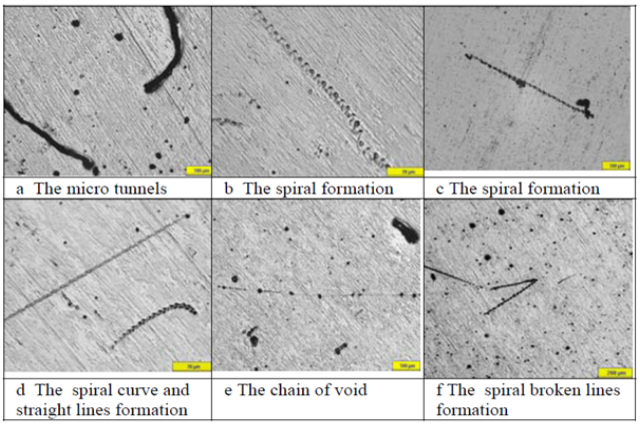


Fig. 15. *Tracks in the study of Rodionov and Savvatimova* [21].

sources (high-voltage electric discharge in an air-water mixture, combustion of propane, charging a smartphone, etc.); they observed extended tracks, craters and spherical particles [22]. Review and results of original experiments are presented in the paper of K.A. Fredericks [23]. A replication of experiments with an electric explosion in water and typical tracks of strange radiation is presented in [24] by C. Daviau et al.

Even a quick glance at the photographs of the tracks suggests that different researchers in different experimental conditions observed the same phenomenon. Some of the works were clearly related to the LENR theme, some were not. To the question posed in the title of this article, the joint consideration of many experiments does not give an unambiguous answer: perhaps LENR and strange radiation are just two phenomena that are noticed by researchers together. After all, in the presence of one anomalous effect, experimenters often pay attention to others at the same time. But does strange radiation always accompany low-energy reactions? Can strange radiation be considered as a marker of LENR? Is LENR the only reason for the strange radiation?

The next section of the article describes experiments that purposefully answered the question: is the appearance of tracks of strange radiation related to the operation of LENR reactors.

3. TRACK STATISTICS FROM OPERATING LENR REACTORS

In order to answer the question of whether there is an unambiguous connection between the operation of LENR reactors and strange radiation, it was necessary to estimate the intensity of strange radiation near and far from operating reactors. This required the creation of a technique for measuring the total track length, as well as the accumulation of statistics in the near and far zones from the reactors [25].

3.1. Materials and methods

Reactors of two types were used as devices in which LENR processes take place. The first device is a Ni - H reactor operating in the mode of continuous generation of excess heat (**Fig. 16***a*). This reactor operated nonstop for 225 days at an average excess heat release power of 200 W [26]. The second reactor is a plasma electrolysis cell in water with movable electrodes "Woodpecker" [27] (Fig. 16*b*). The upper electrode periodically comes into contact with the lower one, which leads to the appearance of plasma in the discharge gap. Used electrodes from graphite, copper, tungsten. In contrast to the Ni-H reactor, which operated in a relatively stable mode, the water reactor operated in various modes with a power consumption of 100–400 W.

To identify the tracks from the reactors, the method of sequential and parallel control was used. Previously, before the exposure at the reactors, the samples of the sensitive material were photographed using an optical microscope at low magnification (x55), then, after the exposure, photography of the entire sample was repeated. For further comparison, photographs of transparent materials were taken using a coordinate grid in the background with a positioning accuracy of 3 mm. Sequential control consisted in the fact that the analysis took into account only those tracks that were absent in the preliminary photos, but appeared in the samples after exposure near the reactors. Parallel control consisted in the fact that in parallel with the exposure at the reactors, the same samples were exposed in other places far from the reactors. The control samples were processed in the same way as the main ones.

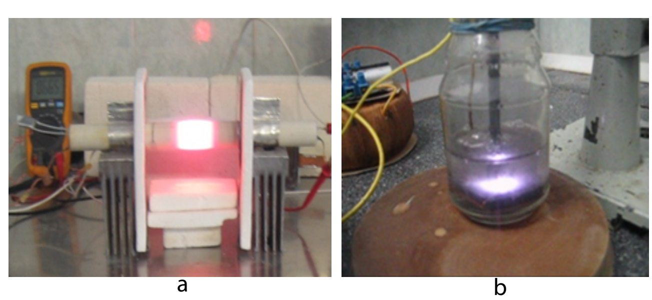


Fig. 16. *Reactor Ni-H (a) and reactor for plasma electrolysis in water (b).*

Various materials were tested to accumulate tracks. Initially, rolls of b/w photographic films and sheet X-ray films were used. However, photographic films turned out to be an inconvenient material for the purposes of this study, since the task was to estimate the rate of appearance of strange radiation tracks as reliably as possible, and not to study the types of tracks, which has been mainly done by researchers so far.

After it was found that tracks are formed on almost any smooth surfaces, we refused to use photographic materials that require rather complex processing, introducing artifacts that are difficult to control.

Convenient detectors for recording tracks that can be placed near a hot reactor are microscope slides.

In addition, muscovite mica with a thickness of ~15...30 μm and a size of 50×50 mm was tested. The accumulation rate of tracks on mica in preliminary studies turned out to be higher than on glass, with equal processing convenience, but this material was available only in small quantities.

The most convenient material turned out to be standard DVD-R disks made of polycarbonate. One side of the disk is very smooth and free from defects. The inner Al layer is a reflective surface. This is useful when analyzing tracks under a microscope. At the same time, DVD-R disks have a marked system of tracks, which creates a diffraction pattern, which can somewhat interfere with shooting and analyzing tracks at some surface illumination angles. The main results of a set of statistics were obtained on a DVD-R . Only the smooth side of the disks (polycarbonate) was analyzed.

The method of numerical estimation of the intensity of tracks consists in calculating the total length of the tracks and comparing the obtained values of the experimental samples with the control. For this, the photographs of the captured areas of the samples were first opened in a graphic editor and the tracks of strange radiation were outlined with a pencil tool of a fixed color and a fixed thickness. Then the total length of the lines of a given color was programmatically calculated from a group of photographs. Thus, the intensity estimation technique contains both a manual part (outlining tracks) and an automatic part (calculating the total length). The counting method does not imply the calculation of the average length of the tracks.

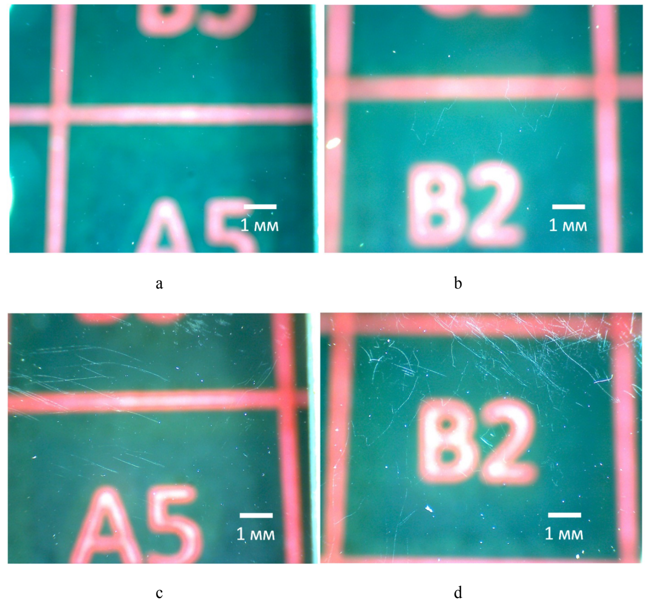


Fig 17. *Photo of mica before exposure (a, b) and after (c, d). Water reactor, distance 5 cm.*

3.2. Examples of tracks

In order to acquaint readers with the main object of this study - extended tracks of strange radiation, we will show several characteristic photos. **Fig. 17** shows a photo of the mica areas - before the exposure at the reactors (*a, b*) and after (*c, d*). It can be seen that the original mica is either clean of tracks (*a*) or has a small number of tracks (*b*), the source of which is unknown (judging by the date of manufacture on the pack, the mica was stored after manufacture for about 30 years). There are many more tracks after exposure. Groups of narrow lines, usually curved, several mm long, visible under lateral illumination appeared (these tracks are especially clearly visible under dark-field microscopy).

Tracks are usually grouped in areas of the order of 1 cm^2. A typical group of tracks on mica is shown in **Fig. 18**. Tracks within a group are often identical in shape (for example, "boomerang" in Fig. 18). Twin

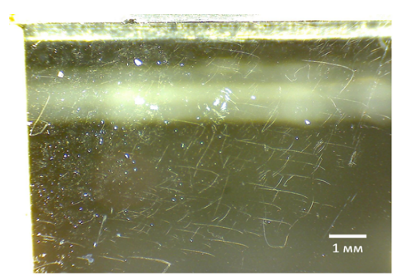
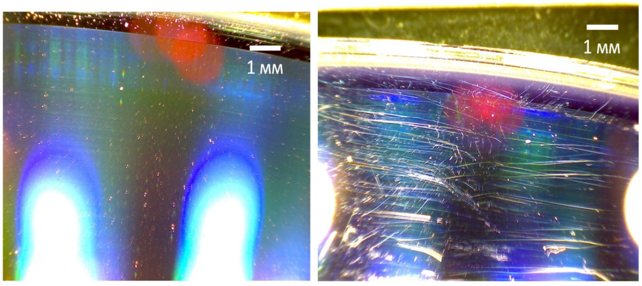


Fig. 18. *Twin tracks on mica: the "boomerang" shape is repeated many times. Ni-H reactor, distance 5 cm.*



a b

Fig. 19. *Photo of the surface of DVD disks. (a) - control (fume hood 2 m from the water reactor), (b) - 10 cm from the water reactor.*

tracks are localized within one group. Tracks in other groups have a different shape.

Similar track features are found on DVDs. In **Fig. 19** for comparison shows a photo of the disks of control (*a*) and experiment (*b*). Here, too, a large number of tracks are in a group with an area of the order of 1 cm^2. They are mostly parallel tracks several mm long. A more detailed analysis of the track structure is presented in [25], but here we present just one illustration concerning the structure of periodic tracks.

Fig. 20-21 show fragments of a periodic track on DVD at different magnifications. The constancy of the step of such tracks has already been indicated by other authors, we can confirm such observations. But a surprise was the complete repetition of the track structure from period to period, with an accuracy up to the resolution of an electron microscope (tens of nanometers). Periodic traces are repeated down to the smallest detail (**Fig. 21**). It is impossible to explain such a picture by anything other than rolling on the surface of a micron-sized solid particle. The ratio of the track width and period length in **Fig. 20** roughly corresponds to 2π. Similar periodic traces were observed on glass , while on mica the nature of surface destruction was different [25].

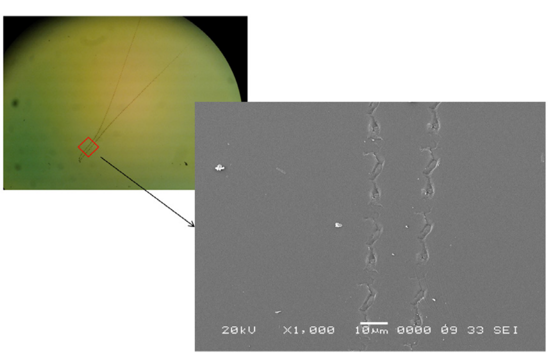


Fig. 20. *Optical and SEM image of a fragment of a track on DVD.*

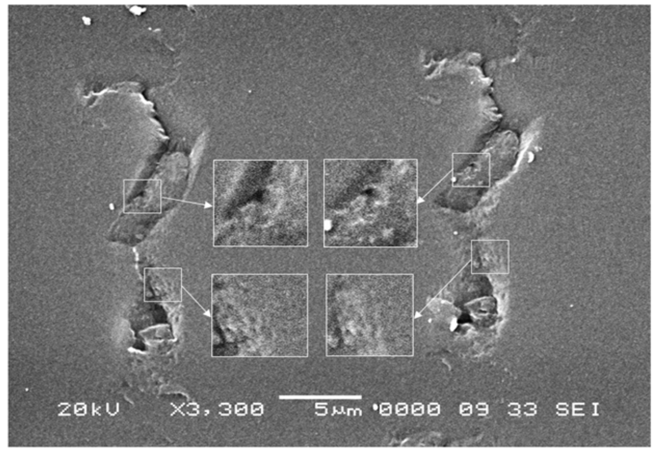


Fig. 21. *Detailed SEM image of a fragment of a track on DVD (increased contrast). Explanations in the text.*

3.3. Track statistics

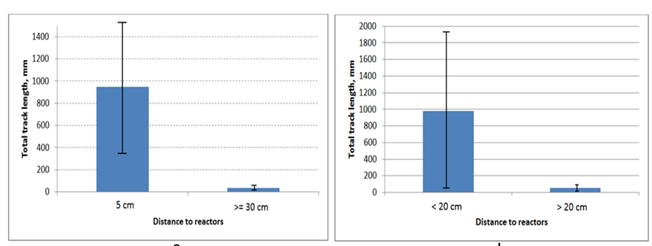
This section presents the main results of analyzing the statistics of the total track length. Exposure conditions and summary results are presented in **Table I**.

Analysis of the data shows that the total track length increases significantly near the reactors.

Results for mica and DVDs obtained near and far from the reactors are shown in **Fig. 22**. Further these areas are referred to as "near zone" (up to 20 cm) and "far zone" (more than 20 cm). Control exposures with parallel control are also included in the far zone.

Sequential control showed that the total length of tracks on mica before exposures corresponds, on average, to parallel control, i.e. far zone. Analysis of the initial surface condition of DVD (before exposure) showed complete absence of tracks.

The average total length of tracks on mica for distances of 5 cm from the reactors (948 mm per sample) exceeds by more than an order of magnitude the average total length for large distances (37 mm



a b

Fig. 22. *Average value of total track lengths for mica and DVD, depending on proximity to the reactor. (a) - for mica at a distance of 5 cm (5 exposures) and at distances from 30 cm (10 exposures); (b) - for DVD at distances <20 cm (49 exposures) and at distances> 20 cm (30 exposures). The intervals show the average deviations.*

Table 1

Summary results of track statistics by exposure conditions.

	Number of samples, pcs.	Total track length, mm	Exposure hours	Hours of operation of the reactor	Average total length, mm	Density of tracks, mm/cm^2	Track accumu-lation rate per exposure, mm/cm^2/h	Track accumu-lation rate during reactor operation, mm/cm^2/h
Mica 50x50 mm								
5 cm to Ni- H reactor	4	4096	1344	1344	1024	41.0	0.1219	0.1219
5 cm to the water reactor	1	642	120	2	642	25.7	0.2140	12.8400
30 cm from Ni-H reactor	2	117	336	336	58.5	2.3	0.0139	0.0139
Fume hood (>2 m from reactors)	4	107	672	0	26.75	1.1	0.0064	
In an adjacent room (> 5 m from reactors)	2	109	336	0	54.5	2.2	0.0130	
Exposure in oven 200C	2	38	6	0	19	0.8	0.2533	
DVD-R								
5-13 cm from Ni- H reactor	7	3928	1440	1440	561	5.6	0.0272	0.0272
20-30 cm from Ni- H reactor	3	247	528	528	82	0.8	0.0047	0.0046
Up to 20 cm from the water reactor	42	44089	7240	194	1050	10.5	0.0609	2.2726
20-60 cm from water reactor	15	513	2520	45	34	0.3	0.0020	0.1140
1 m from water reactor	5	757	512	27	151	1.5	0.0148	0.2804
Fume hood (>2 m from reactors)	7	116	595	0	17	0.2	0.0020	

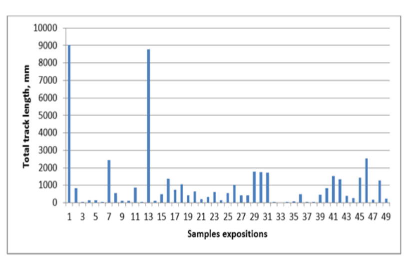
per sample). At the same time, there is a large scatter of values (the figure shows the average deviation[1]). A large scatter is also observed in the far zone, but large values of the sums of track lengths (> 500 mm per sample) are completely absent in exposures in the far zone.

The results on the DVD are similar to those obtained for mica: an average of 980 mm per sample for the near field (up to 20 cm from the reactors) and 54 mm per sample for the far field (over 20 cm). There is also a large scatter of the values obtained both in the near zone and in the far zone, and the absence of large values for the far zone.

To illustrate the large scatter of data, **Fig. 23** shows the total track lengths for various DVD images, separately for the near and far zones on the same scale.

Note that the shown in Fig. 22 data on the total track lengths for mica and for disks were obtained for different areas of the detectors. The area of the mica sheet is 25 cm^2, the working area of the disk is 100 cm^2. The average total length of tracks in the near zone turned out to be approximately the same, but the density of tracks (total length per 1 cm^2) for mica is 4 times higher. There may be several reasons for this difference. First, the susceptibility of different materials to strange radiation is possible. Second: for mica, it is possible to accumulate tracks on both sides, while for DVD, tracks were analyzed only on one side, not covered with paint. Third, the effectiveness of the track counting technique for transparent material (mica) and material with a mirror-like interior (DVD) can be different.

To assess the character of the dependence of the track intensity on the distance, an experiment was carried out, the results of which are shown



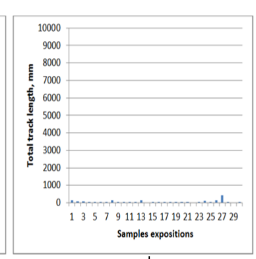


Fig. 23. *Total lengths of tracks on DVD by exposure: (a) - for the near zone, (b) - for the far zone.*

[1]Due to the large scatter of values, the intervals in the graphs show the mean of the absolute values of the deviations of the data points from the mean, rather than the standard deviations, which are about 2 times greater.

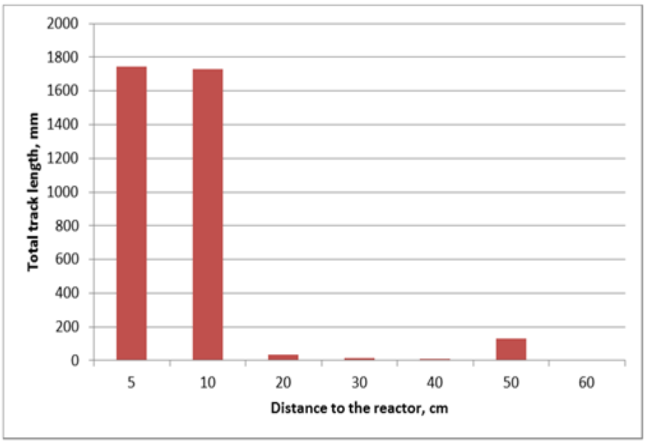


Fig. 24. *Results of the experiment with different distances of the disks from the water reactor.*

in **Fig. 24**. Seven disks were placed at different distances from the water reactor. The disks, which were at a distance of 5 and 10 cm, showed a large number of tracks; at a greater distance, the number of tracks drops by more than an order of magnitude.

Another feature of the results obtained is as follows. The exposure time of the samples in the continuously operating Ni-H reactor was, on average, one week. The exposure time at the water reactor can be calculated in different ways. The total time of its active work per one exposition usually amounted to several hours, while the samples themselves stood continuously at the reactor and during the hours when the reactor was not working (calendar time on average is also one week). Table I summarizes both continuous exposure times and reactor operation times. If we calculate separately the average track density from Ni-H and water reactors in the near zone (the sum of the track lengths, divided by the total area of the samples), we obtain similar values: 10.0 mm/cm^2 for Ni-H reactor and 10.6 mm/cm^2 for a water reactor. However, if we divide them by the time of active operation and obtain the rate of track accumulation during the active operation of the reactors, it turns out that a water reactor produces an order of magnitude more tracks per hour of operation (0.0540 mm/cm^2/h for a water reactor, 0.0036 mm/cm^2/h for Ni-H reactor). Thus, a variant is possible when strange radiation accumulates in the water during the operation of the reactor and gradually comes out of it [1]. To clarify the situation, additional studies were carried out.

3.4. Experiments with aftereffect

Separate exposures were carried out during the operation of the reactor and after shutdown, but with the preservation of the geometry of the arrangement of the disks and the reactor [28].

Test 1

The pulsed plasma electrolysis reactor described in [29] was used as a source of strange radiation. The reactor was turned on for 5 minutes. During his work, disks W1 and W2 were located next to it (10 cm). After turning it off disks were removed to a distance of > 3 m, and instead placed disks A1.1 and A1.2. They stood for one day next to the shutdown reactor. Then they were removed to a distance of > 3 m, and instead of them disks A2.1 and A2.2 were placed for two days. Then they were also removed and instead of them A3.1 and A3.2 were placed - for three days next to the shutdown reactor. In addition to these disks, at a distance from the reactors there were two control disks C1 and C2, which were placed for one day.

In **Fig. 25***a* shows the results in absolute values; Fig. 25*b* - track accumulation rate (mm/h) by disk group. It can be seen, on the one hand, that the tracks are mainly collected already with the reactor turned off, and, on the other hand, the rate of collection is maximum when the reactor is on. The rate of track accumulation after shutdown gradually decreases with time and approaches control on 4-6 days.

Test 2

The accumulation experiment was repeated one more time. In the second experiment, one disk was used during a short turn-on (5 minutes) of the same reactor (W20.02), and one disk each for aftereffect on the first day after shutdown (A20.02), on the second day after shutdown (A21.02), 3-5th days after shutdown (A22.02), as well as the sixth (A25.02) and seventh (A26.02) days after shutdown. There were also two control disks (C27.02*a*, C27.02*b*).

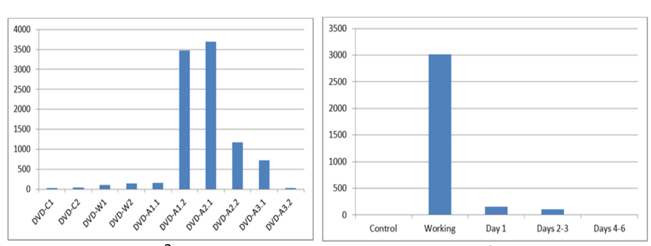


Fig. 25. *Experiment 1 with aftereffect . (a) - total track lengths by disks (mm), (b) - accumulation rate of total track lengths by disk groups (mm/h).*

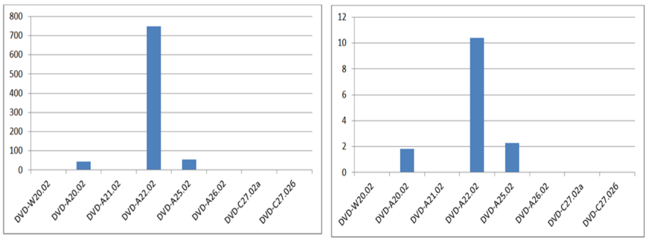


Fig. 26. *Experiment 2 with aftereffect. (a) - total lengths of tracks on disks (mm), (b) - rate of accumulation of total lengths of tracks on disks (mm/h).*

Unfortunately, the results of the experiment revealed the previously noted variability of the track intensity: the total intensity of experiment 2 was an order of magnitude less than for the first experiment with accumulation. There were one disks in each exposure, that is, two times less than in the first experiment. The results are shown in **Fig. 26**.

A noticeable number of tracks appeared only on the disk, which was exposed within three days after the operation of the reactor. The rest of the disks, including "working" showed near-zero track intensities. However, these results do not contradict those shown in the first accumulation experiment, taking into account the variability of the number of tracks from time to time.

There was also an attempt at a third experiment in order to find out what exactly in the reactor accumulates the strange radiation - the vessel or the electrolyte. But practically zero intensities were obtained in it in all disks. On this, experiments to study the aftereffect were discontinued.

At least the results of two experiments indicate that after shutting down the reactor for several days, the reactor itself and/or the environment around it operates as a source of strange radiation tracks. This must be taken into account by LENR experimenters.

3.5. Impact of disk orientation

Experiments were also carried out with different orientations of the disks against the water reactor in the near zone. A diagram of the total track lengths was plotted for three experiments with the same conditions for placing 4 disks around the reactor. The orientation of the disks and the distance from the core to the centers of the disks in each experiment are shown in **Fig. 27**. The sensitive side of the disks at a distance of 2 and 4 cm was directed towards the discharge.

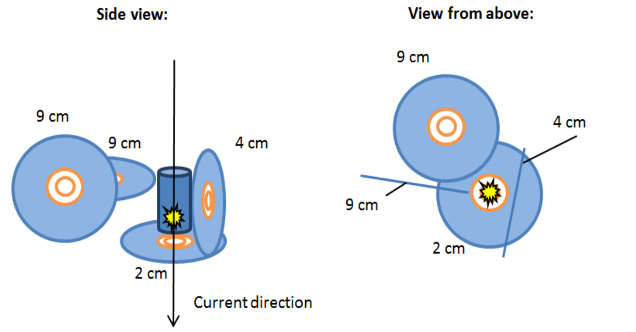


Fig. 27. *The orientation of the disks and the distance to the centers of the disks from the discharge.*

The values from the total track lengths are shown in **Fig. 28**. If we analyze the dependence on the distance, we can see that the average for the sum of the track lengths is approximately the same - about 600 mm per disk for three distances (2, 4, 9 cm) with a large scatter. Also, there is no regularity in the accumulation of tracks by disks, depending on their orientation (for a distance of 9 cm, vertical (v) and horizontal (h) orientations are shown). The operating time of the reactor in two repetitions is 3 hours, in the third - 4 hours.

3.6. Shielding issues

Initially, we believed that the penetrating power of the strange radiation was extremely high, and for some of the exposures, DVDs were wrapped in foil. Surprisingly, there were no tracks in any of the expositions where the disks were wrapped in foil. Therefore, we continued our experiments in this direction purposefully.

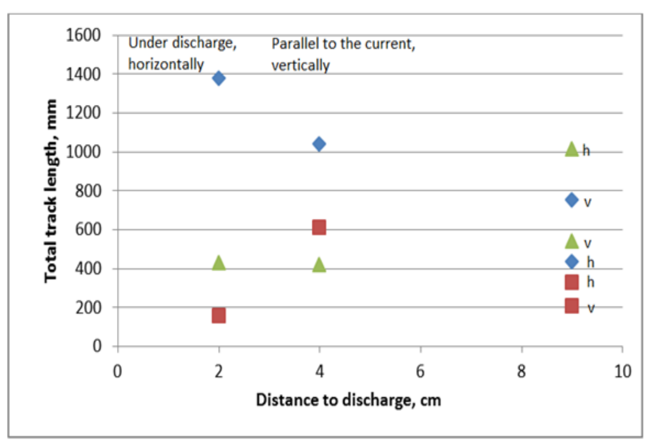


Fig. 28. *Three repetitions of experiments with different orientations of the disks. Diamonds - first repeat, squares - second repeat, triangles - third. The letters "v" and "h" show the vertical and horizontal orientations of the disks for a distance of 9 cm.*

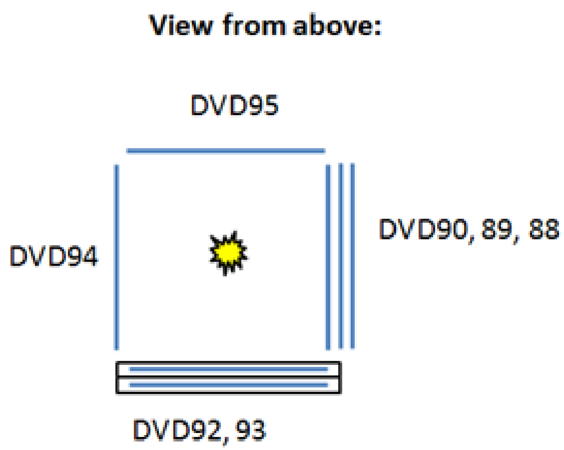


Fig. 29. *Experiment 1 with screening. The layout of the disks near the "Woodpecker" reactor.*

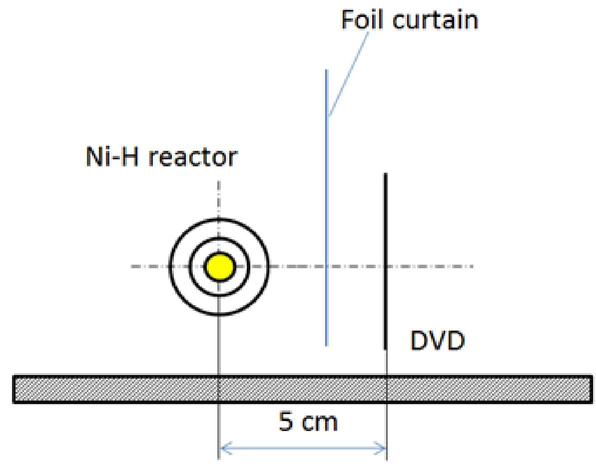


Fig. 31. *Scheme that did not interfere with the formation of tracks on DVD.*

For illustration, we present the results of one of the experiments with screening [28]. Seven disks were exposed near the "Woodpecker" plasma discharge in water reactor (**Fig. 29**) at a distance of 5...10 cm from the reactor, and 2 control disks in one meter from the reactor. The reactor was located in the fume hood. The three disks were stacked, in a row, with the sensitive side to the reactor, in the order of DVD90 - DVD89 - DVD88 from the reactor. The other two disks were each wrapped in 10 μm aluminum foil (DVD92, DVD93). Two more disks were unshielded - DVD94, DVD95, the sensitive side to the reactor. The active operation time of the reactor is 8 hours, the continuous exposure time is 6 days.

The results are shown in **Fig. 30**. It can be seen that in a stack of 3 disks, the closest one received many times more tracks than those that he obscured. Disks in foil showed a relatively small number of tracks. Unshielded disks DVD94, DVD95 show a large number of tracks for first one, the second had a small number, at the level of shielded disks.

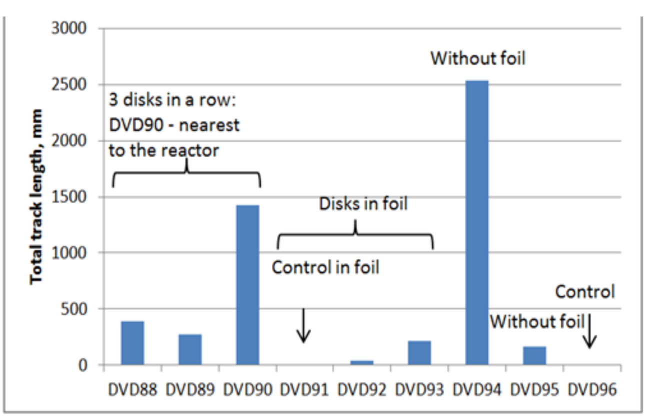


Fig. 30. *Results of experiment 1 with screening.*

The control disks showed no tracks. One of the control disks was opened (DVD96), the other was wrapped in foil (DVD91).

Other experiments confirm the results of the described experiment [28]. Disks in a stack protect each other from tracks. Disks located in a plastic box closed on all sides are also protected from tracks of strange radiation.

However, these results turn out to be paradoxical if we take into account that part of the exposures from the hot Ni-H reactor was performed in the following scheme: an aluminum foil shutter covered the DVD disks from the thermal radiation of the reactor (**Fig. 31**). This shutter did not form a continuous envelope around the disk, and was spaced from the disk at a distance of several cm. In this case, the disks gained a significant number of tracks, in contrast to the control disks located at a distance from the reactor. The track protection works, therefore, only in the case of a solid screen, or a screen covering a large solid angle around the protected object.

4. DISCUSSION

Returning to the question in the title of the article - what is the relation between strange radiation and LENR, let's try to draw conclusions from the experiments carried out. The statistics of the appearance of tracks indicates that a large number of tracks appear in the near zone of operating reactors, and continues to appear for several days after the reactor is turned off. In addition, there is a strange background radiation - its source is unknown, and its intensity is one or two orders of magnitude less.

However, if we refine the question of whether the appearance of tracks is connected with LENR reactions inside reactors (let's call it a strong hypothesis), then the results of the experimental part of this work, although they do not contradict this hypothesis, nevertheless, do not rigorously prove it. To prove this hypothesis, it is necessary to study the possibility of the appearance of tracks from other factors involved in the operation of LENR reactors (electric current, electromagnetic fields, high temperature, sorption/desorption, phase changes, etc.), as well as to test the reactors in regimes without nuclear reactions, but with the participation of these factors.

So, the first conclusion is that strange radiation accompanies the operation of LENR reactors. However, the discovered large variability of strange radiation does not allow drawing a direct analogy with ordinary nuclear reactions and ordinary ionizing radiation (alpha, beta, gamma radiation, neutrons), which are usually considered as a marker of nuclear reactions. Strange radiation appears sporadically near a stably operating reactor: with equal geometry and exposure time, sometimes a lot of tracks appear near the reactor, sometimes there are none at all. This raises the question of both the nature of the strange radiation and the development of methods for measuring its intensity. Perhaps the movements of the particles that cause the tracks are irregular and occur in random directions, and it is necessary to collect the tracks in the entire solid angle. Perhaps we are at such an early stage in the study of the phenomenon that we see only distant and minor consequences of something that generates strange radiation. It may also turn out that the cause of the strange radiation is some elusive third factor, which is also the cause of LENR, but it is still in the shadows and has not been investigated at all. By jointly studying LENR and strange radiation, we can reach their common cause, and then these two phenomena will receive a common explanation.

One of the possible explanatory schemes is that the particles themselves, forming the tracks, directly cause low-energy nuclear reactions. In our studies, using the energy-dispersive method, there were attempts to see traces of nuclear transformations along the tracks, as a consequence of hypothetical nuclear catalysis [25]. Unfortunately, we did not find extraneous elements within the error of the method, in contrast to the studies [7,8].

Summarizing many publications, we can see that strange radiation appears as a result of quite different processes:

• Discharge in vacuum
• Discharge in water
• Glow discharge
• Arc discharge
• Pulsed electric field of a capacitor
• Heating system Ni-H
• Electrolysis
• Laser radiation
• Rotating objects

So far, it cannot be said that all these processes also lead to LENR. In addition, in biological transmutation [30], traces of strange radiation in the form of tracks have not yet been noticed. At least some of the processes may not generate strange radiation, but "release" the accumulated radiation from the substance - the aftereffect gives rise to such a hypothesis. Therefore, it is premature to conclude that LENR is necessary and sufficient for the strange radiation to occur.

The results obtained raise new questions. The structure of the tracks, studied by optical, electron, and atomic force microscopy, directly indicates that the tracks are formed by micron-sized solid particles that are harder than a sensitive surface, including mica, glass, plastic, and aluminum [25,28]. If the source of such particles are LENR reactors, how do these particles pass through a solid reactor vessel, especially multilayer ones? What forces are used to press these particles against the surface of sensitive materials over the course of millimeters and centimeters of their movement over the surface? Why are they grouped and move as a whole group as a whole, forming a kind of solid frame? What causes the abrupt changes in the direction of movement of these grouped particles? At what speed do they move and what is the very nature of these particles? All these questions must be answered not speculatively, but experimentally.

Many researchers, in an attempt to explain the observed tracks, have argued in favor of the hypothesis of magnetic monopoles. There is no reason to believe that the periodic tracks in our study are of any other nature compared to the recognizable tracks in the publications of Urutskoyev, Ivoilov, Adamenko and Vysotsky, Shakhparonov and others. However, the mechanism of periodic motion of magnetically charged particles in the MOS-structure proposed by Adamenko and Vysotsky cannot explain the detailed picture of periodic tracks, where clearly there are traces of a micron-sized solid. Especially if we take into account the appearance of similar tracks on different homogeneous materials, and periodic tracks are only a small part of all tracks. It is in no way the movement of individual elementary particles, to which nuclear physicists are accustomed to analyzing the tracks of radioactive radiation. Track photos like Fig. 21 sharply narrow down the range of possible hypotheses.

Another note concerns possible replications. The author began his experiments with strange radiation [31, 32] with an attempt to repeat the results of the Evmenenko group [19]. Replication was rather unsuccessful - when statistics were accumulated, the number of tracks in the experiment was equal with the number of tracks in the control. The study, however, was useful - it became clear that there was a background component of the strange radiation, the first numerical method for estimating the intensity of tracks was applied, the author was faced for the first time with a large variability of the intensity. But the example of this replication clearly shows that due to a lack of understanding of the strange radiation nature, researchers often find themselves in the position of looking for a black cat in a black room. Worse, they don't even suspect that the cat itself is somewhere - they look through the microscope only the scratches from its claws. But we must eventually find a way to turn on the light in this room.

And, since the picture of the phenomenon really turns out to be unusual, it is worth taking a closer look at adjacent anomalous phenomena. For example, if particles forming tracks of strange radiation exert a force on the surface, it is necessary to pay close attention to the behavior of sensitive detectors with a moving mechanical part: experimenters have long noticed the strange behavior of torsional balance from various factors, for example, from moving water nearby [33,34,35]. If in two studies that are completely different in design, experimenters noticed that strange radiation, passing through various substances, changes its properties (the diameter of microcraters in [17] and the biological effect in [16]), then one should pay attention to publications in which such the effect is also noticed, for example, from the radiation of torsion generators, see, for example, [36,37].

Finally, the development of research on strange radiation and LENR could create a new scientific revolution that integrates many anomalous results and requires bold hypotheses to explain them, which in turn will need to be tested. This will require the mobilization of not only researchers of this narrow topic, but a significant part of the scientific community. But is the scientific community ready for such a mobilization?

5. SUMMARY

1. Many experimenters have noticed that tracks of strange radiation accompany low-energy nuclear reactions in completely different experimental design.
2. The investigated LENR reactors of two types (Ni-H and plasma electrolysis in water) are sources of strange radiation tracks.
3. The intensity of tracks in the zone closer than 20 cm from the reactors is an order of magnitude or two higher than at a greater distance.
4. Besides tracks from reactors, there are background tracks from unknown sources.
5. Tracks appear unevenly both in time and in spatial arrangement on samples. Tracks that are copies of each other are usually localized in areas of the order of 1 cm^2.
6. Tracks are formed when solid microparticles with a size of the order of microns moving along the surface. The nature of the particles and the force pressing them to the surface remain unknown.
7. Tracks of strange radiation are screened by various solid surfaces - plastic, foil. One closely spaced surface can provide good track protection for the other. The continuous screens protect well.
8. Strange radiation, although it has operating LENR reactors as one of its sources, can be accumulated in the substance and leave the substance within several days after the reactors are turned off.

9. The nature of the strange radiation, in our opinion, remains undisclosed; many of its paradoxical properties are still unexplained.

6. CONCLUSION

At this stage, strange radiation is inconvenient to use as a reliable marker of LENR: the large variability of track lengths does not yet allow practical use of tracks as reliable evidence of the occurrence of LENR reactions in reactors. Apparently, without disclosing the nature of strange radiation, we will not be able to make either its reliable detectors, or understand its relation with low-energy nuclear reactions, the nature of which is also still unclear. But progress in this area is possible only in attempts to create new methods of detection and in new experiment designs. New intensive targeted experiments are needed, and bold research programs in related fields are needed. The race is got by running.

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