J. Condensed Matter Nucl. Sci. 36 (2022) 362–376

Research Article

Investigation of LENR Processes Near Incandescent Metals

A.G. Parkhomov*
KIT Research and Development Laboratory, Moscow, Russia

R.V. Karabanov
Scientific Research Center SINTEZTECH, Russia, Sochi

E.O. Belousova
Institute of Experimental Mineralogy, Russian Academy of Sciences

Abstract

This paper describes experiments conducted to test the assumption that the source of the agent that causes nuclear transmutations in LENR can be metals heated to a sufficiently high temperature. Tungsten filaments in incandescent lamps, hot iron rods and tungsten powder were used as the heated metal. Heat releases much greater than the electricity used to heat the material, and the formation of many initially absent chemical elements was found. Based on the experimental results obtained by the authors and other researchers, a generalization of the properties of LENR is made, which can form the basis of a theory of this phenomenon.

Keywords: Hot metals, Nuclear transmutations, LENR, Incandescent lamps, LED, Calorimetry

1. INTRODUCTION

LENR studies have shown a wide variety of manifestations of this phenomenon. It appears in metals with hydrogen dissolved in them [1], [2], in plasma [3], [4], in gas discharge [5], in electrolysis [6] and in biological systems [7], [8]. In addition to energy releases, which far exceed the upper limits of chemical reactions, LENR is characterized by a huge variety of emerging chemical elements. For example, in a nickel-hydrogen LENR reactor created in our laboratory, which worked for 7 months continuously, Ca, V, Ti, Mn, Fe, Co, Cu, Zn, Ga, Ba, Sr, Yb, Hf were found [2]. This proves the presence of nuclear transmutations in the LENR process. The appearance of new elements is found not only in the "fuel" but also in the surrounding matter. In [9], [10], it was suggested that the most effective source of the agent that causes nuclear transmutations in LENR processes is metals heated to a sufficiently high temperature. This paper describes a number of experiments specifically carried out to test this assumption. Let us consider several

*Corresponding author: alexparh@mail.ru

Figure 1. Halogen incandescent lamp and 40W incandescent lamp wrapped in aluminum foil.

confirmatory experiments reported at ICCF-23 and the 26th Russian Conference on Cold Nuclei Transmutations and Ball Lightning [11].

2. MEASUREMENTS OF EXCESS HEAT GENERATION IN EXPERIMENTS WITH HOT METAL

In the experiments described below, a tungsten filament was used as hot metal in incandescent lamps, in particular, in halogen lamps with a tubular quartz shell, with the nominal power of 150 or 300 W (Fig. 1), as well as in a conventional 40 W incandescent lamp. To reduce the power consumption, at which a sufficiently high temperature of the filament is achieved, you can use a reflective coating such as aluminum foil wrapped around the lamp. Aluminum foil was used with the 40-watt lamp.

To avoid problems measuring the electrical power consumed by the reactors, we use conventional alternating current with a frequency of 50 Hz. We use conventional transformers with a switchable or continuously adjustable secondary winding. A typical diagram of the power supply and measuring equipment can be seen in [2]. Digital multimers were used to measure current and voltage. In addition, energy meters were used, which allowed measuring voltage, current, power, power factor and the amount of electricity consumed with an error of no more than 1%.

Dependence of the specific resistance of tungsten on temperature is well known [12]. Therefore, 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 $t(°C) = 197.6(R/R_{20}) - 1.57(R/R_{20})^2 - 176$. 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·I.

2.1. Experiment 1. Measurement of Heat Output Power Using an Air Flow Calorimeter

The halogen incandescent lamp was placed inside a cylindrical stainless steel container with two walls, the space between which can be filled with various substances (Fig. 2). To measure heat output power, air flow calorimeter was used (Fig. 3). The object under study was placed in a thermally insulated cylinder with a diameter of 20 cm and a length of 100 cm. Heat output power was determined by measuring the temperature of the air flowing over the object. The temperature difference between the outlet and inlet air was measured with a differential thermocouple. To create a stable air flow, a fan connected to a stable power source was 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%.

Figure 4 shows the dependence of the thermal coefficient COP (the ratio of the heat output power to the electrical power consumed), and 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 $Li_2B_4O_7$ (10 g). Excess heat generation at temperatures above 2200°C is observed even in the case of an empty container, but a container filled with lithium tetraborate gives a stronger effect. With electrical power consumption of 292 W, the average temperature of the tungsten filament reached 2390°C. Heat output power measured by flow-through air calorimeter, was 428W. Thus, release of power in excess of the power used to heat the filament is 136 W. Further temperature rise leads to an increase

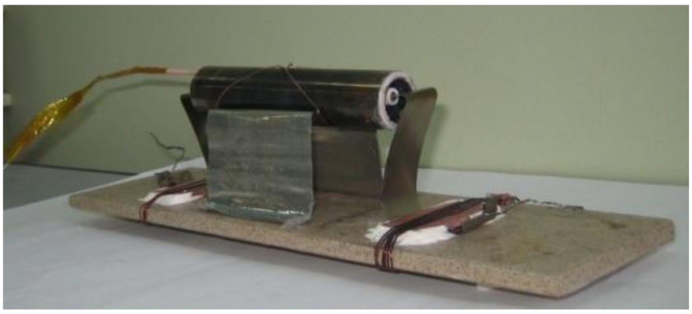

Figure 2. Halogen incandescent lamp inside a cylindrical container.

Figure 3. Air flow calorimeter.

in excess power. However, as can be seen in Fig. 4, 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.

Note that this reactor does not contain hydrogen, yet despite this it reliably produces excess heat. This indicates the need to reconsider the established view that hydrogen is necessary for the LENR reaction. This conclusion is confirmed by nuclear transmutations found in the lead-tin alloy that does not contain hydrogen (see section "*Experiment 6. Halogen incandescent lamp and tin-lead alloy*").

2.2. Experiment 2. Measurement of Heat Generation by the Rate of Temperature Increase in Water

In this experiment, incandescent lamps were immersed in water (450 ml) poured into a glass Dewar vessel (Fig. 5). The heat output was determined by the rate of increase in the water temperature. Temperature was measured with an electronic thermometer, with a range up to 300°C and accuracy of 0.1°C. 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.

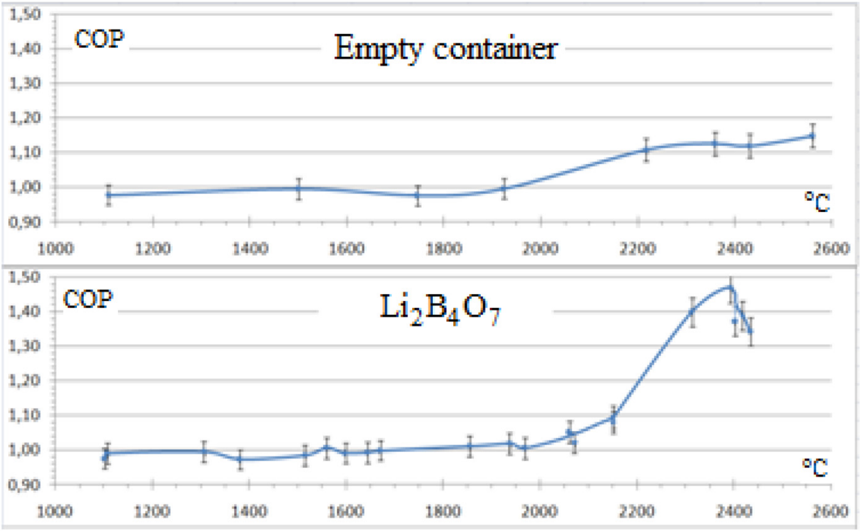

Figure 4. Thermal coefficient as a function of the filament temperature in halogen lamp, measured with an empty container and a container filled with lithium tetraborate.

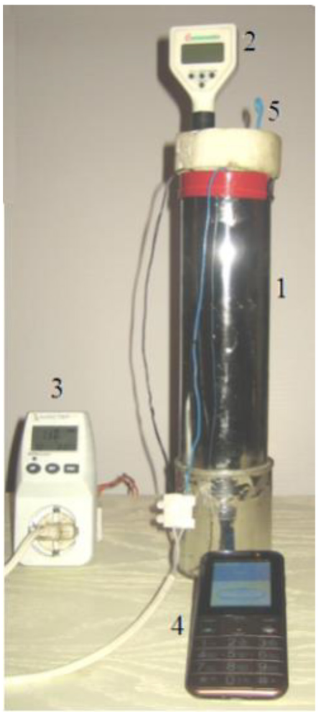

Figure 5. Water calorimeter. 1 – Dewar vessel with water in which an incandescent lamp is immersed, 2 – thermometer, 3 – meter of current, voltage and power consumption, 4 – stopwatch, 5 – stirrer.

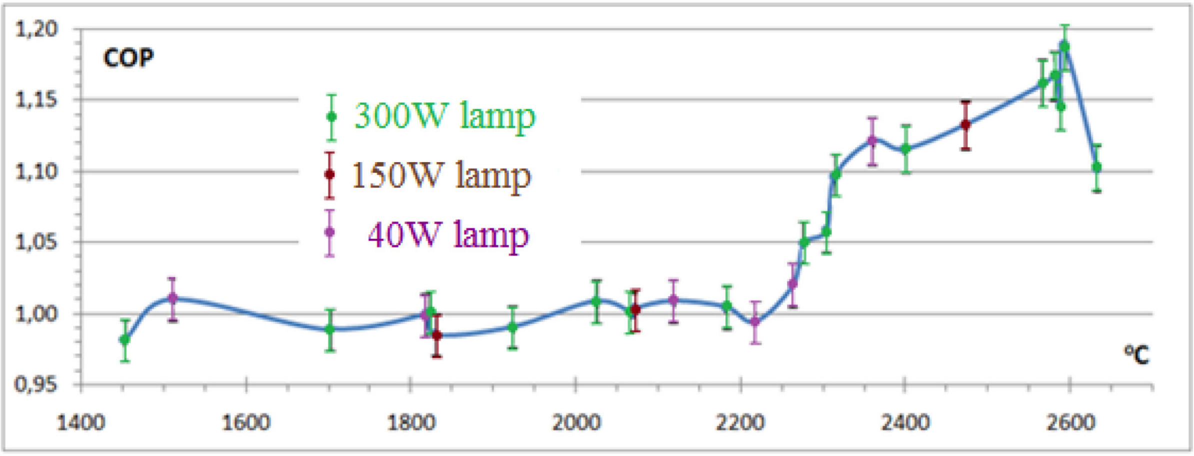

Figure 6. Dependence of the thermal coefficient COP on the filament temperature. Set of data obtained in different experiments.

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°C. Figure 6 shows 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. 1) 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.

Figure 6 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 filament 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 experiment (see Fig. 4).

Excess heat generation can occur in lamp cylinders containing SiO_2 and in water. To make sure that new chemical elements actually appear in the substance near the incandescent lamps, special rather long-term experiments 5,6 and 7 were carried out, which convincingly confirmed the appearance of nuclides that were initially absent.

2.3. Experiment 3. Measurement of Excess Heat Generation in the Installation with Hot Iron (Reactor C3)

The disadvantage of experiments with incandescent lamps is that the mass of the incandescent tungsten filament is very small (about 100 mg). In the C3 reactor (Fig. 7), iron rods with a total weight of 60 g were heated by a tungsten spiral wound on a sapphire tube. The “hot zone” was surrounded by thermal insulation made of porous quartz, wrapped in nickel mesh. Between the grids there was 15 g of nickel powder saturated with hydrogen gas at a temperature of about 300°C.The saturation procedure is similar to the one described in [2]. The outer shell was a quartz tube filled with a mixture of hydrogen and argon. To measure the heat output power, an air flow calorimeter was used (see Fig. 3).

Figure 8 shows 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°C and continuously increases with increasing temperature. The thermal coefficient at a temperature of about 1000°C reaches a value of about 1.3. Increase in temperature does not lead to an increase in COP due to the rapid increase in the power consumed by the electric heater.

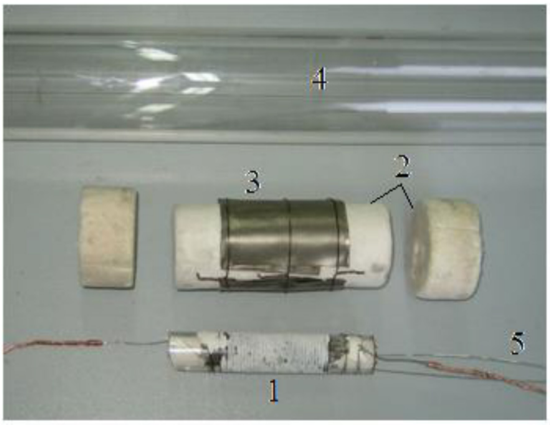

Figure 7. Details of the C3 reactor. 1 - iron rods in a sapphire tube, on which a tungsten heater is wound; 2-thermal insulation; 3-nickel mesh; 4-quartz tube; 5- W-Re thermocouple.

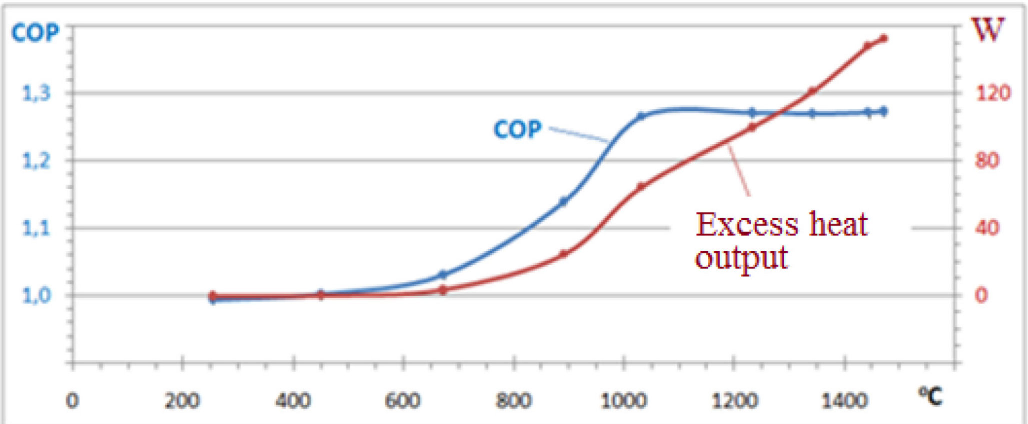

Figure 8. Excess heat output power and the thermal coefficient of the C3 reactor as a function of temperature.

2.4. Experiment 4. Measurement of Excess Heat Generation in the Installation with Hot Tungsten (Reactor W1)

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. The design of the reactor is shown in Fig. 9. Inside the silicon carbide heater there is 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 mesh ("fuel"). A view of the reactor in operation is shown in Fig. 10.

Figure 11 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

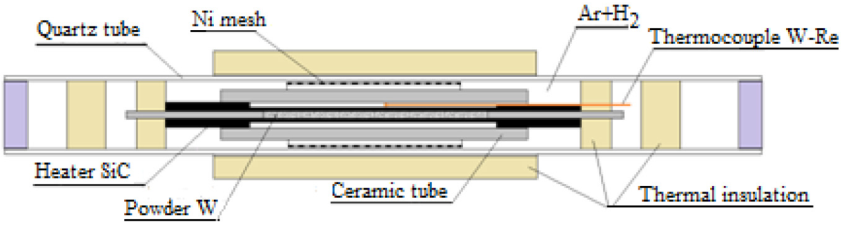

Figure 9. Design of the W1 reactor.

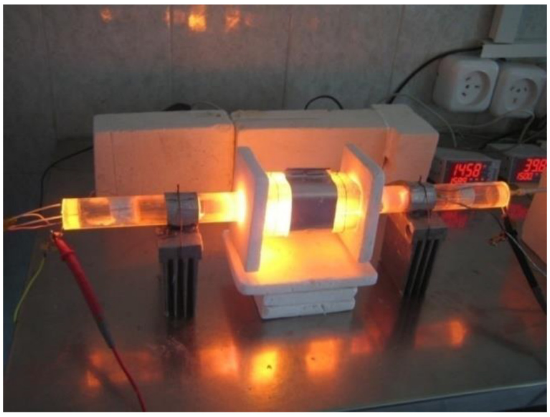

Figure 10. Reactor W1 and the process of operation.

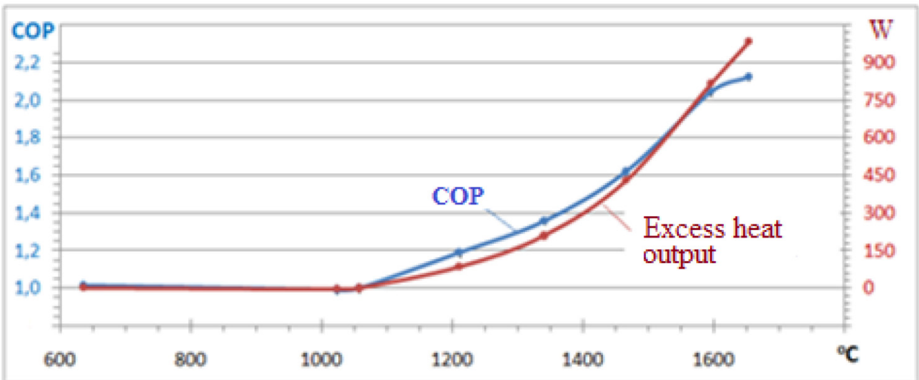

Figure 11. Excess heat output power and thermal coefficient of the reactor W1 as a function of temperature.

at a temperature of 1100°C and increases with increasing temperature. Thermal coefficient also increases, reaching a value of 2.2 at a temperature of about 1600°C. At higher temperatures, growth slows down.

Thus, the use of massive metal cores can significantly reduce the temperature at which excess energy is released.

Figure 12. Experimental setup with a circulating KNO_3 solution and a halogen incandescent lamp.

3. INVESTIGATION OF ELEMENTAL AND ISOTOPIC CHANGES IN MATTER NEAR HOT METALS

In order to be sure that the LENR process is really occurring near the hot metals, 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. The experiments described above showed the presence of excess heat release at a sufficiently high metal temperature, but they were not long enough to accumulate a noticeable amount of new elements. This problem was solved in further experiments.

3.1. Experiment 5. Halogen Incandescent Lamp and Circulating Solution

The halogen incandescent lamp (220V, 300 W) was located in a quartz tube, through which a 10% aqueous solution of KNO_3 flowed. The circulating solution was cooled by passing through a 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 temperature of the tungsten filament is about 2400°C.

Samples of the solution taken before and after exposure to an incandescent lamp, after evaporation, were transferred for analysis of the elemental composition to the SYNTHESTECH 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.

The calcium content increased the most (appearance of calcium is also typical for many other LENR experiments [1]). In this regard, we recall the research of Louis Kervran, who found that a chicken will 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 $^{39}K_{19}+^{1}H_{1}\rightarrow^{40}Ca_{20}+8.337$ MeV, which caused the ridicule of physicists: potassium and hydrogen cannot combine

Table 1. Results of analysis of the samples by XRF and ICP MS methods before and after processing with an incandescent lamp in KNO_3 solution (mass %).

	before		after	
	XRF	ICP MS	XRF	ICP MS
Li		0,007		0,12
B		0,017		0,08
Mg		0,050		0,55
Al		0,010		3,30
K	99,91		86,4	
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	

because of the “Coulomb barrier”, and if this somehow happened, the huge energy release would incinerate the chicken. This experiment shows the reality of the formation of calcium in a medium containing potassium by LENR.

3.2. Experiment 6. Halogen Incandescent Lamp and Tin-Lead Alloy

A 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. 13). The lamp power consumption was 480 W. Heat output power of about 550 W was determined by the water heating rate. The temperature of the tungsten filament was 2400-2450°C. Working time was 40 hours.

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 SYNTHESTECH Research Center. The results of the analyses are presented in Table 2. 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.

Note that the XRF analysis provides information about 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 by the calorimetric experiment with an incandescent lamp and lithium tetraborate, described above (experiment 1).

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		0,0053
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		0,0036		0,040
Pd		0,0002		0,0005
Ag		0,006		0,024
Cd		0,0005		0,0011
Sn	45,7	43,6	40,3	46,00
W	<0,01		1,51	
W		0,00003		0,105
Pb	54,2	44,5	57,9	31,4
Bi		0,0005		0,057

3.3. Experiment 7. Halogen Incandescent Lamp and Boiling Solution

In a glass vessel with 900 ml of distilled water and 14 g of sodium bismuthate ($NaBiO_3$), a halogen incandescent lamp with a rated power of 150 W was immersed (Fig. 10). The duration of the experiment was 20 hours with power consumption of 270 W. Temperature of the tungsten filament was 2200-2300°C. Excess heat generation of about 25W 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 sediment and the evaporated solution, as well as the initial $NaBiO_3$ powder, were performed at the SYNTHESTECH Research Center. The results are presented in Table 3.

In 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 6, a lot of tungsten appeared.

3.4. Experiments 8. Hot Metal or Light?

In 2013, at the Kurchatov Institute, Yu.N.Bazhutov and his colleagues conducted a series of experiments with solutions of LiOH, NaOH, and Na_2CO_3 illuminated by a laser or LED with a wavelength of 625-650 nm [13]. 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.

Figure 13. Halogen incandescent lamp wrapped with a tin-lead alloy tape in a vessel with water. The water is pumped through a fan-cooled coil.

Figure 14. Halogen incandescent lamp in boiling water with $NaBiO_3$ suspension.

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 [14]. This experiment was recently reproduced by Jean-Paul Biberian [15]. After three months of irradiation in the atmosphere of hydrogen or deuterium of a palladium film with a 5 mW laser with a wavelength of 650 nm, initially absent N, O, Na, S, Al, Ca, Fe, Ni, Zn, Mo were detected. The presence of excess heat release was not controlled.

Thus, light exposure causes nuclear transmutations. Our experiments described in this paper are accompanied by very intense light radiation. Perhaps it is due to the action of light that the appearance of new elements and excess heat generation is associated?

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	98.646	4.615

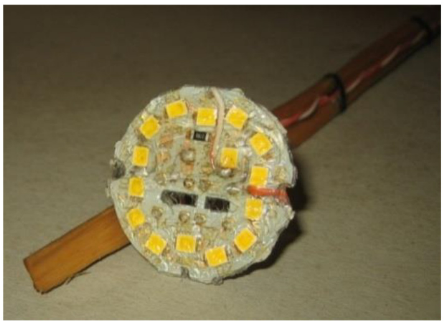

Figure 15. LEDs used in the calorimetric experiment.

LED lamps give very intense light without high temperatures, with low power consumption. If the cause of LENR is light, then the use of LED should provide much stronger effects compared to incandescent lamps.To test this possibility, a calorimetric experiment was conducted with a chain of 15 LEDs extracted from a household LED lamp (Fig. 15). The same calorimeter with water in the Dewar vessel was used, which was used in experiments with incandescent lamps (see Fig. 5).

The measurements showed that LEDs immersed in water do not give a noticeable excess heat release (COP = 1.00±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 with very long-term illumination with powerful light. The efficiency of the reactors described in this paper is precisely correlated to the presence of hot metal.

4. IMPORTANT FEATURES OF LENR

Experimental results obtained by the authors and other researchers allow us to highlight a number of important features of LENR:

a) a huge variety of nuclides appears not only in the “fuel”, but also in the surrounding matter, and, in general, nuclides that are not radioactive appear;
b) energy release is far beyond the upper limits of chemical reactions;
c) neutrons and gamma radiation are emitted during the LENR process. However, the radiation intensity is many orders of magnitude lower than in “normal” nuclear reactions;
d) sufficiently dense medium (solid, liquid, dense plasma) is required;
e) presence of hydrogen or deuterium is not necessary;
f) unusual tracks appear near the reactors.

5. ATTEMPTS TO EXPLAIN THE LENR PHENOMENON

Many attempts have been made to explain the LENR phenomenon. Numerous theories can be divided into several groups:

- proton (deuteron) overcomes the “Coulomb barrier” and merges with the nucleus;
- proton turns into a neutron, for which there is no “Coulomb barrier.” This neutron generates a chain of nuclear transformations;
- LENR processes involve a catalyst;
- the atom goes into a compact state with the release of high energy. In addition, the atom in the compact state more easily overcomes the “Coulomb barrier”.

But so far, it has not been possible to explain all the features of LENR, or at least some of them, without contradicting the rest. Basically, the search went in the direction of finding ways to overcome the “Coulomb barrier”, which prevents a sufficiently close approach of pairs or groups of nuclei. An example of this theory is the well-known Widom-Larsen theory [16], which allows the possibility of converting protons into neutrons. The resulting neutrons react with the nuclei of the surrounding matter, forming new chemical elements. However, in reality, experiments did not detect the intense radiation of neutrons and hard gamma rays, which inevitably occur when neutrons are captured by nuclei. For example, the capture of a neutron by a proton is accompanied by the emission of a gamma quantum with an energy of 2.23 MeV. When a neutron is captured by nickel, gamma quanta with an energy of up to 9 MeV arise [17]. This fact alone refutes this type of hypotheses. Similar inconsistencies are typical for other approaches. It should be emphasized that none of the above approaches provides an explanation for the huge variety of nuclides that arise.

The problem of the appearance of a huge variety of emerging nuclides can be solved by the assumption that they appear as a result of energy-efficient rearrangements of nucleons located in two or more atoms [18], [19]. To do this, they must be exposed to action that covers several atoms at the same time. A possible way to solve this problem is described in [9], [10], [20].

6. CONCLUSIONS

Various experiments have shown that in a substance near metals, when they are heated to a sufficiently high temperature, there is indeed the release of excess heat and the appearance of initially absent chemical elements, which testifies to the course of LENR.

Our experiments, combined with numerous experiments by other researchers, give indications of a number of erroneous directions in the search for an explanation of the LENR phenomenon .In a number of experiments, LENR was detected in the complete absence of hydrogen. This indicates the need to reconsider the traditional approaches to explain LENR, in which hydrogen or deuterium are necessary. Also, theoretical explanations involving neutrons do not stand up to comparison with experimental results. Experiments also show that there is no need for a crystal lattice for LENR, since LENR occurs not only in solids, but also in liquids and dense plasmas.

ACKNOWLEDGMENT

The authors would like to thank T.Timerbulatov, S.Zabavin and I.Stepanovfor supporting the research and helping with equipment; I.Kamputin for high-quality analysis; N.Samsonenko, L.Urutskoev, A.Chistolinov and V.Vysotskii for helpful discussions and valuable criticism; I.Savvatimova, A.Klimov, V.Zatelepin, R.Grinyer V.Zhigalov, G.Levi, A.Prosvirnov, S.Godin, V.Panchelyuga, A.Kovacs and many other people in Russia and abroad for their support and valuable advice.

References

[1] A.G.Parkhomov, K.A.Alabin, S.N. Andreev, etc., Nickel-hydrogen reactors: heat release, isotopic and elemental composition of fuel,*RENSIT*, **9**(1)(2017) 74–93. Available from http://en.rensit.ru/vypuski/article/200/9(1)74-93e.pdf

[2] A.G.Parkhomov, V.A.Zhigalov, S.N.Zabavin, etc., Nickel-hydrogen heat generator, continuously worked for 7 months, *International Journal of Unconventional Science*, 23–24(7) (2019) 57–63 (in Russ.) Available from http://www.unconv-science.org/pdf/23/parkhomov2.pdf English translation: https://drive.google.com/file/d/10tPXOEGHfB95YQeOoePUftdByo7BVnvg/view

[3] A.V.Vachaev, N.I.Ivanov, A.N.Ivanov, G.A.Pavlova, Method of obtaining elements and device for its implementation, *Patent of the Russian Federation* No. 2096846, MKI G 21 G 1/00, H 05 H 1/24 (1994).

[4] Yu.N.Bazhutov, A.I.Gerasimova, V.P.Koretsky, A.G.Parkhomov. Features of electricity consumption, heat release and radiation in the process of plasma electrolysis. Proceedings of the 21st Russian Conference on Cold Nuclear Transmutations and Ball Lightning. Sochi, 2015: 122-131 (in Russ.).

[5] I.B.Savvatimova,Transmutation of Elements in Low-energy Glow Discharge and the Associated Processes, *J. Condensed Matter Nucl. Sci*. **8** (2011) 1–19.

[6] M. Fleischmann, S. Pons. Electrochemically induced nuclear fusion of deuterium. *Journal of Electroanalytical Chemistry and Interfacial Electrochemistry*. **261** (2A) (1989) 301–308.

[7] L.Kervran, *Biological Transmutations*. Happiness Press, USA, Magalia, California, 1998.

[8] A.A Kornilova, V.I Vysotskii. Synthesis and transmutation of stable and radioactive isotopes in biological systems. *RENSIT*, **9(1)**(2017) 52–64.

[9] A.G.Parkhomov. Weak Interactions as Essence of LENR. *International Journal of Unconventional Science*, **E4** (2019) 3–5. http://www.unconv-science.org/pdf/23/parkhomov1-en.pdf

[10] A.G. Parkhomov, R.V.Karabanov, LENR as a manifestation of weak nuclear interactions. New approach to creating LENR reactors, *RENSIT*, **13**(1) (2021) 45–58. Available from http://en.rensit.ru/vypuski/article/372/13(1)45-58e.pdf

[11] A.G. Parkhomov. New approach to the creation of LENR reactors, A.G. Parkhomov, R.V. Karabanov. Investigation of elemental and isotopic changes in matter near incandescent lamps. *Proc. of the 26th Russian Conf. on cold nuclear transmutations and ball lightning*. Moscow, 2020, p. 43-63 (in Russ.) https://www.ozon.ru/product/problemy-holodnoy-transmutatsii-yader-himicheskih-elementov-i-sharovoy-molnii-230215320

[12] I.S. Grigoriev, E.Z.Meilikhov (ed). Physical quantity. Moscow: Energoatomizdat, 1991. p. 438 (in Russ.)

[13] Yu.N.Bazhutov, A.I.Gerasimova, V.V.Evmenenko, V.P.Koretskiy, A.G.Parkhomov and Yu.A.Sapozhnikov. Calorimetric and Radiation Diagnostics of Water Solutions Under Intense Light Radiation. *J. Condensed Matter Nucl. Sci*, **19** (2016) 10–17.

[14] U.Mastromatteo, LENR Anomalies in Pd–H2 Systems Submitted to Laser Stimulation. *J. Condensed Matter Nucl. Sci*. **19** (2016) 173–182.

[15] J.-P.Biberian, Transmutation induced by laser irradiation. *Le colloque RNBE 2020*.

[16] A.Widom, L.Larsen, Ultra Low Momentum Neutron Catalyzed Nuclear Reactions on Metallic Hydride Surfaces. *arXiv:cond-mat/0505026*.

[17] T.S.Belanova, A.V Ignatyuk., A.B. Pashchenko. Radiation capture of neutrons. - Moscow: Energoatomizdat, 1986, 248 p.(in Russ.)

[18] V.Kuznetsov, G.Mishinsky,F.Penkov, V.Arbuzov,V. Zhemenik, *Annales de la Fondation Louis de Broglie*, **28**(2) (2003) 173–213.

[19] D.V.Filippov, L.I.Urutskoev, On the possibility of nuclear transformation in low-temperature plasma from the viewpoint of conservation laws, *Annales de la Fondation Louis de Broglie*, **29** (Hors série 3) (2004) 1187–1206.

[20] A.G. Parkhomov, E.O. Belousova, Huge Variety of Nuclides that Arise in the LENR Processes. Attempt at Explanation. *Journal of Modern Physics*, **13**(3) (2022) 274-284 https://www.scirp.org/journal/paperinformation.aspx?paperid=115710