Element Distribution in the Products of Low Energy Transmutation. Nucleosynthesis

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ABSTRACT. Analysis of experimental data and phenomenological model yield that multiple transmutation processes (processes with participation of both primary and secondary chemical elements – products of previous transmutations) cause an appearance of stable atomic nuclei of all chemical elements in its products. It is assumed that element distribution in hyper-multiple transmutation tends to become “universal”, i.e. independent of element composition of a matter, in which transmutation processes started. Element abundance in the Earth’s crust correlates with element distribution in the case of zirconium transmutation. Based on above circumstances, a hypothesis is offered that nucleosynthesis and power generation in the Universe occur, among other things, due to low energy transmutation processes.

RESUME. Il résulte de données expérimentales et d’un modèle phénoménologique que de nombreux processus de transmutation (auxquels prennent part des éléments chimiques tant antérieurs que postérieurs - produits de précédentes transmutations), donnent naissance, dans leurs produits, à des noyaux atomiques de tous les éléments chimiques. On formule l’hypothèse que la distribution des éléments à la suite d’un grand nombre de de telles transmutations successives tend à devenir "universelle", en ce sens qu’elle ne dépend plus de la composition de la matière dans laquelle le processus a commencé. L'extension des éléments dans l'écorce terrestre est corrélée avec la distribution des éléments dans le cas de la transmutation du zirconium. Sur la base de ce qui vient d'être dit, on émet l'hypothèse que des processus de nucléosynthèse et l'énergétique de l'Univers sont réalisables, en particulier lors de transmutations à basse énergie.
**Introduction**

Experimental results on observation of abnormal physical phenomenon – low energy transmutation of atomic nuclei of chemical elements (other name: low energy nuclear reactions) are discussed in scientific literature, mainly in the Proceedings of the 1-14th International Conferences on Cold Fusion and Proceedings of 1-15th Russian Conferences on Cold Transmutation of Nuclei of Chemical Elements.

The essence of this phenomenon consists in the fact that chemical elements turn into other chemical elements in low excited, from the point of view of nuclear physics, condensed media (~10-100 eV/atom).

In the majority of experiments on low energy element transmutation (hereafter – LEET or transmutation), the medium excitation was achieved by applying to them electrical current or electromagnetic radiation. In other cases, liquid media were excited with ultrasound. For example, the phenomenon of LEET was registered; at the glow discharge in palladium and other metal cathodes [1-5, Appendix], at electron beam melting of zirconium ingots in vacuum furnace [6,9], at electron explosions of metal targets [7, Appendix] and electric explosions of metal foils in liquid dielectric medium [8,9], at application of pulse current to lead [10], at electric discharge in water-mineral medium [11, Appendix], at ultrasound processing of water salines [12,9], in growing biological structures [13] and others.

In addition to the fact that new elements appear in all these experiments, which were absent in initial material prior to beginning of said processes, an isotopes relation of chemical elements distinct from natural distribution [1-8] is registered in transmutation products. As a rule, stable isotopes of elements are transmutation products in the majority of experiments. Moreover, a communication on transformation of radioactive isotopes into stable ones is available [7,12]. In some experiments [3-5,7,10] it was possible to register x-ray and gamma-ray radiation, radiation of charged particles as well as radioactive isotopes. At that, by estimate of authors of publications [3-5], the number of stable isotopes produced as a result of transmutation is $10^{12}$-$10^{13}$ times more than that of radioactive isotopes. Other peculiarity of LEET process is the fact that excessive heat energy [1,2,4,5,6,8,11,12] was registered where it was possible to do so. Some authors underline that transmutation process is accompanied by unknown radiation, which leaves its “strange” traces in photoemulsions, on thin sections of metals, and which, at interaction with matter, changes its structure and chemical composition [6,8,12,14,15]. Some investigations of properties of these particles allow the authors to hypothesize the presence of magnetic charge in those particles [8].
1. Phenomenological model.

Phenomenological model of LEET process was proposed and calculation of possible end products of transmutation with an account for energy balances of nuclear transformations was performed in paper [9]. Though the mechanism of low energy transmutation reactions is unknown, they should obey to main conservation laws: energy, momentum, angular momentum, baryon-number and lepton-number conservation laws. The phenomenological model assumes, as a hypothesis, simultaneous interaction of many atoms (atomic nuclei + their electrons) at transmutation.

Supposition, that at transmutation many atoms interact simultaneously, follows from the fact of obtaining many chemical elements at electron-beam and electric explosions [7-9], including heavy elements: tungsten, tantalum, lead, which are impossible to obtain in pair reactions in relatively element-light medium [7, 9,14]. Therefore two or more of atomic nuclei can take part into inlet and outlet channels of the transmutation reactions. Besides we have to include electrons into inlet and outlet channels, thus supposing a possibility of electro-weak interactions, at that, not breaking conservation laws of electric and lepton charge:

\[
\sum c_i \frac{N}{Z} A_i + e^- \rightarrow \sum c_j \frac{N}{Z} B_j + e^- \sum c_j Z_j + l \nu (\bar{\nu}) + Q \quad (1),
\]

where \( \frac{N}{Z} A \), \( \frac{N}{Z} B \) - nuclides with charge Z and nucleon quantity N; nuclides \( \frac{N}{Z} B \) are as a rule stable; \( e^- \) - atomic electrons; \( c_i, c_j \) - quantity of nuclides \( \frac{N}{Z} A \), \( \frac{N}{Z} B \) in inlet and outlet channels, correspondingly; \( l \nu (\bar{\nu}) \) - \( l \) -number of neutrino or antineutrino. Neutrino and antineutrino appear in reaction equations for conservation of lepton charge. Furthermore, we must be sure that nuclear reactions (1), leading to strange elements observed in experiments, are exothermic \( Q \geq 0 \).

Surely, in calculations, not only mass of a nucleus, but also mass of \( l \) electrons should be taken into account in energy balance. Furthermore, for purity of calculations we took into account also coupling energy of electrons in atoms. For technical reasons we took into account not more than three outlet nuclides, i.e. all reactions were considered:
where \( le^- \), \( l\nu_e \), \( l\bar{\nu}_e \) - number of electrons, neutrino and antineutrino, correspondingly. At that, conservation conditions of quantity of nucleons

\[
\sum_{i} c_i N_i + l \nu_e = N_1 B_1 + N_2 B_2 + l \nu_e + Q ;
\]

\[
\sum_{i} c_i Z_i A + l e^- = Z_1 B_1 + Z_2 B_2 + N_1 B_1 + l \nu_e + Q ;
\]

\[
\sum_{i} c_i N_i A = Z_1 B_1 + Z_2 B_2 + l e^- + l \bar{\nu}_e + Q ;
\]

\[
\sum_{i} c_i Z_i A = Z_1 B_1 + Z_2 B_2 + N_1 B_1 + l e^- + l \bar{\nu}_e + Q ,
\]

where \( le^- \), \( l\nu_e \), \( l\bar{\nu}_e \) - number of electrons, neutrino and antineutrino, correspondingly. At that, conservation conditions of quantity of nucleons

\[
\sum_{i} c_i N_i = N_1 + N_2 \quad \text{and} \quad \sum_{i} c_i Z_i = Z_1 + Z_2 + Z_3, \quad \text{full charge conservation}
\]

\[
\sum_{i} c_i Z_i \pm l = Z_1 + Z_2 \quad \text{and} \quad \sum_{i} c_i Z_i \pm l = Z_1 + Z_2 + Z_3 \quad \text{and} \quad Q \geq 0.
\]

Thus, the done calculations show that the process of appearance of strange elements in low energy transmutation reaction does not contradict to energy conservation law and they can be obtained from initial nuclei at positive energy output [9].

Energy is released in these reactions at the expense of difference in sums of masses of atomic nuclei in inlet and outlet reaction channels. Such processes are known, this is fission of nuclei into two fragments, for example, spontaneous fission of nucleus \(^{238}\text{U}\), and thermonuclear fusion, when, on the contrary, a fusion reaction of two light nuclei takes place. As mentioned above, energy is released in these two processes at the expense of difference in sums of masses of initial and end atomic nuclei. The same occurs in transmutation process, but in this case two nuclei or a whole conglomerate of atomic nuclei can take part in the reaction. At that, both processes are realized in multi-atom transmutation reactions: fusion of many atomic nuclei (atoms) into one common formation and subsequent division of this formation into many atoms. It should be underlined that the above reaction equation (1) represents apparently just the known - nuclear part of this complicated process, but does not reflect in any way, for example, the appearance of unknown radiation in LEET reactions.

It should be noted that the assumption about interaction of several nuclides in transmutation processes was expressed earlier, in papers [4,14]. The authors put forward a hypothesis that formation of foreign elements in a palladium cathode, which are observed after cathode irradiation with deuterium (d) ions in glow discharge, can be explained by “decay” reactions of excited
palladium $^*\text{Pd} \rightarrow \text{N}_i \text{A} + \text{N}_j \text{B}_j$ and by “fusion-decay” reactions: $d + \text{Pd} \rightarrow \text{N}_i \text{A} + \text{N}_j \text{B}_j$, $2d + \text{Pd} \rightarrow \text{N}_i \text{A} + \text{N}_j \text{B}_j$, $3d + \text{Pd} \rightarrow \text{N}_i \text{A} + \text{N}_j \text{B}_j$.

2 Classification of transmutation processes

As it was already mentioned, the end state of transmutation process is a set of stable nuclides (at present, 272 stable nuclides can be counted). This final set of nuclides is different for transmutation processes, which occur either for a short time (electron and electric explosions Fig.1a), or, when in the process of LEET the medium recommences continuously (electric discharge in aqueous-mineral medium Fig.1b), if compared with time-extended processes, in which the medium is not replaced by a new one (melting of zirconium - Fig.1c, ultrasound processing [USP] of salt solutions - Fig.1d). In given figures, it can be seen, that in case of electric explosion and electric discharge the appearance of strange elements is irregular, and in case of Zr-melting and USP transmutation products are a broad spectrum of chemical elements.

As shown in [9], a possible cause of this difference is the duration of LEET processes in these experiments. Actually, electric explosion occurs during tens of microseconds, in two other cases it occurs during tens of minutes – zirconium melting and even days – ultrasound processing. And though it is not known what time the transmutation reaction takes, what time the conditions for its appearance in the medium exist, it is realistic to assume that transmutation reaction density per medium unit is much greater during Zr-melting and USP, than in the case of electric explosion. Due to above it can be assumed that transmutation reactions at electric explosions occur, to significant degree, under participation of initial material only, and in cases of Zr-melting and USP secondary elements – products of previous transmutations – can be involved. Obviously, the last circumstance causes an extension of element spectra, which are obtained in transmutation products.

By present moment, rather many experiments on low energy element transmutation have been carried out, so they can be classified.

- First of all, experiments on LEET can be classified according to a method applied, for example: electric discharge, melting, cavitation, etc.
- Another important feature of the process is repetition factor of participation of chemical elements in transmutation reactions. Single processes can take place in LEET reactions, when initial, primary chemical elements only participate in them. These processes are: experiments on electron explosion [7] and on electric explosion of metallic foils in liquid media [8,9], and ex-
Experiments on electric discharge in water-mineral medium [11, page 28]. Experiments where multiple LEET processes with participation of both primary and secondary chemical elements are: for example, ultrasound processes of aqueous salt solutions [12]. Also, prolonged multiple processes are possible. Let us call them, for short, hypermultiple processes. Mainly secondary chemical elements participate at the end of these processes in transmutation reactions. Electron melting of zirconium ingots in vacuum furnace should be ascribed to such experiments [6].

- Other feature of the process is its energy intensity or, in other words, energy density of excited medium. Obviously, the number of atoms in the input channel of LEET reaction and, consequently, the element composition of transmutation products depends on this feature of the process.
• Initial medium composition by chemical elements obviously influences element composition of LEET products. This is true, at least, for single and multiple transmutation processes.

3 Number of atoms in input channel of transmutation reactions.

When discussing transmutation product spectrum in paper [9] for the case of zirconium melting, it was stated that a broad spectrum of elements can be obtained in two ways: either at serial accumulation first of light elements with a relative low energy coupling, and then on their basis – accumulation of heavy elements, either at once, accumulation of light and heavy elements from a large quantity of initial nuclei in input channel – parallel accumulation.

Obviously, consecutive mechanism in obtaining a broad spectrum of chemical elements in transmutation products takes place in experiments on ultrasound processing of aqueous salt solutions [12]. As can be seen from Fig. 2b, chloride lithium solution (LiCl), after its processing during 8 hours, showed the appearance of such chemical elements as Sc, V, Cr, Zn. Those elements were missing in the solution after its processing during two hours Fig.2a. The amount of F, Mg, P, Ca, Mn, Fe also increased significantly. At the same time (8 hours), heavier chemical elements, which appeared in the solution after 24-hour treatment (Fig.2c) are missing in the solution. For last measurement time, such an element as rubidium (Rb) has a concentration comparable to concentration of zinc, and that is why it should be present in the solution after its 8-hour activation, if we allow not consecutive, and a parallel mechanism of element production (a large amount of initial nuclei in the input channel). The same can be said about cesium (Cs), which concentration exceeds the zinc concentration by more than an order. It may be concluded from this circumstance that, first, light elements starting from $^{19}$F to $^{70}$Zn are produced in water solution in this experiment, which are consequently a material for production of heavier chemical elements. If we assume that at initial stage of transmutation process, when salt concentration is low, mainly water molecules participate in reactions, then we can evaluate a number of molecules participating in transmutation process and area of space occupied by them. To obtain elements from $^{19}$F to $^{70}$Zn, sufficient are 1(+hydrogen) – 4 molecules of water (Fig.2d), and area occupied by them is equal to $\sim 5 \times 10^{-8}$ cm. Thus, a number of atoms participating in transmutation process can amount, in this case to 4-12 atoms ($H_2O$-molecule - 3 atoms).

However, it should be remembered that in experiments with electric explosion [8,9] and electric discharge in distilled water [11] heavy elements – Ta, Pb, Bi (Fig.1c,d) were found in transmutation products, which, according
Fig. 2 Element composition of LiCl-solution after: a) 2-hour and b) 8-hour ultrasound activation and, c) after 24-hour ultrasound activation; d) Calculation of element yield, when 2 to 5 molecules of water are involved in transmutation process.

to calculations [9], can be produced by elements of light medium only. So, the number of atoms participating in transmutation reaction can be significantly higher, i.e. 25 atoms and more, Fig. 5. The changes in the number of atoms in input channel for comparable USP experiments and electric explosion-electric discharge experiments are connected to various values of energy density of excited water medium in these experiments.

So, the greater the energy density of excited medium, the greater the amount of atoms, which can be involved in the input channel of transmutation reaction.
Naturally, this concerns the extension of range of number of atoms in the input channel. The change of number of atoms in the input channel of transmutation process, in its turn, causes a change of element spectrum of products at reaction output. Experiments on electric explosion of titanium foil in glycerin -$C_3H_8O_3$ can confirm this conclusion ([9] Tab.6, Fig.12a). A power of electric explosion, if compared with other three experiments, was increased in experiment No.660, this caused an appearance of lead and disappearance of manganese in the spectrum.

Discussing again the experiments on ultrasound processing of LiCl solution, it should be noted that such elements as titanium ($Z=22$) and nickel ($Z=28$) are present in the spectrum after 24-hour solution treatment with same concentration as that of zinc and are absent in 8-hour spectrum (Fig.2b,c). Thus, for some reason, these elements are also produced in consecutive way. It is obvious that other chemical elements would appear in the solution in case of continuation of transmutation process. This can be well seen on the example of ultrasound processing of CsCl solution during 360 hours (Fig.1d).

4 Element production in the process of transmutation.

The calculations executed also clearly demonstrate that, if secondary elements are involved in transmutation processes, its products may contain atomic nuclei of practically all chemical elements, regardless of from which chemical element or compound those processes started. In Fig.3 shows calculation bar charts of possible end products (outlet channel) of transmutation reactions for various elements in the inlet channel. The abscissa axis shows a charge of chemical element, the ordinate axis demonstrates how many times the present element appeared at calculation in various outlet channels. Two atoms of aluminum $^{27}_{13}Al$ (Fig.3a) or two atoms of zirconium $^{90}_{40}Zr$ (Fig.3b), or two atoms of aluminum $^{27}_{13}Al$ and one atom of zirconium $^{90}_{40}Zr$ (Fig.3c), or two atoms of palladium $^{108}_{46}Pd$ or two atoms of lead $^{108}_{82}Pb$ (Fig.3e) are involved in inlet channel. It is appropriate to note that calculation spectrum for $^{108}_{46}Pd$ (Fig.3d) sufficiently well reflects a spectrum of elements obtained in works with glow discharge with palladium cathode (Fig.8). Two same nuclei are taken here, as an example, in each four cases in the inlet channel. It is clear that involvement of other elements in transmutation reaction from distributions given in Fig.3, causes an extension of spectrum of chemical elements. An increase of atoms in inlet channel causes the same, because of
increased number of possible combinations in outlet channel (Fig. 3c). It is completely obvious that the more elements form a medium at the beginning of transmutation process, the richer is the spectrum of chemical elements in its products.

It should be noted that at the very beginning of time-extended transmutation processes, the maximum of element spectrum obtained in outlet channel will be located not far from initial element.

Significant odd-even fluctuations of elements in the yield of possible end products also draw attention.

Transmutation process will not start within phenomenological model if primary elements are Fe and Ni isotopes with a maximal known coupling energy per nucleon ($^{56}$Fe - 8,790MeV, $^{58}$Fe - 8,792MeV and $^{62}$Ni - 8,794MeV), in other words, if they are in a minimal energetic state. As calculations showed, however, the transmutation process can proceed at the expense of other isotopes of Fe and Ni that have a relatively smaller coupling energy.
Thus, the model demonstrates that *multiple and hypermultiple transmutation processes inevitably cause an appearance, in its products, of atomic nuclei of practically all chemical elements, independently from chemical composition of medium in which these processes started.*

In addition to that, *element spectrum in LEET products can depend on energy density of exited medium, by means of a number of atoms in inlet channel.*

Evidently, phenomenological model allows to produce, as a result of LEET processes, super-heavy elements (Z>100) [7].

5 “Universal” distribution.

It is evident that, if the medium has a set of elements, which turn into each other, the quantitative relations between them should be reflected by a certain distribution.

Let us consider the transmutation processes in more detail by the example of electric explosion and zirconium melting. For obviousness, Fig.4a,b gives assumed energetic schemes of these transmutation processes: electric explosion (Fig.4a) and zirconium melting (Fig.4b). The ordinate axis should show the sum of nuclides masses in energetic units, which are involved in transmutation process. But as a number of atoms involved in the inlet channel of transmutation reaction can vary, it is convenient to proceed to a scale, connected to energy per nucleon E/N. Then, a whole group of initial states can be represented in this scale (with isotope precision) as “one” state. Left column gives initial states, the right one – end states. As was said above, sets of stable elements are end states. Such sets can be infinite in number. However conservation laws – conservation of energy, angular momentum, number of nucleons etc. in each particular transmutation act reduce this set up to countable quantity.

Three groups of initial states Fig.4a are available for case of electric explosion of metallic foil in dielectric medium. The first group (I) is represented by states, when reaction participants are atoms of dielectric medium only, second group (II) corresponds to states, when atoms of metallic foil only take part in transmutation reaction and the third group (III) includes mixed states, when simultaneously both foil atoms and dielectric medium atoms take part in the reaction. Last states represent a “group” even within the scale E/N, because the ratio of medium atoms and metal foil atoms in the inlet channel can vary. As we have assumed that transmutation at electric explosion occurs with involvement of initial material only, then transitions from initial states into end states are single. Each such transition happens with its own probability (w). It would appear reasonable that some transitions prevail.
Fig. 4 Assumed schemes of energetic transmutation processes for cases: Electric explosion (single transitions); b) zirconium melting (hypermultiple processes).

Evidently, it is for this reason that the spectrum of end elements for electric explosion is rather restricted. Probabilities of transitions obviously depend on many values: energy released during transition, angular state momentum, number of nuclides in inlet channel and number of nuclides in outlet channel, number of weak transitions, and most probably, on nuclear features of nuclides themselves. The last assumption is evident from experimental data on electric explosion and aqueous electric discharge. Really, such elements as antimony, tin and lead are practically always present in end products for these cases. Additionally, as was mentioned above, light elements from hydrogen to zinc prevail in transmutation processes in all experiments.

As distinct from electric explosion, at electron melting of zirconium in vacuum furnace, its natural composition is sole initial element (line I, Fig.4b) for production of all elements represented in Fig.1c. As mentioned above, the appearance of such a broad element spectrum is likely to be connected to involvement of products of previous transmutations in consecutive transmutation reactions (group II, Fig.4b).

Let us assume that medium always has conditions for transmutation processes. At initial development stage of transmutation processes, when the number of zirconium atoms prevails over the number of atoms of secondary elements, nuclide distribution of transmutation products will be evidently of non-regular character, i.e. the same as for the case of electric explosion (single transitions). Distribution of stable nuclei is understood here as nuclide distribution. Nuclide distribution can substantially change only then, when a number of zirconium atoms diminishes by that much that secondary element atoms will start to enter transmutation reactions between each other with greater probability, then with atoms of initial matter. As mentioned above,
atomic nuclei of practically all chemical elements will appear simultaneously in transmutation products. In the long run, hypermultiple transmutation processes will lead to a situation, when the number of zirconium atoms will become comparable with or less than a number of atoms of secondary elements. By that time, mutual transformation of elements into each other will lead to a certain, quasi-equilibrium distribution.

The distribution would be in the state of equilibrium, if transmutation reactions proceed without energy loss. It is known from statistical physics and thermodynamics that irreversible processes in closed system inevitably end in its transition into the state of equilibrium [16]. We dared to apply the laws of statistical physics and thermodynamics to transmutation processes basing on the fact that transmutation can be represented not as energy exchange between particles, but as exchange of nucleon portions between nuclides \( E=mc^2 \), though in multi-particle interaction, and all kinds of sets from a limited number of stable nuclides can be used as statistical ensemble. Transmutation processes are really irreversible, but they are executed in an open system, with mass (energy) loss for transmutation reaction itself. The lost mass is transformed into kinetic energy of nuclides, is brought away by neutrino and unknown radiation. It is clear that calculated theoretical [9] and experimental [2] losses in the mass 0.1-10MeV per one reaction, are significantly less than the mass of nuclides entering the reaction \( \ll 1 \text{GeV} \). Thus, hypermultiple transmutation processes are executed in quasi-constant medium, which energy is decreasing. The obtained distribution will be, for this reason, in quasi-equilibrium state.

It should be noted that element group from hydrogen to zinc always appear in all experiments on transmutation, regardless of a medium where this process takes place. Evidently, some elements of this group are in the maximum of quasi-equilibrium distribution. In case of electron melting of zirconium such elements are magnesium and aluminum (Fig.1c), in some zones of transmutation products the maximum is formed by silicon and iron (10 - 45 mass. %) [6]. Paper [12] reports a significant concentration of Al, Si, Mn, Fe, Zn and Pb in transmutation products of the solution \(^{137}\text{Cs} \). For the last case it should be remembered that, due to presence of a large amount of water molecules and their constant involvement in transmutation process, the obtained element distribution for reaction products is far from quasi-equilibrium state.

As already mentioned, if transmutation proceeds without energy loss, then the end nuclide distribution would be in equilibrium state. Additionally, if coupling energy per nucleon is be equal for all elements, the equilibrium distribution would be the same, i.e. it would not depend on initial element composition of matter, where transmutation processes have started. Such
distribution would characterize the transmutation process in its “pure” form. A distribution obtained for the case when transmutation process starts in hydrogen medium is most close to such hypothetical, “universal” distribution.

It is evident that transmutation process will not stop after quasi-equilibrium distribution is realized. Ultimately, it will result, due to exothermic feature, in prevalence of iron and nickel in distribution, as nuclides with maximal coupling energy. The transmutation process will end, when the number of isotopes $^{56,58}$Fe, $^{62}$Ni with maximal coupling energy per nucleon are substantially more than that of other isotopes.

It is clear that for cases, when transmutation process starts in element medium, say, from chromium to zinc, which are elements with approximately equal and close to maximal coupling energy, the quasi-equilibrium nuclide distribution will have its maximum, reasoning from phenomenological model, in the range of $^{56,58}$Fe and $^{62}$Ni. However, as stated above, atomic nuclei of all chemical elements (stable nuclides) will appear in transmutation products during transmutation process. At that, the distribution of these elements will presumably tend to become a “universal” distribution.

If this is true, then in any medium, regardless of its chemical composition, where hypermultiple transmutation processes take place, a “universal” distribution, connected exclusively with transmutation peculiarities will be realized. In addition to that, a maximum in the range of iron-nickel, connected with maximal coupling energy in isotopes of these elements, will be superimposed, with a certain degree of intensity, on the “universal” distribution. The intensity of Fe-Ni maximum will exactly depend on chemical composition of a medium, where transmutation process has started.

During data processing and analysis on electric explosions of metal foils in dielectric medium [9], we draw our attention to higher yield of some groups of elements in transmutation products. These groups are: Na-Si, K-Ca, Mn-Ni, Cu-Zn, Zr-Mo, Ag-Sb, Ta-W, Pb. It is interesting that similar element groups are found in spectra of transmutation products, caused by ultrasound cavitation and zirconium melting. Furthermore, we obtained a similar picture, when calculating yield of elements under involvement, in transmutation process, of N-molecules of water (Fig.5) and other elements (Fig.3c-e). Fig.5 gives, for better visual understanding and to avoid sharp even-odd fluctuations (Fig.2d), the yields of even-charged elements. A decrease of element yield in the range of carbon-silicon with increased number of water molecules involved in the reaction is connected with the fact that calculation in outlet reaction channel allow for not more than three nuclides.
It is rather evident that increased probability of appearance of these elements in transmutation processes is connected to their proximity to maximums available depending on coupling energy of nucleons in atomic nuclei in virtue of their atomic number and a number of isotopes in these elements. These maximums are known to be caused by “magic” shells with a number of protons and neutron equal to: 2, 8, 20, 28, 50, 82 and 126. A higher yield of those elements was cited in the paper on ultrasound cavitation [12]. Really, in equal initial conditions in the inlet channel, presence of “magic” nuclides in the end spectrum increases a number of combinations of other nuclides in outlet channel. A large number of isotopes in a particular element increases the probability of its appearance statistically. Hence, the “universal” distribution will, in addition to Fe-Ni maximum, include peaks caused by “magic” shells.

Thus, a “universal” distribution of nuclides with maximums connected to peculiarities of nuclide coupling energy versus mass number will be realized in transmutation products in any medium, regardless of its chemical composition, where hypermultiple transmutation processes take place. Intensity of Fe-Ni maximum depends on chemical composition of a medium, where the transmutation process has started.

Strictly speaking, because element spectrum in transmutation products depends on energy density of excited medium, quasi-equilibrium distribution, at energy constantly applied to medium, will also depend on this parameter. We can talk about “universality” of end distribution for transmuting systems only
if they are not subject of action of external energy sources or their action is insignificant. And energy required for transmutation processes in such systems is supplied at the expense of transmutation reactions themselves. As mentioned above, the development of LEET process is limited by the Fe-Ni maximum.

The case of ultrasound processing of salt dissolved in water [12] is a multiple process and it is similar to Zr-melting [6]. At ultrasound activation, element composition of salt dissolved in water transmutes into a nuclide distribution, which does not depend on this composition and which will not change due to a constant presence of water molecules in reactions. The same distribution will be obtained if transmutation process starts in clean water. As already mentioned above, the nuclide distribution in the process of transmutation will tend, under diminishing number of water molecules, to “universal” distribution of nuclides.

Certainly, all above reasonings require a strict theoretical justification and experimental check. Such experiments can be realized, using in case of electron melting various metals and their alloys, and in case of ultrasound processing and electric discharge in water-mineral medium – various chemical compositions.

6 Isotopic relationships in transmutation products

If hypermultiple transmutation processes lead to realization of “universal” nuclide distribution in its products, then the distribution will be “universal” both for elements and isotopes. We may rather evidently conclude from this circumstance that in a medium where nuclide distribution has not yet become “universal”, elements should have isotope relationships, which differ from table values. It is especially true for cases of electron explosion and electric explosion, where single transmutation transitions take place.

Substantial isotopic shifts in transmutation products were observed in experiments with glow discharge in palladium and other metallic cathodes [2,4] and in experiments with electron explosion [7]. In other case, when mass distribution for zirconium melting (Fig.1a) was transformed in distribution of chemical elements (Fig.7a), a contribution of each isotope to a particular element had naturally to be taken into account. That is why an isotopic relationship, which is obtained in transmutation products as a result of zirconium melting, has been found at once for each element. If we compare these relationships with natural isotopic relationships (see Table), then it is evident, on the one hand, that their difference is significant, for example: for potassium, chromium, copper, zinc, germanium and barium (*). This circumstance evidences in favor of existence of transmutation phenomenon. On the other
Table. Comparison of natural isotope ratio (Nat.,%) with isotope ratio observed in zirconium transmutation products [6] (LEET, %).

<table>
<thead>
<tr>
<th>Z</th>
<th>A</th>
<th>LEET</th>
<th>Nat.</th>
<th>Z</th>
<th>A</th>
<th>LEET</th>
<th>Nat.</th>
</tr>
</thead>
<tbody>
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<td>Li</td>
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<td>6</td>
<td>7.5</td>
<td>Cr</td>
<td>52</td>
<td>70</td>
<td>83.8</td>
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hand, a rather well match of their isotopic relationships with natural ones for the Earth is observed for the rest of elements [17]. The above mentioned difference in isotopic relationships for specified elements (K, Cr, Cu, Zn, Ge, Ba) can be explained by unfinished transmutation processes and, consequently, by distribution dependence, including isotopic distributions, on initial element, in this case, on zirconium.

7 Low energy transmutation role in the nucleosynthesis process.

The fact that elements, which are zirconium transmutation products, have partly a natural isotopic relationship of the Earth, has lead us to the idea to compare distribution by mass numbers obtained as a result of zirconium melting with element occurrence by their masses in the Earth’s crust [17].

Some difference in compared distributions (Fig.6), as already mentioned above, is likely to be connected with unfinished transmutation processes for the case of zirconium melting and distribution dependence on this element. Really, the “universal” distribution in case of zirconium transmutation was realized on the part of heavy masses relative to assumed distribution maximum in the range of Mg-Si. That is why heavy masses from M=60 to M=175 prevail in nuclide distribution at zirconium melting (M_{Zr} - 90+92, 94, 96), if compared with the Earth’s distribution, because heavy masses can be directly
Fig. 6 Comparison of element distribution in case of zirconium transmutation at its melting with element occurrence in the Earth’s crust. For orientation, zirconium isotopes with their relative content are emphasized with bold lines.

Fig. 7 Comparison of element groups: a) case of zirconium transmutation at its melting (holes: “background” masses); b) element occurrence in the Earth’s crust.
obtained from initial material, and simultaneously, the content of light masses is reduced from $M=6$ to $M=30$.

Furthermore, the distributions show a correlation by element groups. Same elements (Ti, Fe) and element groups (Na-Si, K-Ca, Cu-Zn, Cd-Sb) have maximums in both distributions (Fig.7a,b). The figure represented lacks, for convenience of comparison, lines at spots, which correspond to “background” zirconium masses ($\text{Zr, ZrH, ZrO, ZrO}_2, \text{Zr}_2, \text{Zr}_2\text{O}$) and gas component, which is difficult to account for at the comparison. For gases, masses are given as dots.

Taking into account that low energy transmutation processes that occur under rather “soft” physical conditions if compared with conditions under which thermonuclear processes take place, and tend to reproduce “universal” distribution, the following conclusion can be drawn logically from above material.

Transmutation process is decisive at creation of chemical elements on the Earth. In other words, low energy transmutation process, along with nuclear reactions in stars, is responsible for nucleosynthesis. Furthermore, that nucleosynthesis can be realized directly on planets and form their element composition.

Transmutation process on the Earth was likely to occur at the time, when the Earth was a compressing, liquid, melted ball. It is quite possible that, deep in the Earth, transmutation processes are still going on and the huge energy released at that is observed by us as eruption of volcano. Specialist would know that intra-plate tectonic activity and volcanism can not be explained within plate tectonics. Most common hypothesis, which satisfactorily explains volcanism and tectonic activity within both oceanic and continental lithosphere, is associated with the idea of hot spots and mantle plumes [18]. Probably it is exactly in those hot spots and mantle plumes where transmutation processes take place.

Investigations in these hot spots and plumes demonstrated changes of isotopic relationships in such elements as helium, argon, strontium, neodymium, lead. For example, it was found that helium produced by subcortical layers of the Earth, has isotopic concentration relationship $^{3}\text{He}/^{4}\text{He} = (3\pm1)*10^{-5}$ [19-21]. This relationship is abnormally great and exceeds relationship in helium produced by the rocks of Earth’s crust by hundreds and thousands times. The authors of this discovery put forward a supposition that subcortical helium is residual, primeval one, formed as a result of fusion reactions in stars, for which the relationship is $^{3}\text{He}/^{4}\text{He} = 3*10^{-4}$. But it is rather strange to believe that inert, easily mobile gas helium stayed in the interior of the Earth during its formation. Especially since the relationship $^{3}\text{He}/^{4}\text{He} should diminish at the
expense of increased $^4\text{He}$, obtained as a result of alpha-decay of thorium, uranium and their daughter products (protactinium-bismuth). That is why it was expected, before that discovery, that the increase of occurrence depth of rocks, the relation $^3\text{He}/^4\text{He}$ in them would diminish, because the relationship in the atmosphere is $^3\text{He}/^4\text{He} = 1.4\times10^{-6}$. Thus, an increased isotopic relationship $^3\text{He}/^4\text{He}$ can be explained by transmutation processes occurring in subcortical layers of the Earth. It should be mentioned that the authors have fixed [11] in transmutation products an appearance of helium isotopes both in solid and liquid phase with abnormally high relationship $^3\text{He}/^4\text{He} = 0.2-1$.

Starting from general considerations, previous assumption on transmutation nature of nucleosynthesis is true for other planets too. Availability in many planets, including the Earth, of cores, which mainly consist of iron and similarity of element compositions are also evidences of this assumption.

Next general conclusion would be that transmutation processes should also occur on stars. Let us remember that transmutation processes are accompanied by release of energy. Obviously, the application of transmutation mechanism to nucleosynthesis allows to understand, in easy way, the presence of heavy elements even on most old stars, because nucleosynthesis of all elements and their isotopes up to uranium becomes evident.

Thus, the processes of nucleosynthesis and energy release in the Universe can be realized, along with nuclear reactions, due to reactions of low energy transmutation. It is evident that as soon as transformation of some chemical elements into other elements is discovered, the question about nucleosynthesis emerges at once. That is why the problem on possible involvement of LEET mechanism in nucleosynthesis has been discussed by many scientists: S.E.Jones, T.Matsumoto, S.V.Adamenko, M.I.Solin, V.A.Krivitsky.

**Conclusion**

Here, it is appropriate to emphasize that most new technologies can be developed in the following fields on the basis of transmutation phenomenon: generation of cheap and ecologically clean electricity and heat, production of precious and rare elements and isotopes from cheaper elements, recycling of radioactive waste – its transformation in stable isotopes, recycling of poison-gases and industrial toxic waste etc.

The authors express their gratitude to Penkov F.M. for useful scientific discussions and element yield calculations, to Gareev F.A., Dubovik V.M., Zhemenik V.I., Starkov V.V., and Arbuzov V.I. for useful discussions, critical remarks and support.
Appendix

Here, we continue, started in [9], short review of experimental works on low energy transmutation. It contains most brilliant, from our point of view, experimental works on low energy transmutation issue, which have been checked many times and supported by statistics. In some cases, we represented experimental material, given by authors in the form of tables, as diagrams and plots.

Experiments on element transmutation in glow discharge.

The installation for experiments [1-5] was a chamber with cathode and anode filled with working gas with pressure up to 300 –1000 Pa. Hydrogen, deuterium, argon, xenon and their combinations were used as working gas. The glow discharge was carried out at current densities 10-50 mA/cm² and burning voltage 500-1400 V. The experiments lasted up to 120 hours. 100μm foils made from palladium and other metals (Ti, Ag, Nb and others.) served as material for cathodes. Cathode sample were analyzed for presence of admixtures before and after experiments. To analyze the sample, spark, secondary ion and secondary neutral-mass spectrometry as well as the method of microprobe x-ray spectral analysis were used. Element content in cathode was registered in the pre-surface 100 nm thick layer. The difference in admixture content before and after experiments was determined as a production of “new”, admixture nuclides. The most contribution of admixture nuclides was registered in glow discharge of deuterium in palladium cathode (102,104-106,108,110,112,114,116,118,120)Pd). Main nuclides (with a content over 1%) are \(^{7}\text{Li},^{12}\text{C},^{15}\text{N},^{20}\text{Ne},^{29}\text{Si},^{44,46}\text{Ca},^{56,57}\text{Fe},^{64,66}\text{Zn},^{75}\text{As},^{107,109}\text{Ag},^{110,112,114}\text{Cd},^{115}\text{In}\). Nuclide admixtures, which were produced in Pd-cathode after its irradiation in deuterium discharge during 22 hours, at discharge current 50 mA are given in Fig.8. Absolute atom quantity of these nuclides is up to \(10^{17}\) at irradiation time up to \(2\cdot10^{4}\) s. For such elements as Li, B, C, Ca, Ti, Fe, Ni, Ga, Ge and others, change of natural isotope relation was registered, for some elements by tens of times. For example: the relation \(^{57}\text{Fe}/^{56}\text{Fe}\) changes from 25 to 50 times, while the natural relation is \(^{57}\text{Fe}/^{56}\text{Fe}=0.024\). At that, some main isotopes are missing, for example: \(^{58}\text{Ni},^{70,73,75}\text{Ge},^{113,116}\text{Cd}\). In addition to that, a change of natural relation of palladium isotopes is observed in Pd-cathodes.

During the discharge burning and after switching it off, the gamma-ray radiation in energy range 0.1-3.0 MeV by means of Ge(Li)-detector was registered. The analysis of gamma-spectra demonstrated that irradiators are neutron-rich nuclei with masses from \(A=16\) to \(A=136\), which yield \(\beta\)-radioactive decay chains. However, by estimates of the authors, the number of stable...
Fig. 8 Admixtures of foreign nuclides produced in Pd-cathode in glow discharge of deuterium. Pd-isotopes are emphasized with bold lines, without their relative content.

isotopes produced as a result of transmutation is $10^{12} - 10^{13}$ times higher than that of radioactive isotopes.

In addition to that, tracks of 3 MeV protons and 14 MeV $\alpha$-particles with an intensity $10^{-15}$ s$^{-1}$ cm$^{-2}$ were registered by means of plastic detectors CR-39 in all experiments. Especially, the authors [14,15] drew attention to registration of unknown particles, which leave their “strange” traces-tracks in x-ray and nuclear photoemulsions. The dimensions of these tracks vary from several to tens of millimeters. The shape of these tracks is unusual and diverse; these are interrupted, rectilinear, curvilinear and even spiral-shaped lines consisting of separate spots. The spots, in its turn, can have a shape of circles, ellipses, horse-shoes. The authors underline a remarkable ability of “strange” particles (tracers) to penetrate in metal and to move inside it. Particles can leave the metal, change its structure and composition, leaving traces similar to those, which are left on photoemulsions.

Separately, the author [4-5] investigated the emission of x-ray radiation (XR) from palladium cathode in strong current (up to 150 mA) glow discharge of deuterium and hydrogen as well as production of excessive heat power. In the experiments, the XR with an energy 1.5-2 keV with intensity up to 100 Roentgen/s. was registered and three emission modes of x-ray radiation: diffuse x-ray radiation, radiation in the form of x-ray narrow-directed microbeams and superpowerful generation of XR. Microbeam diameter at a distance 200 mm from the cathode is estimated to be 10-20 $\mu$m, and angular divergence $10^{-4}$. The author underlines an abnormally high penetrating ability of x-ray microbeams in continuous metal media. Stationary
power of super-powerful generation of XR is estimated to be up to 10 W at stationary electrical power of the discharge 50 W.

Excessive power was measured with water flow calorimeter. The system of measurements allowed to monitor the input electrical power and heat power output by cooling water with a precision up to ±0.5 W, at absolute value of electrical power up to 120 W. In some experiments, excessive heat power was equal to several tens of watt and, at full efficiency, up to 150%.

**Element transmutation initiated by electron pulse.**

Experiments [7] consisted in irradiation of a solid-state target by 1 kJ electron pulse during the time \( \sim 10^{-8} \) s. The experiments were carried out in a vacuum \( \sim 10^{-3} \) Pa. Pure materials: Cu, Ag, Ta, Pb were used as targets and surrounding storage screens. As a result of irradiation, the target exploded, target material scattered in radial directions and precipitated on storage screen. The matter precipitated has a form of non-regularly scattered drops, balls, foils etc. In the process of explosion, optical radiation of plasma bunch was registered in target compression zone. Spectral lines of ions of Fe, Ni and other chemical elements Fig.9a, which were not included in initial target composition, but comparable by a number of atoms irradiated, with its main components, are present in plasma bunch spectrum. After explosion, the remnants of target and material, precipitated on storage screens were checked by various analytical methods for availability of admixtures of strange elements. Micro-x-ray spectral, x-ray fluorescent analysis, Auger-electron spectroscopy, thermo-ionization, laser, secondary ion-mass spectroscopy,

![Fig. 9  a) Estimated yield of ion component of plasma clot, experiment № 3981; b) Average element content (lines) and their maximal values (asterisks) for Cu of 15 assays, experiment No.3082 and c) same for Pb of 6 assays, experiment No. 2275.](image)
Rutherford backscattering were used as analytical methods. The results of analysis confirmed the presence of strange elements in products of electron explosion. These elements include: C, O, Mg, Al, Si, P, S, Cl, Ar, K, Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn, Nb, Mo, In, Sn, Sb, La, Ce, Pr, Nd, Hf, Au, Pb.

As an example, average content of strange elements and their maximal values in 15 assays, taken at various surface sections of copper target remnants of experiment No. 3082 and in 6 assays of lead target remnants of experiment No. 2275 and executed by means of x-ray microspectral analysis, are shown in Fig. 9b,c. For copper, square in Fig. 9b and lead, square in Fig. 9c show a minimal value of their presence in all assays. Purity of copper was 99.99%, purity of lead was 99.91%. Total number of strange atoms precipitated on storage screens amounts to \(~10^{18}-10^{19}\) atoms.

In addition to that, secondary ion mass-spectrometric analysis of isotope content of substance precipitated on storage screens showed that the majority of microdoses have a substantially changed ratio of elements isotopes as compared to their natural ratio. As an example, the authors of paper [7] give comparative diagrams for elements: Si, Ar, Ca, Fe, Ni, Cu, Zn, Hf.

The paper describes the results of experiments with targets, which composition included radioactive isotope \(^{60}\)Co. As a result of action of electron pulse on target, the intensity of spectral lines \(^{60}\)Co decreased, on the average for several experiments, by a value equivalent to transmutation of \(~10^{18}\) target nuclei. No lines of other radioactive elements were registered at that.

By means of plastic detectors CR-39, tracks of \(\alpha\)-particles with energies 4-6 MeV, as well as tracks of protons and deuterons with an energy up to 1.6 MeV were registered in experiments. X-ray radiation with a maximum in the range 30-40 keV was registered.

The following unusual results obtained in experiments with targets made from Pt, Pb and Bi should be mentioned. At element composition analysis of storage screen surfaces, the mass spectra showed isotopes of heavy chemical elements with atomic numbers on the boundary and beyond of the known part of Periodic table. In addition to that, non-identifiable peaks of characteristic x-ray and Auger-radiation were found.

**Element transmutation in electric discharge in liquid media.**

Works on element transmutation in electric discharge in liquid media were executed by the method of A.V.Vachaev-N.I.Ivanov [11]. The installation consisted of two pipe-shaped electrodes of an internal diameter of 6 to 50 mm, which were located opposite each other at a distance equal to 1 - 1.5 of their diameter. A specific electric discharge was created between electrodes with liquid medium moving inside them, plasma appeared. Electrodes and
plasma were located inside the coil, which produced magnetic field. Plasma was set on fire by the pulse discharge of additional electrodes located across the jet of liquid, between pipe-shaped electrodes. The plasma between pipe-shaped electrodes was an electroconductive plasma foil, which formed a multi-dimensional figure of rotating hyperboloid type with a squeeze of 0.1-0.2 mm in diameter. The discharge occurred practically without noise with a minimal release of heat and gas phase. The magnitude of current through pipe-shaped electrodes changed within the range 0.1-100 A, in the majority of cases being 20-40 A.

The operation of installation resulted a stable process of transformation of initial material of medium into new elements and their compounds in gaseous, liquid (dissolved in medium) and solid state. Process efficiency increased if two and more installation were connected in series. The investigation of transmutation process yielded that maximal release of solid products was achieved at a liquid velocity equal to 0.55 m/s.

In the experiments, various liquid media were input in the installation: water (distilled, drinking, river water), water-mineral mixtures, sewage water of various manufactures, water-carbon and organic mixtures. All works were carried out in so-called “metallurgical” mode, i.e. with a maximal output of solid phase, up to 300 g/l on the average, and that corresponds to the installation performance of 100 kg/h. Chemical analysis of samples was carried out in three independent laboratories. Fig.10 gives, as an example, yield of strange elements for cases of processing of distilled water, residential waste water and waste water of battery farm. It should be noted that the installation created is practically an industrial installation, which allows to obtain tons of transmutation products during acceptable, real times.

Fig. 10  Elements yield at processing in electric discharge: a) of distilled water; b) of residential waste water and c) of waste water of battery farm.
References


(Manuscrit reçu le 9 juillet 2008)