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## LENR as a manifestation of weak nuclear interactions. New approach to creating LENR reactors

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**Abstract:** Hypothesis is suggested about the generation of neutrino-antineutrino pairs in collisions of particles of matter at temperatures of several thousand degrees. Particularly intense generation should occur in metals and dense plasma. Resulting neutrinos and antineutrinos can excite exothermic nuclear reactions in the surrounding matter. A number of experiments were carried out that confirmed the energy release predicted by the hypothesis in a substance near a metal heated to a high temperature. The source of the neutrino-antineutrino (hot metal or dense plasma) can be separated from the "fuel" - the substance where nuclear transformations occur. This opens up the possibility for designing highly efficient LENR reactors. Several reactors based on this approach have been tested. In all reactors, at a sufficiently high temperature of the metal core, heat was detected in excess of the electricity consumed. A number of experiments indicate that the participation of hydrogen in nuclear transmutations is optional.

**Keywords:** hot metals, dense plasma, neutrino, collisions, nuclear transmutations, LENR, incandescent lamps, LED, calorimetry

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## 1. INTRODUCTION

Researches in the field called LENR (low-energy nuclear reactions, cold nuclear transmutations, cold nuclear fusion) have shown the diversity of this phenomenon. These are processes in metals with hydrogen dissolved in them [1,2]. These are processes in plasma [3,4], in gas discharge [5], in electrolysis [6], and even in biological systems [7,8]. In addition to energy release, which far exceeds the capabilities of chemical reactions, LENR is characterized by a large variety of emerging chemical elements. For example, after water treatment in the Energoniva reactor [3], Li, Be, B, C, Mg, Si, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Sn, Se, Pb, Bi were detected. In the nickel-hydrogen LENR reactor, which worked for 7 months [2], Ca, V, Ti, Mn, Fe, Co, Cu, Zn, Ga, Ba, Sr, Yb, and Hf were found. Initially, the content of these elements in the "fuel" and structural materials was negligible. An overview of elemental and isotopic changes in nickel-hydrogen LENR reactors is provided in the article [1].

Huge variety of chemical elements can be explained by nuclear transformations in nuclide collectives initiated by low-energy neutrinos (antineutrinos) [9,10].

## 2. INTERACTION OF LOW-ENERGY NEUTRINOS WITH COLLECTIVES OF ATOMS. VARIETY OF POSSIBLE TRANSFORMATIONS

De Broglie wavelength  $\lambda = h/p$  ( $h$  is Planck's constant,  $p$  is the momentum) characterizes the size of the interaction region. Neutrinos (antineutrinos) with an energy of about 1 MeV, which occur in nuclear reactions, have  $\lambda \sim 10^{-12}$  m. Distance between the atoms in a liquid or solid substance is  $\sim 10^{-10}$  m, i.e. the possibility of nuclear transformations under the action of such neutrinos does not go beyond one atom. At a sufficiently low energy, value  $\lambda$  exceeds the distance between the atoms, and the interaction can cover many atoms. For example, a neutrino with a mass of 0.28 eV with a kinetic energy of

0.2 eV (average energy of thermal motion at a temperature of about 2000°C) is  $\sim 3.2 \cdot 10^{-6}$  m, i.e., much larger than the interatomic distance. Nuclear transformations become possible, in which two or more atoms are transformed into two or more other atoms, and electrons can be included in these transformations. In this case, the laws of conservation of the baryon charge (i.e., the number of nucleons), electric and lepton charges must be fulfilled. Since neutrinos at low energies cannot make a significant contribution to the energy of the reaction, only transformations with a positive energy balance can occur. Law of conservation of momentum defines the distribution of reaction products by the velocities and angles of expansion.

Transformations without participation of electrons can be written in the form of equations [11]:

$$(A1, Z1) + (A2, Z2) + \nu \rightarrow (A3, Z3) + (A4, Z4) + \nu' + Q$$

$$A3 + A4 = A1 + A2, Z3 + Z4 = Z1 + Z2$$

или

$$(A1, Z1) + (A2, Z2) + \bar{\nu} \rightarrow (A3, Z3) + (A4, Z4) + \bar{\nu}' + Q$$

$$A3 + A4 = A1 + A2, Z3 + Z4 = Z1 + Z2,$$

например,  $\nu + {}^7\text{Li}_3 + {}^{16}\text{O}_8 \rightarrow {}^{11}\text{B}_5 + {}^{12}\text{C}_6 + \nu' + 1.504 \text{ МэВ}$ .

Neutrino (antineutrino) on the left side of the equations must have a sufficiently low energy so that the de Broglie wavelength (the interaction region) is greater than the distance between the reacting atoms. Neutrino (antineutrino) in the right part acquires a significant part of the energy  $Q$  and freely carries it away, reducing the amount of energy given by the emerging nuclei to the environment.

For transformations involving two nuclei involving electrons, the following processes are possible [12]:

- *Rearrangement of nucleons*

$$(A1, Z1) + (A2, Z2) + e + \bar{\nu} \rightarrow (A3, Z3) + (A4, Z4) + Q$$

$$A3 + A4 = A1 + A2, Z3 + Z4 = Z1 + Z2 - 1,$$

for example,  ${}^{60}\text{Ni}_{28} + {}^1\text{H}_1 + e + \bar{\nu} \rightarrow {}^4\text{He}_2 + {}^{57}\text{Fe}_{26} + 0.569 \text{ МэВ}$ .

- *Rearrangement of nucleons with the release of electrons*

$(A1, Z1) + (A2, Z2) + \nu \rightarrow (A3, Z3) + (A4, Z4) + e + Q$   
 $A3 + A4 = A1 + A2, Z3 + Z4 = Z1 + Z2 + 1,$   
 for example,  ${}^{61}\text{Ni}_{28} + {}^{64}\text{Ni}_{28} + \nu \rightarrow {}^{63}\text{Cu}_{29} + {}^{62}\text{Ni}_{28} + e + 0.995 \text{ M}\text{eV}.$

Computer calculation of possible transformations of two stable nuclides into two other stable nuclides without and with the participation of electrons is made [11,12]. The abundance of such transformations is striking. More than a million variants have been identified. The results obtained can be taken from the author of this article in the form of an EXCEL file.

It suggests that the abundance of emerging chemical elements in LENR processes is of the same nature. But everyone knows about the extremely weak intensity of the interaction of neutrinos with matter. Therefore, for the appearance of tangible effects, neutrino fluxes of enormous magnitude are needed. Where can they come from in a LENR reactor? From Outer Space? According to [13, 14], the density of the galactic neutrino flux is about  $10^7 \text{ cm}^{-2}\text{s}^{-1}$ . This is clearly not enough to initiate the kilowatt power processes achieved in a number of LENR reactors.

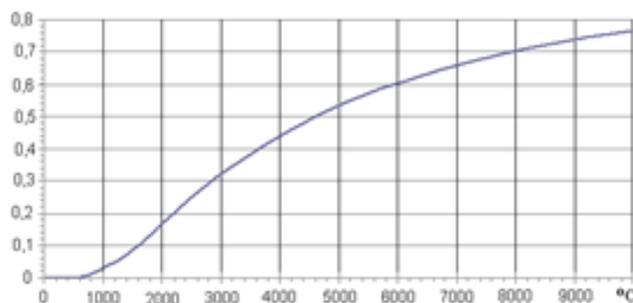
To find a possible source of intense neutron fluxes, we pay attention to one characteristic feature of LENR processes: they have quite a noticeable energy threshold. This is especially clearly seen in the case of nickel-hydrogen reactors, where excessive heat release is detected only at temperatures above  $1200^\circ\text{C}$  [1,2], i.e. when average energy of the matter particles during thermal motion exceeds 0.1 eV. In electroplasma reactors [3,4], temperature reaches several thousand degrees (tenths of eV). In installations with a glow gas discharge plasma [5], electron energy is of the order of 1 eV. At first glance, the processes in which LENR features are detected at room temperature (electrolysis [6], biology [7,8]) are an exception to this rule. But in fact, for acts of energy exchange, both in electrochemistry and in the processes of cellular

metabolism, it is the energy of the order of 1 eV that is characteristic.

Neutrino has a very small mass (currently it is believed that the mass of the electron neutrino and antineutrino does not exceed 0.28 eV [15]), so they can be formed as a result of inelastic collisions of matter particles (electrons, ions, neutral atoms) during their thermal motion. Since there are no exact data on the mass of neutrinos, we will assume that the minimum energy for the formation of a neutrino-antineutrino pair is 0.5 eV. Average energy of 0.5 eV has particles in a body heated to  $3200^\circ\text{C}$ . Recall that average energy of thermal motion  $\bar{\epsilon} = 1.5kT$  ( $k = 1.38 \cdot 10^{-23} \text{ J/K}$  is the Boltzmann constant,  $T$  is the absolute temperature). Some particles have the same and higher energy at a lower temperature. Using the particle energy distribution function in thermal motion [16]

$$f(\epsilon) = \frac{2\sqrt{\epsilon}}{\sqrt{\pi}(kT)^{3/2}} \exp\left(-\frac{\epsilon}{kT}\right),$$

it is possible to find the dependence on the temperature of the fraction of particles having an energy higher than the specified one. For an energy of 0.5 eV, this dependence is shown in **Fig. 1**. At room temperature, the fraction of such particles is  $10^{-8}$ . A noticeable fraction of particles with an energy higher than 0.5 eV appears only at a temperature of about  $1000^\circ\text{C}$ . At a temperature of  $1600^\circ\text{C}$ , such particles are already 10%, and at a temperature of  $4500^\circ\text{C}$ , 50%. Therefore, when you made assumptions threshold thermal generation of neutrino-antineutrino pairs of about  $1000^\circ\text{C}$ .



**Fig. 1.** Fraction of particles having an energy above 0.5 eV, depending on the temperature.

At present, the level of knowledge about the properties of neutrinos is insufficient to reliably determine the probability of the formation of neutrinos and antineutrinos in thermal collisions of matter particles. It is only clear that the probability of this is small. A small probability is compensated by a large number of collisions. Let's estimate the number of collisions per second during thermal motion in metals. Most often in metals, electrons collide with atoms. The length of the run between collisions is about  $10^{-8}$  m. The velocity of the electrons at a temperature of 2000K is about  $2 \cdot 10^5$  m/s [17, p.117]. Consequently, the electron under its thermal motion experiences  $2 \cdot 10^{13}$  collisions per second. Given that the number of free electrons in  $1 \text{ cm}^3$  of metal is about  $10^{23}$  [17, p.115], we find the number of collisions per second in  $1 \text{ cm}^3$  of metal:  $2 \cdot 10^{36}$ .

Such a huge number of collisions suggests that neutrinos and antineutrinos arise in hot metals with an intensity sufficient to initiate nuclear transformations that give significant energy release even with very small probabilities of processes associated with neutrinos. Let's assume that only one of the  $10^{10}$  collisions generates a neutrino-antineutrino pair, and only one of the  $10^{10}$  neutrinos or antineutrinos causes a nuclear transformation. Even with such huge losses,  $1 \text{ cm}^3$  of hot metal produces  $2 \cdot 10^{16}$  nuclear transformations per second. In each act of such transformations, about 1MeV is allocated. Since 1 J is equivalent to  $6.25 \cdot 10^{12}$  MeV, the power of the released energy is approximately 2 kW.

We will make a similar estimate for a gas heated to a temperature sufficient for thermal generation of neutrinos (several thousands °C). In a gas, even at such temperatures, there are significantly fewer electrons and ions than neutral atoms (molecules), so it is mainly atoms (molecules) that collide. The speed of their movement is about  $10^3$  m/s, and the length of the run before the collision at atmospheric pressure is about  $10^{-7}$  m [18]. Hence, an atom (molecule) experiences about  $10^{10}$  collisions per

second.  $1 \text{ cm}^3$  of hot gas at atmospheric pressure contains about  $10^{19}$  atoms (molecules). It has about  $10^{29}$  collisions per second, which is 7 orders of magnitude less than in metals. Thus, in a gas heated to a temperature of several thousands degrees, the thermal generation of neutrinos and antineutrinos, although possible, occurs with an intensity many orders of magnitude lower than in metals.

For intensive generation of neutrinos and antineutrinos, a hot, dense medium with a high content of free electrons is needed. In addition to metals, such a medium is high-density plasma, which occurs briefly, for example, during explosions of metal conductors or with a sufficiently strong pulsed energy release in liquids.

Thus, the assumption of the possibility of nuclear transmutations under the action of low-energy neutrinos arising in hot metals or dense plasma allows us to explain two empirically discovered properties of LENR: the variety of chemical elements that arise and the temperature threshold of the order of  $1000^\circ\text{C}$ . One can also understand the absence of hard nuclear radiation. In the proposed mechanism, rearrangement of nucleons occurs without introducing energy that could cause the excitation of nuclear levels, which could lead to the emission of gamma quanta. Lack of energy input leads to the fact that out of all possible variants of transformations, those are realized in which the most stable nuclides are formed, which are not prone to either alpha or beta radioactivity, or to emission of neutrons. Released energy is realized in the form of the kinetic energy of the resulting nuclides. Despite the fact that they can have an energy of up to several MeV, when they are decelerated, hard radiation does not occur, since massive charged particles, even at high energies, lose their energy mainly as a result of ionization and excitation of the atoms of the medium in which they move [19]. At the same time, electromagnetic radiation is emitted, but "soft", with the energy of quanta up to several

keV. In addition, the radiation of "soft" quanta occurs when the deformed electron shells of the resulting nuclides are normalized. This allows us to explain the appearance of soft X-rays near the operating LENR installations.

Note that in weak nuclear interactions (beta processes) involving neutrinos (antineutrinos), there is no "Coulomb barrier problem", which for a long time was the justification for the "impossibility" of cold nuclear transmutations.

**3. EXPERIMENTS SUPPORTING THE HYPOTHESIS OF THE ROLE OF NEUTRINOS IN COLD NUCLEAR TRANSMUTATIONS**

Above hypothesis predicts that a metal heated to a temperature of about 1000°C or higher emits neutrinos and antineutrinos, which cause the appearance of initially absent chemical elements in the surrounding matter. This is accompanied by release of heat. Let us consider several confirmatory experiments reported at the 26th Russian Conference on Cold Nuclei Transmutations and Ball Lightning [20].

In the experiments described below, tungsten filament was used as hot metal in incandescent lamps, in particular, in halogen lamps with a tubular quartz shell with a nominal power of 150 or 300 W (Fig. 2), as well as in a conventional incandescent lamp with a power of 40 W. To reduce the power consumption, at which a sufficiently high temperature of the filament is achieved, you can use a reflective coating of the lamp cylinder. Such a coating of aluminum foil had a lamp with a power of 40 watts.

Dependence of the specific resistance of tungsten on temperature is well known [21].



**Fig. 2.** Halogen incandescent lamp and 40W incandescent lamp wrapped in aluminum foil.



**Fig. 3.** Halogen incandescent lamp inside a cylindrical container.

Therefore, the temperature of the tungsten filament is easy to determine by measuring its resistance at room temperature  $R_{20}$ , as well as the voltage  $U$  and current  $I$  in the operating mode. Knowing the voltage and current, we determine the resistance  $R = U/I$ , and then the temperature by the formula  $t(^{\circ}C) = 197.6(R/R_{20}) - 1.57(R/R_{20})^2 - 176$ . It should be noted that the described method of determining the temperature gives an average value, since the filament has colder (at the ends and near the supports) and hotter areas.

Using the same data, you can determine the power consumed by the lamp  $P = U \cdot I$ .

**3.1. EXPERIMENTS 1. MEASUREMENT OF HEAT OUTPUT POWER USING AN AIR FLOW CALORIMETER**

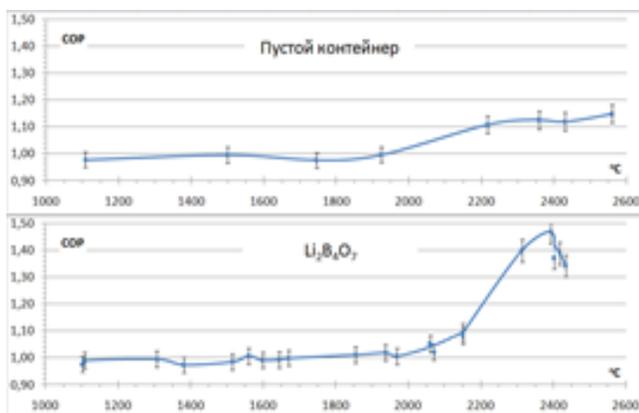
The halogen incandescent lamp is placed inside a cylindrical stainless steel container with two walls, the space between which can be filled with various substances (Fig. 3). To measure heat output power, air flow calorimeter is used (Fig.4). Heat output power is determined by increasing the temperature of the air washing the object under study, located in a thermally insulated cylinder with a diameter of 20 cm and



**Fig. 4.** Air flow calorimeter.

a length of 100 cm. The temperature difference between the outlet and inlet air is measured by a differential thermocouple. To create a stable air flow, a fan connected to a stable power source is used. Calibration measurements showed that the measurement error of this calorimeter at a heat output power of 100 to 2000 W does not exceed 3%.

**Fig. 5** shows the dependence of the thermal coefficient COP (the ratio of the heat output power to the electrical power consumed) the temperature of the filament in the halogen lamp. The measurements were made with an empty container and with a container filled with lithium tetraborate  $\text{Li}_2\text{B}_4\text{O}_7$  (10 g). Excessive heat generation at temperatures above  $2200^\circ\text{C}$  is observed even in the case of an empty container, but a container filled with lithium tetraborate gives a stronger effect. With an electrical power consumption of 292 W, the average temperature of the tungsten filament reached  $2390^\circ\text{C}$ . Heat output power measured by a flow-through air calorimeter, 428W. Thus, the release of energy in excess of the spent on heating the thread is 136 watts. Further temperature rise leads to an increase in excess power, however, as can be seen from Fig. 5, the thermal coefficient decreases. This is due to the fact that at high temperatures, the power required for heating grows much faster ( $\sim T^4$ ) than the excess heat release, the growth of which is similar to the dependence shown in Fig. 1.



**Fig. 5.** Thermal coefficient as a function of the filament temperature in halogen lamp, measured with an empty container and a container filled with lithium tetraborate.

Note that this reactor does not contain hydrogen, and, nevertheless, reliably gives excessive heat generation. This indicates the need to reconsider the established view that hydrogen is necessary for the LENR to flow. This conclusion is confirmed by the nuclear transmutations found in the lead-tin alloy that does not contain hydrogen (see the section "Experiment 4. Halogen incandescent lamp and tin-lead alloy").

### 3.2. EXPERIMENTS 2. MEASUREMENT OF HEAT GENERATION POWER BY THE RATE OF TEMPERATURE INCREASE IN WATER

In these experiments, incandescent lamps were immersed in water (450 ml) poured into a glass Dewar vessel (**Fig. 6**). The heat output was determined by the rate of increase in the water temperature. Calibration experiments have shown that by varying the measurement time, this calorimeter can measure the heat output power in the range of 10-500 W with an error of no more than 1%. To speed up the establishment of thermal equilibrium, a manual stirrer was used.

Several different types of incandescent lamps have been tested. In all experiments, excess heat was detected when the average temperature of the filament exceeded  $2200^\circ\text{C}$ . **Fig. 7** shows



**Fig. 6.** Experimental installation with a water calorimeter. 1 - a Dewar vessel with water in which an incandescent lamp is immersed, 2 - thermometer, 3 - meter of current, voltage and power consumption, 4 - stopwatch, 5 - stirrer.

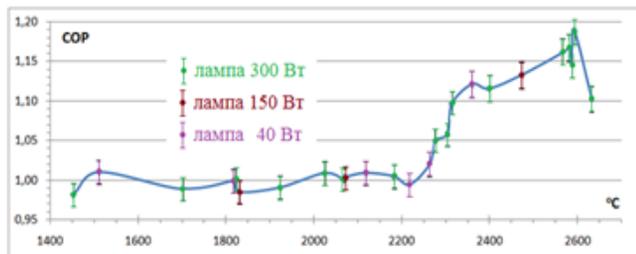
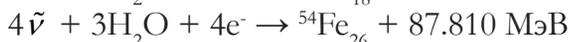
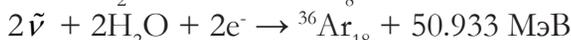
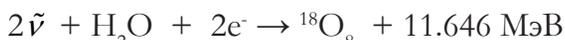
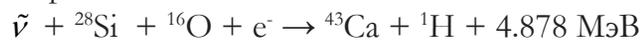


Fig. 7. Dependence of the thermal coefficient COP on the filament temperature. Set of data obtained in different experiments.

a set of data obtained in experiments with an incandescent lamp with a nominal power of 40 W and halogen lamps of a tubular design (Fig. 2) with nominal power of 150 and 300 W. Due to the stronger cooling of the lamp shells with water compared to air, 60-70% higher than the rated power is required to achieve a sufficiently high filament temperature.

Fig. 7 shows that for all the tested lamps, which are very different in power and design, a noticeable increase in the thermal coefficient is observed at temperatures above 2200°C. At a thread temperature of about 2500°C, the thermal coefficient reaches a value of 1.18, but at a higher temperature it decreases. This is due to the fact that at high temperatures, the power required for heating grows much faster than excess heat generation. This effect was also observed in type 1 experiments (see Fig. 5).

Excessive heat generation can occur in lamp cylinders containing SiO<sub>2</sub> and in water. For example, the following nuclear transformations are possible:



To make sure that new chemical elements actually appear in the substance near the incandescent lamps, special rather long-term experiments were carried out, which convincingly confirmed the appearance of nuclides that were initially absent.

#### 4. INVESTIGATION OF ELEMENTAL AND ISOTOPIC CHANGES IN MATTER NEAR INCANDESCENT LAMPS

To confirm above hypothesis about the generation of neutrino-antineutrino pairs in the collision of particles of matter at temperatures of several thousand degrees, it is important to make sure not only that a lot of heat is released in the substance surrounding a hot metal, but also that new chemical elements appear in accordance with nuclear reactions that can be produced by low-energy neutrinos [11,12]. The experiments described above showed the presence of excessive heat release at a sufficiently high metal temperature, but they were not long enough to accumulate a noticeable amount of new elements. This problem is solved in further experiments.

##### 4.1. EXPERIMENT 3. A HALOGEN INCANDESCENT LAMP AND A CIRCULATING SOLUTION

The halogen incandescent lamp (220V, 300 W) was located in a quartz tube, through which a 10% aqueous solution of KNO<sub>3</sub> seeped (Fig. 8). The circulating solution was cooled by passing through heat exchanger. The reactor operated for 20 hours at power consumption of 450 W. Heat output power, determined by the heating rate of the solution, is about 500 W. Average



Fig. 8. Experimental setup with a circulating KNO<sub>3</sub> solution and a halogen incandescent lamp.

temperature of the tungsten filament is about 2400°C.

Samples of the solution taken before and after the experiment, after evaporation, were transferred for analysis of the elemental composition to the SYNTHESSTECH Research Center. Two methods were used: X-ray fluorescence (XRF) and mass spectral (ICP MS). The results of the analyses are presented in **Table 1**.

It can be seen that the content of many elements after treatment of the solution increased by tens or even hundreds of times. Using the tables of possible transformations of nuclides [11,12], it is possible to detect many possible nuclear transformations, which result in the chemical elements indicated in Table 1. The starting elements can be potassium, nitrogen, oxygen, and hydrogen. Below are some of the possible nuclear transformations that result in the detected lithium, boron, magnesium, aluminum, calcium, and iron:

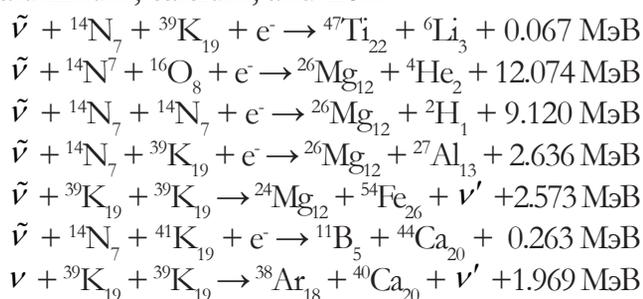


Table 1.

Results of analysis of  $\text{KNO}_3$  samples by RFA and ICP MS methods before and after treatment in an incandescent lamp unit in  $\text{KNO}_3$  solution (mass %).

	Before		After	
	XRF	ICP MS	XRF	ICP MS
Li		0.007		0.12
Be		0.017		0.08
Mg		0.050		0.55
Al		0.010		3.30
K	99.01		86.04	
Ca	<0.01		10.2	
Fe	<0.01		0.66	
Cu	0.018		2.04	
Cu		0.010		1.10
Zn	<0.01		0.58	
Zn		0.010		0.13
Ni	<0.01		0.048	

The calcium content increased the most (the appearance of calcium is also typical for many other LENR experiments [1,2]). The last of the written equations are just two of the many possible ways in which calcium can appear. In this regard, we can recall the research of Louis Kervran, who found that chickens continue to lay eggs, the shell of which contains a lot of calcium, even if it is completely deprived of its sources of calcium, replacing calcium with potassium [7]. He suggested that calcium occurs as a result of the nuclear reaction  ${}^{39}\text{K}_{19} + {}^1\text{H}_1 \rightarrow {}^{40}\text{Ca}_{20} + 8.337 \text{ MeV}$ , which caused the ridicule of physicists: potassium and hydrogen cannot combine because of the "Coulomb barrier", and if this somehow happened, the huge energy release of the chicken would incinerate. However, if this happens as a result of weak interactions  $\nu + {}^{39}\text{K}_{19} + {}^1\text{H}_1 \rightarrow {}^{40}\text{Ca}_{20} + \nu' + 8.337 \text{ M}\text{eB}$ , both the problem of the "Coulomb barrier" and the problem of huge energy release are removed. According to the laws of conservation of energy and momentum, if energy is released in a system of two particles, it is distributed inversely to the masses. Since the mass of the neutrino is much less than the mass of the calcium nucleus, almost all of the released energy is carried away by neutrino. Where do the neutrinos that initiate the nuclear reaction come from? As already noted, cellular metabolism is characterized by energies of the order of 1 eV, which is sufficient for the formation of neutrinos and antineutrinos.

#### 4.2. EXPERIMENT 4. HALOGEN INCANDESCENT LAMP AND TIN-LEAD ALLOY

The 300-watt halogen incandescent light bulb was wrapped in lead-tin alloy tape and placed in a container of water. To avoid overheating and boiling, the water was cooled by pumping through a fan-cooled coil (**Fig. 9**). The lamp power consumption is 480 W. Heat output power of about 550 W was determined by the water heating rate. Temperature of the tungsten filament is 2400-2450°C. Working time is 40 hours.



**Fig. 9.** Halogen incandescent lamp wrapped with a tin-lead alloy tape in a vessel with water. The water is pumped through a fan-cooled coil.

Samples of the lead-tin alloy before and after processing in the described installation were transferred for analysis of the elemental composition by XRF and ICP MS methods to the SYNTHESSTECH Research Center. The results of the analyses are presented in **Table 2**.

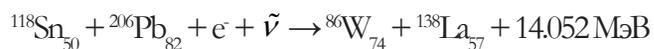
Table 2.

Content of some elements in the lead-tin alloy before and after processing (mass %)

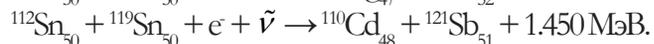
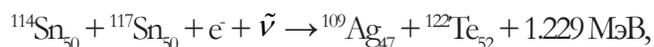
	Before		After	
	XRF	ICP MS	XRF	ICP MS
Li		0.0001		0.0063
B		0.0012		0.012
Na		0.13		1.16
Al		0.001		0.024
K		0.056		0.75
Ca		0.018		0.34
Fe	<0.01		0.27	
Fe		0.014		0.13
Co		0.0002		0.014
Ni	<0.01		0.073	
Ni		0.0006		0.018
Cu		0.012		0.041
Zn		0.0038		0.040
Pd		0.0002		0.0005
Ag		0.006		0.024
Cd		0.0005		0.0011
Sn	45.7	43.6	40.3	46.0
W	<0.01		1.51	
W		0.00003		0.105
Pb	54.2	44.5	57.9	31.4
Bi		0.0005		0.057

It can be seen that the content of many elements after processing has increased many times. Especially strongly increased the content of lithium, sodium, aluminum, potassium, calcium, iron, cobalt, silver, cadmium, tungsten, bismuth.

The alloy of tin and lead is favorable for the appearance of tungsten: tin has 12 isotopes, lead has 4 isotopes. Combinations of these isotopes open up 32 channels for converting tin and lead to tungsten [12]. We show one of the variants of such transformations:



Rearrangements between tin isotopes can give rise to the formation of silver in 8 channels and cadmium in 9 channels, for example:



Using the tables of possible transformations of nuclides [11,12], it is possible to detect many possible nuclear transformations, which result in the chemical elements indicated in Table 2.

Note that the XRF analysis provides information about the elemental composition in the thin surface layer of the test sample. Therefore, it is quite possible to participate in transmutations in this layer of hydrogen, which is part of the water that washes the sample during the experiment. In contrast to XRF, ICP MS analysis provides thickness-averaged information. Hydrogen cannot penetrate deep into the lead-tin alloy. Therefore, if the participation of hydrogen in transmutations is necessary, the analysis of the composition of the samples during the ICP MS study would reveal significantly smaller changes than changes in the surface layer by the XRF method. However, strong changes were detected by both methods, which confirms that the participation of hydrogen in nuclear transmutations is optional. This is also indicated the calorimetric experiment with an incandescent lamp and lithium tetraborate, described above.



**Fig. 10.** Halogen incandescent lamp in boiling water with  $\text{NaBiO}_3$  suspension.

#### 4.3. EXPERIMENT 5. HALOGEN INCANDESCENT LAMP AND BOILING SOLUTION

In a glass vessel with 900 ml of water and 14 g of sodium bismuthate ( $\text{NaBiO}_3$ ), a halogen incandescent lamp with a rated power of 150 W is immersed (**Fig. 10**). The duration of the experience is 20 hours with a power consumption of 270 W. The temperature of the tungsten filament is 2200-2300°C. Excess heat generation with a power of about 25 W was determined by the evaporation rate of water. Since sodium bismuthate is insoluble in water, it was suspended during the operation of the setup.

After the end of the experiment, XRF analyses of the precipitate and the evaporated solution, as well as the initial  $\text{NaBiO}_3$  powder, were performed at the SYNTHESTECH Research Center. The results are presented in **Table 3**.

In the starting material, except for bismuth, only platinum was found. The presence of a number of other elements was revealed in the formed sediment and in the solution. In particular, as in experiment 4, a lot of tungsten appeared. This can happen, for example, in the following ways:

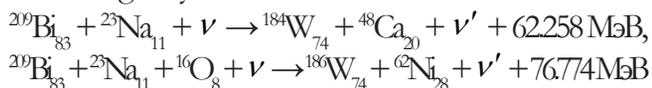


Table 3.

Results of the analysis of the content of chemical elements before and after the experiment (mass %).

	Starting powder	Treated	
		Sediment	Solution
S	<0.01	<0.01	6.167
Ca	<0.01	0.231	<0.01
Fe	<0.01	0.092	<0.01
Cu	<0.01	<0.01	0.396
Dy	<0.01	<0.01	0.451
Ta	<0.01	0.246	<0.01
W	<0.01	0.289	88.371
Pt	0.562	0.496	<0.01
Bi	99.498	99.646	4.615

#### 4.4. EXPERIMENTS 6. HOT METAL OR LIGHT?

In 2013, at the Kurchatov Institute, Yu.N.Bazhutov and his colleagues realized a series of experiments with solutions of LiOH, NaOH, and  $\text{Na}_2\text{CO}_3$  illuminated by a laser or LED with a wavelength of 625-650 nm [24,25]. It was found that a tritium appears in the solutions (1 tritium atom per  $10^{13}$ - $10^{14}$  radiated photons). No noticeable excess heat generation was detected.

Ubaldo Mastromatteo discovered the appearance of C, O, Na, Si, Al, Mg, S, Cl, K, Ca, and Cu in the atmosphere of hydrogen and deuterium as a result of two weeks of laser irradiation with 633 and 405 nm wavelengths of palladium film [26]. This experiment was recently reproduced by Jean-Paul Biberian [27]. After three months of irradiation in the atmosphere of hydrogen or deuterium of a palladium film with a 5 mW semiconductor laser with a wavelength of 650 nm, initially absent N, O, Na, S, Al, Ca, Fe, Ni, Zn, Mo were detected. The presence of excessive heat release was not controlled.

Thus, light exposure causes nuclear transmutations. Our experiments described in this article are accompanied by very intense light radiation. Perhaps it is due to the action of light that the appearance of new elements and excessive heat generation is associated? Photons with a wavelength of 650 nm have an energy of about 2 eV, which is more than enough to produce a

pair of neutrinos-antineutrinos that cause nuclear transmutations. Such energy is also sufficient to generate a monopole-antimonopoly pair with masses of 0.048 eV, which, as it is assumed, can also cause nuclear transmutations [28].

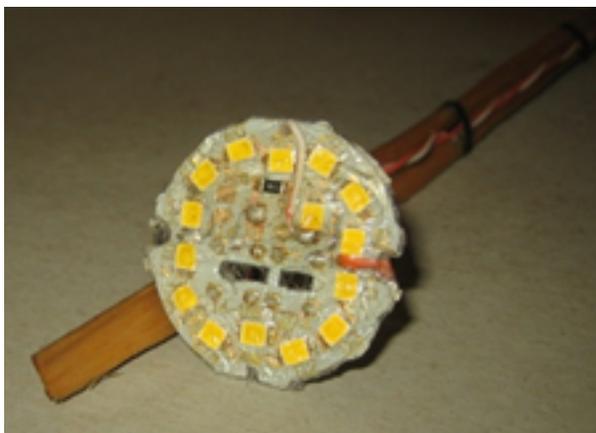
To test this possibility, a calorimetric experiment was conducted with a chain of 15 LEDs extracted from a household LED lamp (Fig. 11). The same calorimeter with water in the Dewar vessel was used, which was used in experiments with incandescent lamps (see Fig. 6).

The measurements showed that the LEDs immersed in water do not give a noticeable excess heat release ( $COP = 1.00 \pm 0.01$ ). The LED block, surrounded by aluminum foil or quartz, also gave no noticeable excess heat generation.

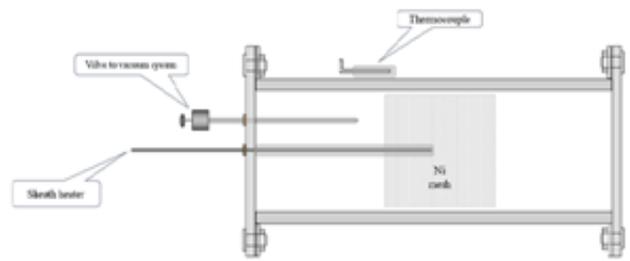
It can be concluded that, although light causes nuclear transmutations, they can only be noticed when very long-term illumination with powerful light. The efficiency of the reactors described in this article is related precisely to the presence of hot metal.

**5. NEW APPROACH TO CREATING  
LENR REACTORS**

In structures that have already become traditional, the zone with a high temperature (metal saturated with hydrogen, plasma) is surrounded by a layer of a substance that performs the contradictory tasks of thermal insulation and heat removal. This does not allow us to create powerful reactors with a high ratio of released and consumed energy.



**Fig. 11.** LEDs used in the calorimetric experiment.

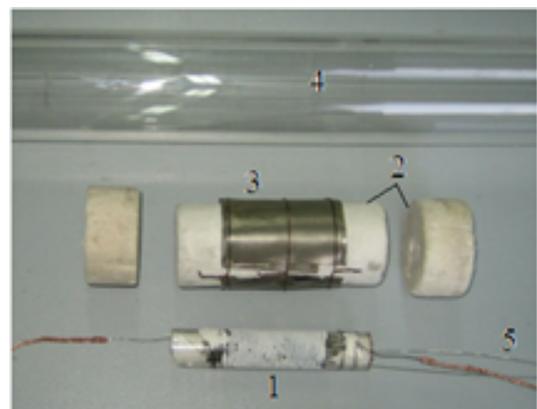


**Fig. 12.** Diagram of the Mizuno reactor.

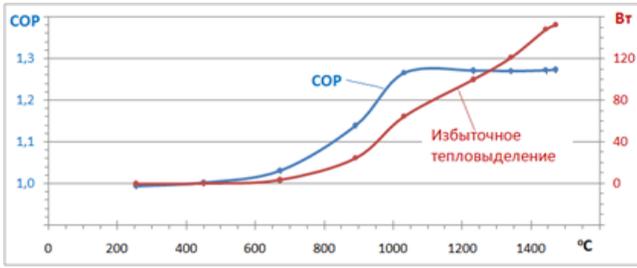
The presented hypothesis allows a new approach to the design of LENR reactors. The source of the agent that causes nuclear transmutation (hot metal or dense plasma) can be placed inside the thermal insulation. This allows you to reach a high temperature using a low-power heater. Fuel (a substance where processes with a large heat release occur) can be located on the periphery, which allows you to efficiently remove the heat generated.

This is the configuration of the reactor created by Tadahiko Mizuno [22] (Fig. 12), which, consuming 300 watts of electrical power, produced 2-3 kW of heat. In this reactor, the high-temperature heater is located inside a thermal insulation - rarefied deuterium gas. The fuel (nickel mesh with a thin layer of palladium deposited on it, in which deuterium is dissolved) is located at the periphery in thermal contact with the outer wall of stainless steel.

In the C3 reactor (Fig. 13), an iron cylinder weighing 60 g was heated by a tungsten spiral



**Fig. 13.** Details of the C3 reactor. 1 - iron cylinder in a sapphire tube, on which a tungsten heater is wound; 2-thermal insulation; 3-nickel mesh; 4-quartz tube; 5- thermocouple W-Re.

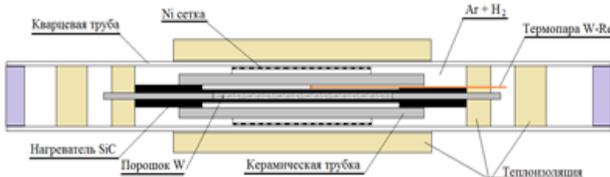


**Fig. 14.** The excess heat output power and the thermal coefficient of the C3 reactor as a function of temperature.

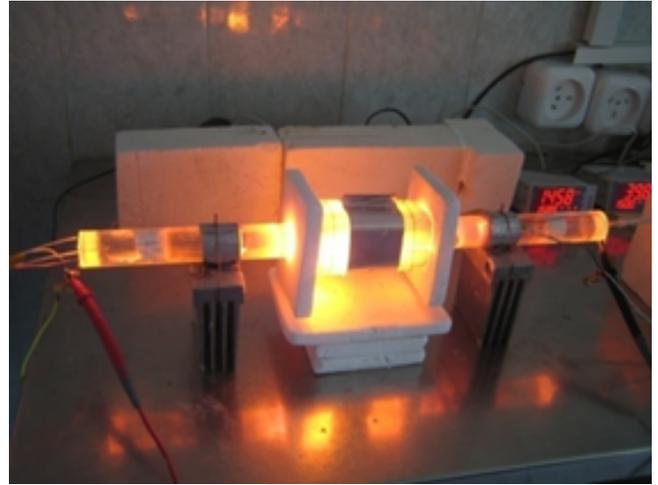
wound on a sapphire tube. The "hot zone" is surrounded by thermal insulation made of porous quartz, wrapped in nickel nets. Between the grids there was 15 g of nickel powder saturated with hydrogen. The outer shell is a quartz tube filled with a mixture of hydrogen and argon. To measure the heat output power, a flow-through air calorimeter was used (see Fig. 4).

**Fig. 14** shows the dependence of the excess heat output power and the thermal coefficient of the C3 reactor on the temperature. A noticeable excess heat release is observed already at the iron core temperature of  $800^{\circ}\text{C}$  and continuously increases with increasing temperature. The thermal coefficient at a temperature of about  $1000^{\circ}\text{C}$  reaches a value of about 1.3. An increase in temperature does not lead to an increase in COP due to the rapid increase in the power consumed by the electric heater.

The W1 reactor uses a tubular silicon carbide heater and a tungsten core, which allows for a higher temperature than the C3 reactor, which has an iron core. Design of the reactor is shown in **Fig. 15**. Inside the silicon carbide heater there is a tungsten powder weighing 3.1 g. The heater is surrounded by thermal insulation made of porous ceramics. Between the thermal insulation and the outer quartz pipe is hydrogen-rich nickel



**Fig. 15.** Design of the W1 reactor.



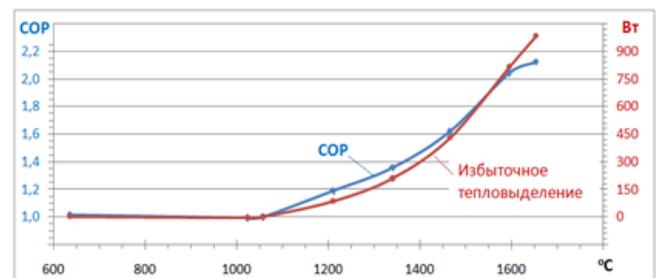
**Fig. 16.** Reactor W1 and the process of operation.

mesh ("fuel"). A view of the reactor in operation is shown in **Fig. 16**.

**Fig. 17** shows the dependence of the excess heat output power and the thermal coefficient of the C3 reactor on the temperature. This reactor produced up to 1.000 W of excess power. A noticeable excess heat generation appears at a temperature of  $1100^{\circ}\text{C}$  and increases with increasing temperature. The thermal coefficient also increases, reaching a value of 2.2 at a temperature of about  $1600^{\circ}\text{C}$ . At higher temperatures, growth slows down.

## CONCLUSION

A number of experiments have been carried out to confirm the hypothesis that low-energy neutrinos, which occur as a result of collisions of matter particles during their thermal motion, can cause nuclear transformations. The energy release predicted by the hypothesis in a substance near a metal heated to a high temperature is confirmed. Analysis of changes in the elemental composition in the substance



**Fig. 17.** Excess heat output power and thermal coefficient of the reactor W1 as a function of temperature.

around incandescent lamps showed a significant increase in the content of a number of chemical elements.

The presence of such changes, along with the detected excess heat release, proves that, indeed, the hot metals emit an agent that initiates nuclear transformations in the surrounding matter. The correspondence of the detected transformations to possible nuclear reactions initiated by neutrinos (antineutrinos) indicates that these agents are neutrinos and antineutrinos.

This allows a new approach to design of LENR reactors. Source of the agent that causes nuclear transmutation (hot metal or dense plasma) can be placed inside of thermal insulation, which allows you to achieve a high temperature with low energy consumption. Fuel (a substance where processes with a large heat release occur) can be located on the periphery, which allows you to efficiently remove the heat generated. Several reactors manufactured according to this scheme have been tested. One of them managed to achieve an excess heat output of 1 kW (COP = 2.2).

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