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LENR as a manifestation of weak nuclear interactions

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Rough translation by Bob Greenyer

Abstract - The small neutrino (antineutrino) mass makes it possible to generate them intensively as a result of collisions of particles of matter during thermal motion. The resulting neutrinos (antineutrinos) have an energy of about 0.1 eV. With such an energy, the De Broglie wavelength is about 5 microns. This means that a huge number of atoms are involved in nuclear weak interactions, which makes the effects of nuclear transformations involving neutrinos (anti-neutrinoes) really observable. Considering the thermal generation of neutrinos as the basis for nuclear transformations in the LENR process allows us to explain a number of features of this phenomenon.

I. INTRODUCTION

An extensive class of phenomena that are called "low-energy nuclear reactions" (LENR) or "cold nuclear transmutation" (CNT) or "cold fusion" are neither low energy (there is a lot of energy released) nor cold (is it possible to call a process cold that proceeds at a temperature of a thousand degrees?). The unsatisfactory terms used are obvious to all researchers of this phenomenon. But until the physical mechanism of this phenomenon is clarified, only conditional terminology is possible. Moving forward, we will use the most popular term, both at home and abroad, "LENR".

LENR is very diverse. There are processes in metals with hydrogen dissolved in them. There are processes in plasma, in a gas discharge, and even in biological systems. At first glance, these processes have nothing in common. But on closer examination, you can see four features that unite them.

The first feature is that they have a quite tangible energy threshold. This is especially clearly seen in the example of nickel-hydrogen reactors, in which intense excessive heat generation occurs only at temperatures above 1200°C [1], [2], i.e. when the average energy of particles of a substance during thermal motion exceeds 0.1 eV. In electroplasma reactors [3], [4], the temperature reaches several thousand degrees (tenths of eV). In installations with plasma of a glowing gas discharge [5], [6], the electron energy is of the order of 1 eV. At first sight, processes in which LENR symptoms are detected at room temperature (electrolysis [7], biology [8], [9]) are an exception to this rule. But in fact, it is the energies of the order of 1 eV that are characteristic of energy exchange acts both in electrochemistry and in the processes of cellular metabolism.

The second feature is that the LENR processes occur in a fairly dense medium (solid, liquid, or dense plasma).

The third feature is the large variety of nuclides arising in the LENR process.

The fourth feature is the absence (or very low intensity) of hard nuclear radiations (neutrons, gamma quanta), which, it would seem, should inevitably arise during nuclear transformations.

These features can indicate the search path for the LENR physical mechanism. It is necessary to look for a mechanism that appears at energies greater than 0.1 eV, which gives a large variety of nuclides, and where changes at the nuclear level do not cause the appearance of hard radiations. In addition, the mechanism sought must solve the problem of the "Coulomb barrier," since energies of the order of 1 eV are completely insufficient to overcome it in the process of nuclear collisions.

In a number of papers it was suggested that in order to solve the problem of explaining LENR, it is necessary to involve weak nuclear interactions [10], [11], [12], [13]. I will try to show that by taking this path, all the indicated features of LENR can be explained. I would like to note that there is no Coulomb barrier in weak interactions (beta-processes).

II. LENR THRESHOLD

The presence of neutrinos (antineutrinos) is a necessary condition for nuclear transformations to occur due to weak interactions . Since neutrinos have a very small mass (at present, it is believed that the mass of electron neutrino and antineutrino does not exceed 0.28 eV [14]), they can, although with a low probability, result from inelastic collisions of particles of a substance (electrons, ions, neutral atoms) during their thermal motion. Generally, in inelastic collisions of particles, photons are produced, not neutrinos. If born photons have sufficient energy,

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[6] The electron energy is 1 eV.

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they are unlikely to break up into a pair of neutrino-antineutrinos. Since there is no exact data on the neutrino mass, we will assume that the minimum energy for the formation of the neutrino-antineutrino pair is 0.5 eV. The average energy of 0.5 eV has particles in a body heated up to 3200°C. Let me remind you that the average energy of thermal motion $\bar{\varepsilon}$ = 1.5kT (k = 1.38x10^{-23} J/K - Boltzmann constant, T = t (°C) + 273.15 - is the absolute temperature). Some particles have this and higher energy even at lower temperatures. Using the energy distribution function of particles during thermal motion [15]

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

it is possible to find the temperature dependence of the fraction of particles with an energy higher than a given one. For a threshold energy of 0.5 eV, this dependence is shown in Fig. one. At room temperature, the fraction of such particles is 10^{-8} . A noticeable fraction of particles with an energy above 0.5 eV appears only at a temperature of about 1000°C. At a temperature of 1600°C such particles are already 10%, and at a temperature of 4500°C 50%. Thus, under the assumptions made, the threshold of thermal generation of neutrino-antineutrino pairs is about 1000°C.

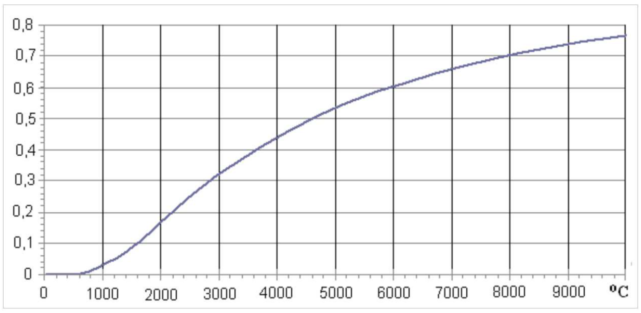

Fig. 1. The proportion of particles with energy above 0.5 eV, depending on temperature.

III. THE NEED FOR A DENSE ENVIRONMENT

Currently, the level of knowledge about the properties of neutrinos is insufficient to reliably determine the probability of neutrino and antineutrino formation during thermal collisions of particles of matter. It is clear only that the probability of this is small. A small probability is compensated by a large number of collisions. We estimate the number of collisions per second during thermal motion in metals. Most often, electrons collide with atoms in metals. The distance between collisions is about 10^{-8}m. The speed of movement of electrons at a temperature of 2000K about 2x10^{5} m / s [16, p.117]. Consequently, an electron with its thermal motion experiences 2x10^{13} collisions per second. Given that the number of free electrons per 1cm^3 of a metal is about 10^{23} [16, p.115], we find the number of collisions per second per cm^3 of metal: 2x10^{36}. So many collisions suggest that in sufficiently hot metals, neutrinos and antineutrinos arise with an intensity sufficient to initiate nuclear transformations, giving a significant energy release even with the very low probabilities of processes associated with neutrinos. Suppose that only one of 10^{10} antineutrino, and only one of 10^{10} neutrinos or antineutrino causes nuclear transformation. Even with such huge losses, 1cm^3 of hot metal produces 2x10^{16} nuclear transformations per second. In each act of such transformations, an order of 1MeV is allocated . Since 1J is equivalent to 6.25x10^{12} MeV, the power of the energy released is about 2 kW.

We make a similar estimate for gas, heated to a temperature sufficient for thermal generation of neutrinos (several thousand °C). In a gas, even at such temperatures, electrons and ions are much smaller than neutral atoms (molecules), therefore atoms (molecules) collide predominantly. The speed of their movement is of the order of 10^3 m/s, and the path length before the collision at atmospheric pressure is about 10^{-7} m. 117J- Therefore, an atom (molecule) experiences about 10^{10} collisions per second. 1cm^3 of hot gas at atmospheric pressure contains about 10^{19} atoms (molecules). About 10^{29} collisions per second occur in it, which is 7 orders of magnitude less than in metals.

Thus, in a gas heated to a temperature of several thousand degrees, thermal generation of neutrino and antineutrino is possible, but occurs with an intensity that is many orders of magnitude lower than in metals. Intensive generation requires a hot, dense medium with a high content of free electrons. In addition to metals, such a medium is a high-density plasma, which briefly arises, for example, during explosions of metallic conductors or at a sufficiently strong pulsed energy release in liquids.

IV. MULTI-NUCLEI INTERACTIONS AND THE VARIETY OF NUCLIDES THAT ARISE

As indicated in [11], [12], [13], a huge variety of nuclides arising in the LENR process can be achieved if several nuclei are involved in the interaction at once. A paper on computer computation of possible variants of energy-efficient nuclear transformations of two stable nuclides to two other stable nuclides involving electrons and neutrinos (antineutrino), in which the laws of conservation of electric, baryon and lepton charges are fulfilled, was reported in [13] . Considered:

rearrangements of nucleons with electron absorption:

$$(A1, Z1) + (A2, Z2) + e^- + \tilde{\nu} \rightarrow (A3, Z3) + (A4, Z4) + Q$$
$$A3 + A4 = A1 + A2, Z3 + Z4 = Z1 + Z2 - 1,$$

for example, ${}^{60}Ni+{}^{1}H+e^{-}+\tilde{\nu}\rightarrow{}^{4}He+{}^{57}Fe+0.569$ MeV,

and rearrangements 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, ${}^{61}Ni+{}^{64}Ni+\nu\rightarrow{}^{63}Cu+{}^{62}Ni+e^{-}+0.995$ MeV

263546 variants of transformations of the first type and 433536 variants of the second type were found. The number of options identified is huge. But this is not all possibilities. More than two nuclei can be involved in processes of this kind ; processes involving several electrons are possible.

Processes associated with weak nuclear interactions are extremely unlikely if the neutrinos (antineutrinos) participating in them have an energy of the order of 1 MeV and higher. Such neutrinos (antineutrinos) arise in beta decay processes or are generated at accelerators. But when they occur as a result of thermal collisions, the situation is much better. Such neutrinos (antineutrinos) have a kinetic energy of no more than tenths of an eV. Unlike the "nuclear" neutrinos, they have a de Broglie wavelength significantly exceeding the inter atomic distances . With a mass of 0.28 eV and a kinetic energy of 0.1 eV, the de Broglie wavelength is about 5 microns. This means that the interaction region covers a huge number of atoms (of the order of 10^{13} in a solid or liquid substance), which makes possible transformations that capture many atoms and nuclei, as a result of which even unlikely processes become noticeable [18], [19].

V. LACK OF HARD NUCLEAR RADIATION

In the described mechanism, the rearrangement of nucleons occurs without the introduction of energy, which could cause the excitation of nuclear levels, the emission of which could lead to the emission of gamma rays . The deficiency of the introduced energy leads to the fact that of all the possible transformation variants, those that produce the most stable nuclides, which are not prone to alpha or beta radioactivity, or emit neutrons, are realized. The released energy is realized in the form of the kinetic energy of the resulting nuclides. Despite the fact that they can have energy up to several MeV, when they are braked, hard radiation does not occur, since massive charged particles lose their energy even at high energies mainly as a result of ionization and excitation of atoms of the medium in which they move [20] . At the same time, electromagnetic radiation is emitted, but "soft", with energy of quanta up to several keV. In addition, the emission of "soft" quanta occurs when the deformed electron shells of the resulting nuclides are normalized.

VI. CONCLUSION

Neutrinos are considered to be practically elusive , manifested only in the most complex experiments on huge installations. But it does not take into account that the properties of neutrinos at very low energies are just as different from those of "nuclear" neutrinos, for example, as light differs from gamma radiation or helium gas differs from alpha particles. And the interaction of a huge number of atoms leads to a significant increase in the interaction of neutrinos with matter, resulting in groups of many atoms being involved in nuclear transformations all at once. This makes it possible to explain a number of features of the LENR process.

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