On low-energy nuclear reactions

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Based on our recent theoretical findings (Phys. Rev. C **99**, 054620 (2019)) it is shown that proton and deuteron capture reactions of extremely low energy may have accountable rate in the case of all elements of the periodic table. Certain numerical results of rates of nuclear reactions of two final fragments of extremely low energy are also given. New way of thinking about low-energy nuclear reactions (LENR) phenomena is suggested. Possible explanations for the contradictory observations announced between 1905-1927 and possible reasons for negative results of 'cold fusion' experiments published recently by the Google-organized scientific group (https://www.nature.com/articles/s41586-019-1256-6) are given.

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I. INTRODUCTION

Between 1905 and 1927, before the birth of quantum mechanics, such authors as e.g. J. J. Thomson, W. Ramsay, J. N. Collie and H. Patterson debated the possibility of creating H, He and Ne in gas discharges [1]. The discussion was started by C. Skinner in *The Physical Review* [2] and other articles appeared in periodicals like *Nature, Proceedings of the Royal Society of London A* and *Science.* The case remained open until nuclear physics answered it in the negative showing that the probability of reacting two free nuclei of like electric charge at room temperature is below any measurable value. However, the problem came to the fore again in a modified form 30 years ago when it was reported [3] that during electrolysis excess heat and extra neutrons were generated in deuterized metal hydrides, that could be attributed to and interpreted as evidence of nuclear fusion. After a short period of heated debate scepticism has overcome the scientific community [4] related to the phenomenon called 'cold fusion' at the time. Researchers were soon divided according to their opinion on the possibility of 'cold fusion' and in spite of the prevailing negative attitude of most (nuclear) physicists the quest for low-energy (temperature) nuclear reactions (LENR) has been going on during the last three decades [5]-[8]. Unfortunately, experimental data are often controversial and not clear enough to describe the essential features of LENR. The situation requires theoretical guide lines to proposals of experiments of new type. The main cause for the lack of proper guidelines has been the missing theoretical answer to the basic question: how the repelling nuclei can come close enough together to be able to take part in nuclear processes if the kinetic energy ε of relative motion is very small. (The problem is usually connected to the problem of tunneling through a large potential barrier caused by Coulomb repulsion.)

Recently however, the necessary step to solve the basic problem was taken [9]. In what follows the theoretical results of [9] are summarized.

From the point of view of LENR the magnitude of the wavefunction of reacting particles in nuclear range is crucial. The original Coulomb solution [10] yields with decreasing ε vanishing contact probability density in the nuclear volume that in this case leads to disappearing rate of nuclear reactions. In [9] the problem of forbidden nuclear reactions was compared to the forbidden optical transitions, particularly to the case of the forbidden $2s_{1/2}-1s_{1/2}$ transition of the hydrogen atom where the transition of the electron is accompanied by the emission of two photons that can be traced by second order perturbation calculation [11]. Accordingly in [9] it is pointed out that '*any perturbation* can mix states with small but finite amplitude to the initial state resulting in finite cross section (and rate)' also in the case of originally vanishing contact probability. The statement was illustrated by modification of nuclear reactions due to impurities in a gas mix of atomic state. Standard time independent perturbation calculation of quantum mechanics [12] was used to determine the change of the wavefunction of reacting particles in nuclear range due to their Coulomb interaction with impurity leading to a nonvanishing wavefunction and contact probability density in nuclear volume even if their ε goes to zero. The rate of nuclear processes discussed is proportional to $n_1 n_2 n_3$, where n_j is the number density of the participating particles j. It was also obtained in [9] that this proportionality remains valid at the surface of solids where in this case $n_1 = N_c/v_c$ with v_c the volume of unit cell and N_c the number of atoms in it. Consequently, the higher the product $n_1 n_2 n_3$ is the better the process works. The results in [9] are general and the model is applicable in the cases of gas discharges, heated metal-gas systems and electrolysises where LENR phenomena usually happen.

The cross sections of reactions of

$$ {}^{A_1}_{z_1}V + {}^{A_2}_{z_2}w + {}^{A_3}_{z_3}X \rightarrow {}^{A_1}_{z_1}V' + {}^{A_4}_{z_4}Y + \Delta \tag{1} $$

and

$$ {}^{A_1}_{z_1}V + {}^{A_2}_{z_2}w + {}^{A_3}_{z_3}X \rightarrow {}^{A_1}_{z_1}V' + {}^{A_4}_{z_4}Y + {}^{A_5}_{z_5}W + \Delta \tag{2} $$

were determined. Here z_j and A_j are charge and mass numbers and Δ is the reaction energy which is the difference between the sum of the initial and final mass excesses [13]. Numerical evaluations indicate that the rate of reactions that were expected to be negligible small, may become of accountable magnitude due to Coulomb assistance by the impurity ${}_{z_1}^{A_1}V$.

Based on the theoretical findings presented in [9] and the further results to be disclosed here, in this paper we are going to propose a new approach to understanding the divers experimental results in the field of LENR. Especially, the explanation of negative results concerning the existence of 'cold fusion' published and disclosed recently by the Google-group [14], needs placing 'cold fusion' into a broader context of LENR. We also try to reconcile the occasional transmutations observed in early experiments [1] and point out the possible reasons for the failures of recent 'cold fusion' experiments [14]. It will be discussed in more detail in the second part of the paper.

II. CROSS SECTION CALCULATION

The cross section $\sigma_{23}^{(2)}$ of processes (1) and (2) can be determined as

$$v_{23}\sigma_{23}^{(2)} = n_1 S_{\mathrm{reaction}}, \tag{3}$$

where v_{23} is the relative velocity of particles 2 and 3. In the case of reaction (2) S_{reaction} can be deducted from astrophysical factors $S(\varepsilon)$ from Eqs.(27) and (28) of [9] with the aid of $S(0)$ in the long wave approximation. Since the calculated $S_{\mathrm{reaction}}(\sim z_1^2 S(0))$ values of reactions of two final fragments are connected to experimental observations they are nuclear model independent. The rate and power densities are $r_{\mathrm{reaction}} = n_1 n_2 n_3 S_{\mathrm{reaction}}$ and $p_{\mathrm{reaction}} = r_{\mathrm{reaction}}\Delta = n_1 n_2 n_3 S_{\mathrm{reaction}}\Delta$, respectively. (In the case of reactions ${}^{15}N(p,\alpha_{0,1}){}^{12}C$ the $S(\varepsilon)$ function determined by [15] is applied with the aid of Eqs.(49)-(50) of [16]. Here and below the subscripts 0 and 1 refer to ground and first excited final nuclear states.)

Conversely, in the case of reaction (1), which is an assisted capture reaction, the calculations can not be based on the astrophysical factors of reactions ${}_{z_2}^{A_2}w + {}_{z_3}^{A_3}X \rightarrow {}_{z_4}^{A_4}Y + \gamma$ since it is governed by electromagnetic interaction while the nuclear part of (1) is governed by strong interaction and therefore the cross section calculations of (1) are strongly nuclear model dependent. In [9] the cross section of ${}_{z_1}^{A_1}V + p + d \rightarrow {}_{z_1}^{A_1}V' + {}^3He + 5.493$ MeV was determined in a very simple model with an assisting nucleus of mass and charge numbers A_1 and z_1. The result indicates that the most significant increase of the cross section caused by Coulomb interaction of reacting particles (2 and 3) with ${}_{z_1}^{A_1}V$ originates from factors f_{23} which come from the Coulomb solutions of particles 2, 3 of high ε. According to perturbation calculation [9] these Coulomb states are mixed to the state of $\varepsilon = 0$ and factors f_{23}, which come from these Coulomb solutions, are defined as

$$f_{23}^2(s,\Delta) = \frac{2\pi\eta_{23}(s,\Delta)}{\exp\left[2\pi\eta_{23}(s,\Delta)\right] - 1} \tag{4}$$

with

$$\eta_{23}(s,\Delta) = z_2 z_3 \alpha_f \frac{a_{23}}{a(s)} \sqrt{\frac{m_0 c^2}{2a_{14}\Delta}}, \tag{5}$$

where $a(s) = \left|-A_3\delta_{s,2} + A_2\delta_{s,3}\right| / (A_2 + A_3)$ with $s = 2, 3$. $m_0c^2 = 931.494$ MeV is the atomic energy unit, c is the velocity of light in vacuum, α_f is the fine structure constant and $a_{jk} = A_j A_k / (A_j + A_k)$ is the reduced mass number of particles j and k of mass numbers A_j and A_k with rest masses $m_j = A_j m_0$, $m_k = A_k m_0$. The cross section and the rate are proportional to a sum which contains terms proportional to products $f_{23}(s,\Delta) f_{23}(s',\Delta)$.

In the case of proton capture ($z_2 = 1$, $A_2 = 1$) the $s = 2$ case with $a(2) = A_3/(1 + A_3)$ gives the largest f_{23} value therefore only the leading $f_{23}^2(2,\Delta)$ will be studied on. (One should remember that $f_{23}^2(2,\Delta)$ must be compared to $\exp\left[-2\pi\eta_{23}(\varepsilon)\right]$ which comes from cross section $\sigma(\varepsilon) = S(\varepsilon)\exp\left[-2\pi\eta_{23}(\varepsilon)\right]/\varepsilon$ of usual nuclear reactions between charged particles 2 and 3 of charge numbers z_2 and z_3 [17] where $S(\varepsilon)$ is the astrophysical S-factor, $\eta_{23}(\varepsilon) = z_2 z_3 \alpha_f \left[a_{23} m_0 c^2/(2\varepsilon)\right]^{1/2}$ is the Sommerfeld parameter and ε is the kinetic energy taken in the center of mass coordinate system. If $\varepsilon \rightarrow 0$ then $\sigma(\varepsilon)$ and the rate disappear.)

III. NUMERICAL RESULTS

Capture reactions of type (1) will have cross section $\sigma_{23}^{(2)}$ of accountable magnitude if $\eta_{23} < 1$ (if $\eta_{23} = 1$ then $f_{23}^2 = 0.012$). In the case of proton capture using $\eta_{23}(2,\Delta)$ the $\eta_{23} < 1$ leads to condition $z_3 \lesssim \left[2a_{14}\Delta/\left(\alpha_f^2 m_0 c^2\right)\right]^{1/2}$. In the case of heavy 1, 3 and 4 particles, $A_1 \simeq A_3 \simeq A_4$ and $a_{14} \simeq A_4/2 \gtrsim z_4 \simeq z_3$ one has $z_3 \lesssim 2\Delta/\left(\alpha_f^2 m_0 c^2\right) = 40.30 \times \Delta(\text{in MeV})$. For d-capture the condition modifies as $z_3 \lesssim \Delta/\left(2\alpha_f^2 m_0 c^2\right) = 10.08 \times \Delta(\text{in MeV})$. All this means that e.g. even the ${}^{238}U + d + {}^{235}U \rightarrow {}^{238}U' + {}^{237}Np + 9.182$ MeV d-capture reaction can happen with a non-negligible probability (rate). As a result we are faced with plenty of possible p- and d-capture reactions of type (1). Obviously the ${}_{z_1}^{A_1}V + d + d \rightarrow {}_{z_1}^{A_1}V' + {}^4He + 23.845$ MeV reaction may also happen. An essential consequence of the possibility of p- and d-capture reactions of type (1) is the possibility of nuclear transmutation of all the elements of the periodic table.

The results of our S_{reaction} and rate density calculations can be found in Tables I and II. The energies (spin^{parities}) of the considered excited states are: ${}^{12}C$, 4.439 MeV (2^+); ${}^{20}Ne$, 1.634 MeV (2^+) and ${}^{23}Na$, 0.4400

Reaction	$S_{reaction}$	Δ	$r_{reaction}$
$S(\varepsilon)$			
$^{15}N(p,\alpha_0)^{12}C$	8.20×10^{-51}	4.965	1.61×10^{11}
$^{15}N(p,\alpha_1)^{12}C$	1.63×10^{-51}	0.526	3.19×10^{10}
$S(0) = 100$			
$^{23}Na(p,\alpha_0)^{20}Ne$	5.59×10^{-52}	2.377	1.10×10^{10}
$^{23}Na(p,\alpha_1)^{20}Ne$	4.43×10^{-52}	0.743	8.68×10^{9}
$S(0) = 3.5 \times 10^7$			
$^{14}N(^7Li,\alpha_0)^{17}O$	9.71×10^{-52}	16.155	1.90×10^{10}
$^{14}N(^6Li,\alpha_0)^{16}O$	4.92×10^{-51}	19.262	9.64×10^{10}
$^{16}O(^7Li,\alpha_0)^{19}F$	2.43×10^{-53}	9.233	4.76×10^{8}
$^{16}O(^6Li,\alpha_0)^{18}F$	2.13×10^{-53}	6.051	4.18×10^{8}
$^{17}O(\alpha_0,n)^{20}Ne$	3.46×10^{-54}	0.587	6.79×10^{7}
$S(0) = 1.0 \times 10^{16}$			
$^{12}C(^{12}C,\alpha_0)^{20}Ne$	2.24×10^{-58}	4.617	4390
$^{12}C(^{12}C,\alpha_1)^{20}Ne$	4.43×10^{-63}	2.983	0.087
$^{12}C(^{12}C,p_0)^{23}Na$	8.11×10^{-67}	2.241	1.60×10^{-5}
$^{12}C(^{12}C,p_1)^{23}Na$	4.39×10^{-70}	1.801	8.61×10^{-9}

TABLE I: S_{reaction}(in $\mathrm{cm}^6\mathrm{s}^{-1}$) and rate density r_{reaction}(in $\mathrm{cm}^{-3}s^{-1}$) of Ni (of mass number 58) assisted reactions with two final fragments. Δ(in MeV) is the energy of the reaction. $S(0)$(in MeVb) is the astrophysical factor at $\varepsilon = 0$, where ε is the center of mass kinetic energy. $r_{\mathrm{reaction}} = n_1 n_2 n_3 S_{\mathrm{reaction}}$ is the rate density that is calculated with $n_1 n_2 n_3 = 1.861 \times 10^{61}$ cm^{-9}. The subscripts 0 and 1 refer to ground and first excited final nuclear states. The energies (spin^{parities}) of the considered excited states are: ^{12}C, 4.439 MeV (2^+); ^{20}Ne, 1.634 MeV (2^+) and ^{23}Na, 0.4400 MeV($5/2^+$). $S(\varepsilon)$ is taken from [15], $S(0) = 3.5 \times 10^7$ MeVb, $S(0) = 100$ MeVb are taken from [17], [18], respectively. Furthermore, the $S(0) = 1.0 \times 10^{16}$ MeVb [19] value seems to be an under-estimation of $S(0)$ [20].

Reaction	$S_{reaction}$	Δ	$r_{reaction}$
$S(0) = 100$			
$^{16}O(d,\alpha_0)^{14}N$	1.86×10^{-51}	3.011	3.66×10^{10}
$^{17}O(d,\alpha_0)^{15}N$	2.11×10^{-51}	9.800	4.15×10^{10}
$^{18}O(d,\alpha_0)^{16}N$	1.96×10^{-51}	4.245	3.85×10^{10}
$S(0) = 3.5 \times 10^7$			
$^{16}O(d,\alpha_0)^{14}N$	6.52×10^{-46}	3.011	1.28×10^{16}
$^{17}O(d,\alpha_0)^{15}N$	7.40×10^{-46}	9.800	1.45×10^{16}
$^{18}O(d,\alpha_0)^{16}N$	6.86×10^{-46}	4.245	1.35×10^{16}

TABLE II: S_{reaction}(in $\mathrm{cm}^6\mathrm{s}^{-1}$) and rate density r_{reaction}(in $\mathrm{cm}^{-3}s^{-1}$) of Pt (of mass number 195) assisted reactions with two final fragments. Δ(in MeV) is the energy of the reaction. $r_{\mathrm{reaction}} = n_1 n_2 n_3 S_{\mathrm{reaction}}$ is the rate density that is calculated with $n_1 n_2 n_3 = 1.861 \times 10^{61}$ cm^{-9}. $S(0)$(in MeVb) is the astrophysical factor at $\varepsilon = 0$, where ε is the center of mass kinetic energy. $S(0) = 3.5 \times 10^7$ MeVb, $S(0) = 100$ MeVb are taken from [17], [18], respectively.

MeV ($5/2^+$). $S(\varepsilon)$ is taken from [15], $S(0) = 3.5 \times 10^7$ MeVb, $S(0) = 100$ MeVb are taken from [17], [18], respectively. Furthermore, the $S(0) = 1.0 \times 10^{16}$ MeVb [19] value seems to be an under-estimation of $S(0)$ [20].

It was found that not only in the case of the earlier investigated reactions (the reactions from $d(d,n)^3He$ up to $^{11}B(p,\alpha)^8Be$, see Table I of [9]) but in view of the results obtained above for reactions discussed here (reactions from $^{15}N(p,\alpha_0)^{12}C$ up to $^{12}C(^{12}C,\alpha_1)^{20}Ne$, see Table I here and the reactions of Table II) the reaction rate can have accountable magnitude if the number densities n_j $(j = 1,2,3)$ of the initial particles reach appropriately high values.

IV. INTERPRETATION OF LENR EXPERIMENTS OF CONTRADICTORY AND NEGATIVE RESULTS

A. Experiments of contradictory results

Now, as a first example we discuss the early contradictory observations related to H, He and Ne creation in gas discharges [1]. In the experiment by Skinner [2] a testing electrode from NaK alloy remained in open connection with the discharge tube where the test (metal) electrodes operated, therefore ^{23}Na–^4He interaction could happen. Due to this interaction assisted by Na atoms of the alloy the $^{23}Na+$ $^{23}Na+$ $^4He \rightarrow$ $^{23}Na' + p +$ $^{26}Mg + 1.821$ MeV reaction could take place. Calculating the rate taking $n_1 = n_3 = 1 \times 10^{23}$ cm^{-3} for Na atom number density in the alloy, $n_2 = 1.02 \times 10^{17}$ cm^{-3} which corresponds to the applied ^4He content (pressure) and using $S(0) = 3.5 \times 10^7$ MeV, $S_{\mathrm{reaction}} = 5.41 \times 10^{-55}$ $\mathrm{cm}^6\mathrm{s}^{-1}$ and $r_{\mathrm{reaction}} = 2.08 \times 10^8$ $\mathrm{cm}^{-3}\mathrm{s}^{-1}$ rate density are obtained. The disappearance of H at the Al anode can be put down to the Al assisted $^{27}Al+$ $^{27}Al + p \rightarrow$ $^{27}Al'$ + $^4He+$ $^{24}Mg + 1.600$ MeV reaction. Moreover, the $^{23}Na+$ $^{23}Na+$ $p \rightarrow$ $^{23}Na'+$ $^4He+$ ^{20}Ne reactions (see for similar reactions Table I) could also work if the glass from which the discharge tube was made had some Na content.

Now we consider the occasional He and Ne creation in gas discharges [1]. Discharge tubes are constructed sometimes from quartz and sometimes from borosilicate that may have some Na content too. During discharge protons bomb the wall of the experimental apparatus due to ambipolar diffusion, and if the discharge tube was made from borosilicate glass with Na content then reactions $^{10}B(p,\ \alpha_0)^7Be$,$^{11}B(p,\ \alpha_0)^8Be$ (the ^8Be spontaneously decays to 2α) and $^{23}Na(p,\alpha_{0,1})^{20}Ne$ could happen producing He and Ne. A fact that can explain the mystery of their occasional production since in the absence of B and Na, which is the case when using quartz, the nuclear reactions do not happen. In addition, if the discharge tube has constriction as was the case of the apparatus of [21] then the effect caused by ambipolar diffusion is stronger.

B. Experiments of negative results of Google-organized research group

In [14], three principal directions of research were specified: highly hydrated metals, calorimetry under extreme conditions and low-energy nuclear reactions. (This later terminology was to define a special pulsed deuterium plasma device [22] which was applied to induce nuclear reactions of low energy.) However, nuclear transmutation [5]-[8], which is the most important phenomenon connected to LENR, was missing. It was shown above that nuclear transmutation is possible for all the elements of the periodic table therefore it is expected that traces of it must be present in all LENR observations. There exist very sensitive methods which are capable to determine small amounts of changes of chemical composition of materials and show the appearance of nuclear transmutation. Thus omission of search for nuclear transmutation is the main fault in the program of [14].

1. *Highly hydrated metals*

The ^4He production in electrolysis seemed to be accompanied by extra heat production, that was attributed to $d + d \rightarrow {}^4He + \gamma$ reaction with the implicit expectation of occurrence of $d(d,t)p$ and $d(d,n)^3He$ reactions bringing up the problem of the missing γ, n and t. However, as can be seen from Table I here and in [9] and Table II ^4He production can occur in many other reactions too. The sum of their energy production may significantly exceed the sole energy production of ${}^{A_1}_{z_1}V + d + d \rightarrow {}^4He + {}^{A_1}_{z_1}V'$ (the appearance of which in itself can partly solve the problem of missing γ in ^4He production) and the rate of n, t and ^3He productions in assisted $d(d,t)p$ and $d(d,n)^3He$ reactions may be considerably smaller than the total rate of ^4He production. In electrolysis-type experiments one usually focuses on the cathode and searching for nuclear reactions attached to the anode is omitted. In order to demonstrate the possible importance of nuclear reactions which may be connected to the anode, the rates of a few (d,α) reactions of type (2) assisted by $Pt(A_1 = 195,\ z_1 = 78)$ at two possible $S(0)$ values are listed in Table II. Comparing the obtained rate numbers with the rate numbers of Table I one can recognize that the rates of Table II are approximately equal to or larger than the numbers of Table I which fact calls attention to the possible importance of nuclear processes happening near the surface of the anode. It is stated that large D/Pd ratio of loading D in Pd is necessary to observe effects [7], [23]. Although this observation suggests that the most important nuclear reactions take place in the loaded Pd, since other parameters (e.g. current density of electrolysis) must also have extreme values in order to reach the desired high D/Pd ratio, more advantageous circumstances may come about in other places of the experimental equipment that permit other concurrent nuclear reactions of high power density to start. [It is worth mentioning that e.g. the ${}^{A_1}_{z_1}V + {}^{16}O + p \rightarrow {}^{14}O + {}^4He + {}^{A_1}_{z_1}V'$ reaction is endothermal ($\Delta = -5.218$ MeV) and the reaction energy ($\Delta = 0.600$ MeV) of ${}^{A_1}_{z_1}V + {}^{16}O + p \rightarrow {}^{17}F + {}^{A_1}_{z_1}V'$ capture reaction is small. These reactions can take place in electrolysises in normal water.] In view of the above it must be emphasized that any seemingly tiny detail of geometry and chemical composition of structural elements can be crucial. Therefore precise and very detailed documentation of the applied experimental apparatus is required.

2. *Calorimetry in extreme conditions*

The calorimetry performed in extreme conditions in [14] has been focused on powdered $Ni - H - LiAlH_4$ systems. In these and similar experiments metals (Ni and Pd) were used in order to break the (mainly two-atomic) molecules into atomic state. Since the mechanism works on the surface of metals [24] it is tacitly assumed that the nuclear reactions too take place very close to the metal surface. In the experiments of the early 1990s [25], [26] where Ni rod $-$ H gas systems were investigated ceramic holders were applied to keep metal rods inside the experimental chamber. The chemical composition of the ceramic holder is unknown but it is reasonable to assume that it may have contained elements which took part in nuclear reactions and produced measurable excess heat. In the experiments on powdered $Ni - H - LiAlH_4$ systems after 2011 N_2 gas buffer was also applied. (There was an N_2 gas container visible in an unpublished internet-picture so it is of great probability that in order to avoid H_2 explosion buffer gas N_2 was used.) The $^{15}N(p,\alpha_0)^{12}C$, $^{15}N(p,\alpha_1)^{12}C$, $^{14}N(^7Li,\alpha_0)^{17}O$ and $^{14}N(^6Li,\alpha_0)^{16}O$ reactions may contribute to large fraction of power generation which may explain negative experimental results [14] obtained without N_2 gas buffer in the active volume.

3. *Reactions induced by pulsed deuterium plasma beam*

Finally, a special device [14], [22] was used to investigate nuclear dd reactions induced by pulsed deuterium plasma beam bombarding palladium targets with deuterons producing more flux than that of ion beams of commonly used low energy accelerators. However, since the vacuum chamber contained deuterium gas (D_2) at about 1 torr the product $n_1 n_2 n_3$ remained much below the necessary 10^{61} cm^{-9} order of magnitude value to reach accountable rate.

V. CONCLUSION

Based on the recent theoretical results [9] it was shown that a huge number of nuclear reactions may have significant rate even if the kinetic energy of the colliding particles is down to that of room temperature. The necessary condition to reach accountable rate is that the product $n_1 n_2 n_3$, i.e. the product of the number density of the assisting particles and the number densities of the reacting particles, should reach appropriately high value. Since the participants of possible nuclear reactions can come from the whole periodic table of elements, it is advised to drop old stereotypes in thinking about LENR and a new approach is necessary to understand what is going on in this field.

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