Why do the condensed matter nuclear reactions occur?

By V. Filimonov

ABSTRACT

Why can low energy nuclear reactions (LENR) occur, while no state of condensed matter is able to provide for either the high-energy excitation of nuclei or the effective screening of their electric charge needed?

Firstly, contrary to common delusion, it is because the dynamical behavior of related systems can provide for a sufficient probability of the nuclei multi-quantum excitation up to partial energies E_n sufficient for overcoming Coulomb barriers. The above hypothesis does not contradict to various CMNS theories of 'screening' and 'catalysis', but helps them to avoid evident quantitative limitations. By present, within the frame of this hypothesis there have been carried out successful experimental investigations. However, it is not possible yet to explain the predominant production of stable nuclides by LENR.

Secondly, the 'neutrino-driven nuclear reactions' have appeared as a result of analysis of a wide range of 'anomalous' effects. This hypothesis can explain both the D-D fusion and transmutation of conventionally 'stable' nuclides as well as suppression of high-energy emissions and production of unstable nuclides. It suggests certain experimental means, such as driving a natural flux of a not-high energy neutrino or generation of the latter in the experiment conditions. Also, there have been carried out a further theoretical development of its main idea on the electron-neutrino pair formation in atom and its significant role in CMNS/LENR.

INTRODUCTION

Why can nuclear reactions occur in condensed matter? This point is related to that type of nuclear reactions, which are in the sphere of concern of the condensed matter nuclear science (CMNS) and are termed as low-energy nuclear reactions (LENR); earlier they have been referred to as cold nuclear fusion (CF) or transmutation of nuclei, and, in general, they are considered as impossible within the frame of the conventional nuclear physics.[1]

From a traditional point of view, they are primarily not possible for the reason that no state in a solid matter or liquid can provide for a high-energy excitation of reacting agents (nuclei of hydrogen isotopes as well as nuclei of the elements constituting the matrix). At the same time, for overcoming by nuclei the Coulomb barrier of similar charges repulsion approaching the distance of nuclear interaction, the excitation up to the high (by chemical standards) energy levels is required. However, there are certain thermodynamic limitations that cannot but interfere with existence of the condensed phase; specifically, it is the absolute fact that the binding energy between the atoms of solids amounts to about 10 eV per a bond. In molecular liquids like water the binding energy between molecules is even less, i.e. about 0.5 eV per a bond. In reality, the critical densities of energy, under which the condensed phase ceases its existence, are even less and they do not exceed some few tenths of an eV per an atom, that is the energy, required for heating the condensed matter to boiling point (373K for water and $2\text{-}4\cdot10^3$ K for the majority of solids). The higher energy density in any of the domains of the condensed phase will inevitably result in decomposing the structure of the condensed state with subsequent transition into the

---

[1] In this paper we are making use of the following two acronyms, CMNS and LENR, which are the first in the order of their appearance in the text and the last in chronology, as they are not identical in their value; while the first of them apparently includes considering the adjacent (those related to materials science, energy etc.) and other relevant aspects of LENR phenomena, the second one is limited to considering only the nuclear-and-physical aspect of such phenomena. Being disused, the term 'cold nuclear fusion' and CF as a corresponding acronym are used herein exclusively for the purpose of denoting the deuterium-to-helium fusion reaction.

vapor phase, in which any proceeding of nuclear processes the more is impossible because of the much smaller (as low as three decimal degrees of magnitude or thousandfold) density of the matter with a corresponding retardation of all second-order reactions (i.e. those ones, which are provided with pair collisions of participating agents) for six decimal orders of magnitude or millionfold.

Similar objections are raised by the conventional science in regard to the suggested possibility of anomalous nuclear reactions, falling within the CMNS domain, by reason of shielding the charge of reacting nuclei by the unbound electrons of the solid phase, which is revealing a metal character of the binding between atoms and abundance of unbound conductivity electrons. The case is that in the basic (equilibrium or steady) thermodynamic state the electron density is admittedly insufficient to provide for an effective shielding of the electric charge of interacting nuclei. However, increasing the electronic density substantially (at least by three decimal degrees) would be interfered by the same energy limitations as in the previous case.

And finally, the version of quantum tunneling as a mechanism for overcoming the Coulomb barrier of nuclei repulsion meets with opposition for the reason that the latter process shows a weak dependence on the surroundings of interacting nuclei. Accordingly, the probability of its proceeding should not differ essentially, let us say, in stoichiometric deuterium oxide (heavy water D_2O), in which LENR as such can not occur, and in non-stoichiometric palladium deuteride, which is the basic matter of CMNS.

SYNERGETIC ACTIVATION MODEL AND ITS EXPERIMENTAL VERIFICATION

From the viewpoint of a defender of CMNS, these objections can be opposed by some basic concepts, namely: a) catalysis, b) collective interactions and c) dynamics.

Our initial hypothesis in this area was termed as 'synergetic activation' (SA) that meant the multi-quantum excitation of the atoms of hydrogen isotopes in the conditions of self-organization in the dynamic system. Thus, the idea united concepts b and c. By that hypothesis, a dynamic behavior of the system under study (more or less dense gas of atoms of protium or deuterium in a three- or two- dimensional matrix of metal) can provide for a situation, when the multi-quantum excitation of the former can achieve specific energies E_n, sufficient for overcoming the Coulomb barrier by some part of the nuclei of hydrogen isotopes. At this, the average energy per an atom in the matrix will make up a shade more than E_0 that corresponds to its non-excited state and maintains a solid state of the crystalline matrix unchanged. Contrary to general misconception, a multi-step excitation, if compared with a single-step one, will result in a much greater (rather than much lesser) probability of achieving by one of the participating particles the energy level required for the nuclear reaction:

$$p_i >> P^n = \prod_{i=1}^{n} p_i = \prod_{i=1}^{n} \exp\left(-\frac{E_i}{E_{i-1}}\right) = \left(\frac{E_i}{E_{i-1}}\right)^{-\gamma} >> \exp\left(-\frac{E_n}{E_0}\right) \equiv P^1$$

where p_i - a conventional probability of the single-quantum excitation to the proximate as to the energy level, i.e. from E_0 to E_1, from E_{i-1} to E_i etc.; P^n - probability of the multi-quantum excitation from level E_0 to level E_n under conditions of continuous energy pumping; P^1 - a conventional probability of the single-quantum excitation from level E_0 to level E_n (in equilibrium conditions), γ - the exponent of a power (γ = 1-3), depending on the energy structure of the matrix, i.e. the ratio of the energies, which are the proximate as to the energy of excitation levels.

Fig. 1 serves to illustrate the above statement.

The effective multi-quantum excitation requires the residence time of elements of the system (either atoms or particles) in each of the excited states between E_0 and E_n to be longer than or equal to the period of atomic oscillation in this system. This excludes a premature relaxation of atoms with their transition to the basic level E_0 inasmuch as the latter case suggests a single-quantum excitation as the only possibility. The simplest option for implementing the given requirement would be a spatial separation of the subsystems with various energies of atoms, ranging from E_0 to E_n (and with identical energies of atoms E_i within every i- subsystem). We have reasonably suggested that the atoms, being in their various excitation states, due to the difference in sizes of electronic clouds of outer (valence) electrons and, consequently, the difference in their atomic volumes can get separated by the latter attribute under a unidirectional external impact. The similar effect was observed under the impact of a shock wave (SW) upon some alloys: the alloy components, representing the atoms of various elements with different values of nuclear volume, separated in the form of alternating layers after SW passing through a sample.

The multi-step excitation of the atoms of hydrogen isotopes within the spatial-temporal boundaries of an explosion shock wave is an apparent experimental mean to provide the required dynamics. We proposed that method in 1994; further on, in 1997, our team managed to carry out some preliminary experiments. As it turned out, R.Monti was the first, who proposed a similar method, which was experimentally tried out for transmutation of radioactive waste. In 1994 a similar method of the nuclear transmutation was independently developed by the research team of the Belarus Scientific and Research Institute of Impact Processes.

Later on, we suggested that the above spatial separation of subsystems with various specific energies E_i in case of the chemically identical elements of the system (and in distinction from the given example of the alloy layering) was not necessarily caused by diffusion displacement of atomic elements of the system. Instead, we considered a hypothetical process of a directional drift of intrinsically excited states in a rather stable matrix of the crystal lattice, and then, in the systems with unidirectional energy flows, the establishment of resonances between the subsystems of the equally excited atoms without displacement of the latter and spatial localization of subsystems. To this end, the computer modeling of such formalized systems had been carried out in a wide range of system sizes (up to 10^8 particles), number of energy levels (up to 10^2) and duration of self-organization processes (up to 100 iterations). The modeling results obtained had supported the sufficient efficiency of the multi-quantum excitation for providing the observable efficiency of LENR in the condensed systems (see Fig.2).

In contrast to the possibility of explosive initiation of the specified hypothetical processes, which seems to be obvious, the time-stationary process of collective self-organization of hydrogen atoms as an experimental mean for implementing the multi-quantum excitation is, to our opinion, not self-explanatory enough. Such process can go best in the lattice of a metal with a high mobility of hydrogen (deuterium) atoms under thermodynamic conditions, which determine a collective nature of transfer. Such requirements include, firstly, availability of the separation area of phases with various contents of hydrogen in the metal-hydrogen (metal-deuterium) system, let us say, the phases of solid solution Me (H), Me (D) and phases of non-stoichiometric compounds MeH_x, MeD_x. Secondly, essential will be intrusion of hydrogen into the matrix in its temperature zone, which corresponds to or is close to the temperature limit of the separation area of the phases specified. And thirdly, the process has also to be carried out in the proper range of compositions, i.e. when the content of hydrogen (deuterium) in the matrix is to be close to the corresponding co-ordinate of the phase separation area (see Fig.3).

It is rather hard to observe such requirements in the static condition of the system; that is why there was suggested the end-to-end transport of hydrogen isotopes through the metal matrix instead of the all-around loading of the matrix with hydrogen (deuterium). In its turn, that called for an appropriate geometrical organization of the matrix (i.e. that of cathode in an electrochemical option of implementation) in the form of a thin plate with a shielded back surface or a thin-walled tube with the partitioned outer and inner spaces.

It is also necessary to make clear the requirements we have developed to the structure of the metal matrix, capable of providing for intensive and long-time process of self-organization of the hydrogen (deuterium) subsystems in the metal matrix. The first requirement is the minimal number of extended (one- and two-dimensional) defects in the crystalline structure (dislocations and grain boundaries). It should be noted that a number of authors point out to the positive role of the cathode defect structure for the yield of excess heat and other indications of LENR in an electrochemical cell at heavy water electrolysis, though, at large, experiments have lent no support to such dependence. We can, however, admit that in the specified cases the point at issue is the undetermined ordering of some certain type, associated with the non-stoichiometry of Me-D composition, rather than the defect structure itself.

In accordance with the given approach, we have carried out our experiments on electrolysis of deuterium oxide without supersaturation of metal cathodes with deuterium, but with intense transfer of the latter through the said cathodes. Those experiments made use of niobium cathodes (instead of palladium ones) as they corresponded to a greater degrees to structural and thermodynamic criteria given above. The cathode plates were subjected to pre-treatment for the purpose of reducing the number of extended defect, i.e. dislocations and grain boundaries. Due to that treatment the dislocation density grew down from 10^6-10^7 to 10^4-10^5 cm^2; as for grain boundaries, we managed to obtain in the unannealed plate with the initial size of crystallites of about 1 micron the single crystal blocks with the area of up to $2см^2$ on the front face of the plate and the depth from 1-2 to 4-5 mm through the entire thickness of the cathode (see Fig. 4). The electrolysis, carried out at temperatures close to boiling point (99 degrees centigrade) and by applying the high density direct current (nearby 1 $Amp\cdot cm^{-2}$), produced a high yield of heat in comparison with both the test experiment carried out under the same conditions with the use of 'crude' cathode plates, i.e. those which had not undergone pre-treatment, and the experiment carried out at 25-30 degrees centigrade (see Fig.5).

It is exemplary that while carrying out the pulsed electrolysis with the use of pre-treated cathodes at temperatures, which were not much higher than the ambient temperature, one could not observe any excessive heat generation, but instead there had been revealed the neutron emission from the electrolysis cell, the intensity of which was symbate to the amplitude (10-100 V), duration (10^1-10^4 microsecond) and frequency (10^2-10^4 Hz) of voltage pulses; the most intense neutron emission was observed after switching off the current of electrolysis; its value reached the intensity of the laboratory background. Detection was carried out by means of the slow neutron detector equipped with 16 gas-filled (He^3) proportional counters in polyethylene moderator. Energy discrimination of counter impulses was performed with the purpose of revealing significant events. The reliable identification of neutron emission was carried out by the neutron spectrometry method with the spectrometer of the Neutron Physics Laboratory, Joint Institute for Nuclear Research (JINR), in Dubna. The continuous period of the experiment made up eight hours (see Fig. 6).

Our participation in Kaliev's experiments (1994-1996) on the 'impactive' gas-phase deuteration of single crystals of non-stoichiometric oxide sodium-tungsten bronzes $Na_{1-x}WO_3$ seems to allow us to obtain one more verification in support of the dynamic model of the synergetic activation. At the initial stage of our joint work we could actually observe synchronous and value correlated (in relation to the value of non-stoichiometry, determined by the integral of the passed ionic current) effects of the excessive heat generation at deuterium penetrating into the lattice of oxidic bronze and neutron emission from crystals. Subsequently, both the values of observable effects and their reproducibility fell down, and, as we believe that mainly happened because of requirements to perfection of the crystalline matrix had been eventually leveled down that could, though implicitly, confirm our hypothesis.

The above experiments were carried out throughout the period from 1993 to 1998 on different project sites, and in aggregate they had convincingly shown the possibility of carrying out CF of nuclei without super-saturation of the metal crystal lattice with deuterium (hydrogen).

OTHER EVIDENCES IN FAVOUR OF THE LENR SYNERGETIC ACTIVATION MODEL

The fact that the criterium of the deuterium high volume content in the condensed phase makes no sense in isolation from other criteria is actually evident without considering the results of the above experiments. As we can see, the concentration of deuterium in the same heavy water (D_2O with density of 1.1 grams·cm^{-3}, equivalent density of 0.11 gram-equivalents·cm^{-3}) is eventually the same as it is in the stoichiometrical deuteride of palladium (PdD_1 with density of about 12 g·cm^{-3}, equivalent density of 0.11g-equ·cm^{-3}), but nobody has observed so far the cold fusion of deuterium with a subsequent formation of helium in deuterium oxide. The aforesaid is referred to the equilibrium thermodynamic states. In the non-equilibrium conditions one can possibly observe both the super-stoichiometric content of deuterium in palladium (PdD_{1+x}), and, as like as not, proceeding of LENR in D_2O, but this fact only lends support the assertion about the dominating role of the dynamics in CMNS.

To our opinion, the SA model (multi-quantum excitation of atoms of hydrogen isotopes) in the condensed phase can be supported even to a greater extent by the results obtained by Lipson on neutron emission from DKDP crystals (potassium dideuterium phosphate) at temperature scanning of the crystalline second-order phase transformation (PT-II).[2] It is interesting to point out that in phase transformation the effect becomes equally apparent in both directions, i.e. with increasing and decreasing temperature. At that, no changes take place either in the deuterium content volume, or in the energy of its nuclei (PT-II is not accompanied by any heat generation); hypothetically, the distance between deuterium atom nuclei can grow down at their incidental (!) ingress into closely spaced lattice sites in consequence of the lattice disorder caused by PT-II.[3]

The essential role of self-organization in the systems investigated by CMNS can be implicitly supported by outstanding and so far unmatched results on the excess heat generation in LENR, which were obtained with the use of Patterson Power Cell (PPC). Such cell applies the cathode in the form of a fluidized bed of plastic peas, the surface of which has been electrochemically covered with an active coating of palladium Pd, nickel Ni or atomically homogeneous Pd-Ni alloy. The fluidized bed is organized by means of a bottom-upwards vertical flow of electrolyte on the basis of light water (about 99.98 % of H_2O, about 0.02 % of D_2O) or the light water completely free of deuterium (100 % of H_2O). In the course of electrolysis, the peas in the top of the fluidized bed are loaded with hydrogen, evolving due to electrochemical reaction, where some part of that hydrogen diffuses from the electrochemically active metallized coating inside a plastic base of a pea and is absorbed by the latter. Within certain limits of a plastic base being loaded with hydrogen, its volume (as well as the volume of the pea as a whole) remains unchanged; while its weight increases due to the sorbed hydrogen (the same is true for an entire pea). Inasmuch such a pea has a higher density; it consequently passes to lower sections of the fluidized bed. There, the metallic coating of the pea appears to be substantially shielded from the electrolysis current that causes desorption of hydrogen from a coating surface, followed by a backward diffusion of hydrogen from the depth of the coating and plastic base to the surface with further desorption. The pea therefore reverts to its original state, its density decreases, and it, so to say, ‘upfloats’ to the fluidized bed boundary, where the entire process goes around. Thus, PPC has implemented a self-organizing process of hydrogen

---

[2] However, there is a possibility for alternative interpretation of these experiments on the basis of NNN generation at PT-II (see below).

[3] The exclamation mark in brackets is thus related to the fact that the effect can take place both in the course of 'order-disorder' PT-II and 'disorder-order' PT-II, under which, however, no additional disorder is expected; it also serves as an indication that 'an incidental' ingress of deuterium nuclei in the sites favorable for fusion cannot provide for statistically reliable intensities of the effects observed; and this is also true for other cases of 'activation' and 'shielding'.

sorbtion-desorbtion to-from the surface of peas, composing the cathode, and also the process of the alternate inside-outside diffusion of the same hydrogen through the peas metallized coating. This largely corresponds to the criteria we have suggested for a favorable organization of LENR in electrolytic systems, and by no means has this corresponded to the criterium of 'overloading'.

Nevertheless, most of us are still in captivity of some wrong ideas, taking a semblance of the reality, namely the idea that the deuterium overloading is required to provide for intense LENR of the D-D fusion in a crystalline lattice. Having no scientific basis but just alleged ‘evidence’, this idea was experimentally disproved by the author and other researchers many years ago.

NEUTRINO-DRIVEN NUCLEAR REACTIONS: VIRTUES AND DRAWBACKS OF LENR NEUTRINO CATALYSIS MODEL

On the other hand, we believe that no one activation hypothesis can give insight into the qualitative difference between LENR in the condensed systems and the conventional nuclear reactions, specifically, those of suppressing the channels with $^3T + ^1H$, $^3He + n$ at the outlet in comparison with the non-radiating channel with ^4He at the outlet in case of the $^2D + ^2D$ fusion etc. This contradiction of CMNS can be adjusted within the limits of the catalysis concept, that is, with reference to the nuclear reactions, within the models considering suppressing or shielding the Coulomb barrier of repulsion of nuclei. The catalysis is known as an effect of accelerating the activation process with involvement of a catalytic agent, which is evidently not in the balance of the given process neither at its inlet, nor outlet. Acceleration normally takes place for the reason that the catalytic agent forms with initial substances/elements[4] a certain intermediate and the so-called reacting complex, the formation of which calls for smaller amount of energy than the formation of the reacting complex with participation of the same substances/elements but without the catalytic agent. Accordingly, overcoming the reduced activation barrier will take place with a higher probability and require less time.

The above brief reference to a well-known effect is given to remind of the active role of the catalytic agent in a catalyzed process, not only in a quantitative sense (acceleration of the process), but qualitatively as well: the products formed in the cause of the catalytic process are not necessarily identical to the products of the process with participation of the same initial substances in the absence of the catalytic agent. The thing is that the real composition of the reacting complex differs in both cases, either with involvement of the catalytic agent or without it. In view of combination of the above features, specific qualitative differences of catalytic processes lie in the fact that the composition of their products is less diversified, while the products themselves are less energy-densed than in case of uncatalyzed processes.

The last principle in the best way agrees with the specific character of CMNS, which takes for granted the formation, as it would seem in a mysterious way, of essentially stable nuclear products, while the channels of formation of metastable nuclides and the intensity of ionizing radiations are suppressed by many decimal degrees of magnitude. By present there has been suggested a variety of models for conducting the LENR catalysis by various agents including hypothetical ones. That group of hypotheses can also include the models of collective processes (in sense of them being many-particle ones) available in CMNS, as well as hypotheses and theories that consider shielding of the Coulomb barrier by means of increasing the electron density in the reaction zone that takes place due to some assumed interactions. For the role of LENR catalytic agents there were proposed both real particles such as, for instance, neutrons as well as hypothetical ones: bineutrons, magnetic monopoles etc. The not-high energy neutrino was also considered for that role. Sophistication of all such hypotheses and theories is partially associated with the fact that natural fluxes of catalyzing particles are not always sufficient to provide for observable rates of reactions, attributed to CMNS. It is even more difficult to explain

---

[4] They are referred herein to in a general sense rather than in a specifically 'chemical' meaning of these words.

why the behavior of the above fluxes is different in case of LENR and in other cases, which fall within the conventional nuclear physics. The distinctive feature of the given group of the models is the basic ‘uncontrollability’ of these fluxes, which at early stages of CMNS development was often used as an explanation to the sporadic nature of observable effects, but it started to create some additional difficulties for interpreting experiments with appearance of reliable and easily reproducible methods.

Investigation into a wide range of the so-called anomalous effects in various areas of knowledge appeared to be the basis for our developing the hypothesis of neutrino-driven nuclear reactions (NDR). Throughout many years researchers would observe a variety of effects associated with transmission of interactions and information, which could hardly be associated with involvement of conventional carriers of the said effects. Thereupon there were proposed various hypothetical interactions and their carriers such as torsion, scalar, longitudinal magnetic and other fields, and also the particles that included axions, microleptons, ψ-particles etc. General properties of hypothetical carriers, which came from the specific nature of observable effects, were as follows: high penetrability at low energy of particles (or field quanta), availability of nonzero spin, lack of electric charge, and zero or close to zero mass.

To our opinion, **n**ot-high **en**ergy **n**eutrino (NNN) (and/or antineutrino as its antiparticle) is quite a suitable candidate for the role of the carrier of the effects mentioned; it has all of the above specific features and is also the carrier of a half-integer spin ($s = \pm \frac{1}{2}$ for a particle and antiparticle, respectively). The traditional objection to the given hypothesis is referred to the fact that the NNN does not interact with substance, i.e. it has vanishingly small absorption cross-sections σ_{abs}. However, such objection applies to the immediate interaction of neutrino with atom nuclei of various elements. This is a purely observational fact, while there are no theoretical provisions, prohibiting interaction of the NNN with substance, since the existing theory has been in fact adjusted to the observable situation; at the same time, known is the non-conventional theory, which points out to a sharp increase in the interaction cross-sections of neutrino with nuclei as the energy of the former tends to zero. And even this fact ($\sigma_{abs} \to 0$) we deem to be unsubstantiated as we believe that possible interactions of such kind cannot be diagnosed by conventional methods of the nuclear physics by virtue of some reasons, which will be touched upon below.

We suggest that the NNN can interact with substance at the atomic rather than at nuclear level, and at the first stage it can form a pair with one of the electrons in the atom by means of exchange interaction of spins.

$$\nu_{\uparrow}^{0} + e_{\downarrow}^{-} = e\nu_{\uparrow\downarrow}^{-}$$

where superscripts are used for denoting the sign of an electric charge of interacting particles, while subscripts - for denoting the spin sign ($s = \pm \frac{1}{2}$ for participating particles and $s = 0$ for a pair).

It is also suggested that an electron-neutrino pair to be formed hereinafter will show the behavior similar to that of the electron-electron pairs, which determine the interatomic binding in substance. Thus, in addition to the basic energy level, it has excited levels, the energy of which generally differs from both the energy of excited (nonbonding or antibonding) molecular orbitals, and from the energy of excited atomic orbitals of unpaired electrons.

Among other things, it is supposed that radii of excited electron-neutrino orbitals can be shorter rather than longer unlike their purely electronic counterparts: earlier such situation has been considered, however not in connection with neutrino. The extreme case of such excited state will be the atom, which will have one of its electronic clouds collapsed to the size, smaller by orders of magnitude than an equilibrium one. The case, when this atom belongs to one of hydrogen isotopes, will be the most interesting as by virtue of uniqueness of the electron, containing in the atom; the latter in this case will turn into a neutral quasi-particle, namely a quasi-neutron for protium ^{1}H and hypothetical quasi-bineutron for deuterium ^{2}D:

$$e\nu^{-}_{\uparrow\downarrow} + p^{+}_{\uparrow} \leftrightarrow (n^{*})^{0}_{\uparrow}$$
$$e\nu^{-}_{\uparrow\downarrow} + d^{+}_{\uparrow} \leftrightarrow (nn^{*})^{0}_{\uparrow}$$

where p^{+}, d^{+} - proton and deuteron, respectively, n^{*} and nn^{*} - quasi-neutron and quasi-bineutron, respectively. Let us remind that earlier (1994) Istomin published his explicit model of LENR catalysis by hypothetical bineutrons. Then theory of 'Barut-Vigier atom' became public knowledge (1995), then Dufour published his paper on experimental formation of hypothetical 'hydrex' (1997); those papers referred to atoms of hydrogen isotopes with collapsed electron clouds as LENR catalytic agents. Though these models did not involve neutrino, they adequately described the probable channels and products of LENR.

Within the limits of CMNS participation of such metastable hypothetical quasi-particles can explain many, if not all reactions of hydrogen isotopes: D-D fusion and various reactions of transmutation with participation of nuclides (conventionally viewed as 'stable') of heavy elements. Explanations can be also rendered to various reactions, including fusion, decay and fission as well as suppression of channels with high-energy radiations and formation of radionuclides. Mechanisms of such reactions are given below. This list can be extended by reactions of transmutation with 'detachment' of ^{4}He alpha-particles and their multiple nuclei of ^{8}Be, ^{12}C, ^{16}O etc.

SYNTHESIS OF LENR ACTIVATION AND CATALYTIC MODELS

The formal description of the LENR catalysis model by means of not-high energy neutrino does not make clear the mode of managing the process, and in this respect this particular model differs little from other catalytic models suggested within the frame of CMNS. In this respect there are still many issues left to be answered. I doubt that any further suggestions as to whether it is possible, and if it is possible, then how one can regulate the intensity of LENR, catalyzed by a natural flux of neutrino, could contribute into credibility of the hypothesis and accepting it by the CMNS scientific community. On the other hand, such assumptions are related to experimentally verified modes of excitation of the said LENR, and any successful implementation of a specific mode will contribute to acceptance of the entire model.

So, we admit the following possibilities of regulating the process in ascending order of their probability.

1. The first possibility is associated with generation of NNN in the experiment conditions. So, we assume the following: the electromagnetic fields (EMF) with plane-of-polarization rotation (PPR)[5] that we apply for interacting with a CMNS object, consist of waves, which predominately have a right-hand or left-hand polarization, while the 'common' fields contain the right and left waves in equal parts. If considering the above in terms of quanta, then in the fields we apply there prevail photons γ with predominantly similar (positive or negative) value of spin. Up to the present such fields have not been studied adequately yet, and so we can assume that conventional stability of a photon in a 'common' field is associated with its pairing and caused by the resonance of the following type:

---

[5] Earlier [] we used the term 'circularly polarized', but it is not good enough because of its being ambiguous.

$$\gamma^{+1} + \gamma^{-1} \leftrightarrow 2\gamma^{0}$$

Because of the absence or deficiency of paired photons in 'uncommon' EMF with PPR there prevails the following hypothetical equilibrium:

$$\gamma^{+1} \leftrightarrow 2\nu^{+1/2}$$
$$\gamma^{-1} \leftrightarrow 2\tilde{\nu}^{-1/2}$$

Such assumptions call for a serious theoretical substantiation as well as a properly arranged experimental verification. We do hope the latter will become possible in the course of further advances of our experimental technique. It should be noted that in addition to hypothetical possibilities of hardware to generate NNN, within the limits of the given model we also consider their formation in phase transition (PT-II), in what connection the energy of formed neutrino is clearly defined by entropy jump at PT-II:

$$1/2\,\omega = k\delta S$$

where ω - the frequency related to energy of quantum ε by a known correlation: $\varepsilon = h\ \omega$ (h - Plank constant), k - the coefficient with the dimension of T/h (T -phase-transition temperature).

2. We associate the second possibility with densification (or, if using the optics terminology, with focusing) fluxes of not-high energy neutrino in the experiment conditions by means of electromagnetic lenses with PPR. We assume that a spin-similar flux of photon ($s = \pm 1$) and that of neutrino ($s = \pm 1/2$) interact with each other, and focusing of the former will cause focusing of the latter.

3. The third possibility is associated with activation of products of the primary interaction of neutrino natural fluxes with substance rather than with variation of such fluxes. What is meant here is integrating hypotheses SA and NDR into the 'one-piece' model. In accordance with the second of the said models, the NNN-substance cross-section interaction not equals to zero, and at the first stage of such interaction there formed is electron-neutrino pair $e\bar{\nu}_{\uparrow\downarrow}$ mentioned earlier. It is assumed that current concentration of pairs in substance is not so high that it can essentially affect its measurable macroscopic properties, or, better to say, that the latter can be **always** measured in the presence of equilibrium content of the said pairs in conditions of a slightly fluctuating natural background of neutrino. Such absorption of neutrino by substance is reversible, and in the absence of some additional stimulation will not bring about any subsequent changes. However, excitation of the formed paired states will eventually result, as has been said earlier, in collapse of electronic clouds, formation of quasi-neutron states of the atoms of hydrogen isotopes and fusion of the latter with nuclei of neighbors (either similar atom penetrated into interstitial lattice sites or atoms of the matrix elements located in the sites of such matrix). Yet the highest efficiency of excitation can be provided, as has already been shown, by the mechanism of 'synergetic activation' SA, which is multi-quantum excitation of atoms in the course of self-organization of dynamic system.

In addition to active participation of stable nuclides (commonly regarded as such) in CMNS processes, separately should be mentioned the yet intriguing fact of predominant formation of stable products in the course of such processes. The above mentioned analysis of various 'anomalous' effects has enabled us to suggest earlier that one of the results of any nonreversible elementary process will be generation of a certain particle (identified by us as

NNN), i.e. a quantum of a hypothetical radiation, the frequency and energy of which is defined by the degree of irreversibility of the process, correlating with the rate of the latter:

$$\left(\sum_{\chi=0}^{1}\delta\chi\right)\Big/\tau_{\chi}=\tfrac{1}{2}\omega$$

where χ is the so-called co-ordinate of the process, τ_{χ} - duration of the process.

As the NNN catalyzed processes and SA processes are faster if compared with conventional thermonuclear reactions by virtue of an incomparably higher probability of the elementary event proceeding, the major share of their energy efficiency is attributed to neutrino and carried away with the latter.[6] In the result, the LENR products and namely the forming nuclei of daughter nuclides will have minimum of excess energy and be predominantly stable

At the same time, revealing their quantitative content calls for either a high-sensitivity technique for carrying out the elemental analysis, or the methods of experimental procedures specifically adapted for production of daughter nuclides in measurable quantities. It is nothing but this fact rather than some principle infeasibility of NNN interacting with substance is the reason as to why the conventional nuclear physics has been 'ignoring ' the proceeding of LENR.

CONCLUSION

The hypothesis of neutrino-driven nuclear reactions, complemented with SA model, can become a connecting link between various CMNS/LENR theories, mostly within the frames of some groups of theories, hypothesizing suppression (shielding) of the Coulomb barrier as well as the high-energy excitation of atoms, facilitating the 'kinetic' overcoming the Coulomb barrier. Such hypothesis does not contradict to various theories of 'shielding' and 'catalysis', and can be combined with the models that suggest quantum tunneling through the Coulomb barrier. Further theoretical development of the hypothesis, namely that of its keynote concept on formation of the electron-neutrino pair in atom and its significant role in CMNS/LENR, was carried out recently by Fukuhara (2005).

As a matter of principle, even combination of the existing accelerating hypotheses and shielding theories with SA model (as a constituent part of the hypothesis we have offered) is viewed as a creative step, inasmuch the latter does not specify the nature of excitation in the system, but enable the mentioned theories go around the obvious quantitative limitations. The given observation is however applicable to those theories, which are in position to offer their own explanations to the fact that both participants and products of the SMNS processes appear to be stable nuclides.

Within the frame of the given hypothesis it is possible to offer experimental methods for guiding natural neutrino fluxes (at least in terms of displacement of equilibrium in the natural NNN absorption), and also those one for generation of the latter in the experiment conditions that should not be excluded, though is less probable.

The above idea can be validated experimentally and can look to practical feasibility. However we have not succeeded to prove this idea experimentally yet, and are not aware of any experimental verification carried out so far by other researchers.

---

[6] In this case we are referring to the neutrino of nuclear energy scales of about MeV fractions or unities; such neutrinos show a conventional behavior, i.e. practically they do not interact with substance so long as they can form no electron-neutrino pair in the atom.