A LOW-ENERGY METHOD OF CONTROLLED NUCLEOSYNTHESIS

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Among timely problems of the contemporary science, of the highest priority is the controlled transmutation of elements and isotopes. This problem is a key one for the solution of such urgent tasks as the ecologically safe (without reactors) use of nuclear energy, technological fusion of rare isotopes, safe and efficient neutralization and utilization of radioactive wastes (in particular, worked-out nuclear fuel), and fusion of superheavy transuranium nuclei. Large scientific centers of developed counties have tried to solve these problems during decades by attracting the most skilled experts and huge financial and technical resources. However, any attempts to achieve essential results which would be widely introduced in practice have not met with success. At the same time, a change of conceptual approaches enabled us to get quite reassuring experimental results.

Up to now, the field of nuclear transformations is dominated by the conception of the so-called "force" method. Its adherents consider that the problem of controlled nucleosynthesis can be solved by using more and more powerful technical means (accelerators with maximally high energy, neutron sources with maximally high intensity, systems of controlled synthesis of the "Tokamak" type, etc.), which requires high cash investments measured in billions of dollars. However, this way is erroneous in principle, because the technological resources of our civilization are bounded, and the force-based attempts to reproduce the processes, which occur in abnormal astrophysical objects of the type of pulsars or neutron stars, under laboratory conditions are unrealistic.

We have tried to find the other method to solve this problem which would ensure the achievement of supercritical conditions not with the use of a strong external action on a nuclear system but through the stimulation of powerful processes of internal self-organization of matter on the nuclear level. In this case, the role of technological factors of an external action is significant only on the initial stage of a controlled stimulation of the process. Further, this process runs according to the own harmonic dynamic model, in which the decisive role is played by the natural self-consistent laws.

The organization of works aimed at the creation of conditions for the stimulation of the synergetic process of nuclear transformations became the purpose of activity of the Electrodynamics Laboratory "Proton–21" established in Ukraine in 1999. Its staff includes skilled scientific researchers and engineers, and its financing is realized solely by private investors.

The methodical base of activity of the Laboratory is a preliminarily grounded hypothesis concerning the possibility of controlled stimulation of a collapse of the condensed substance, which organizes itself under certain initial conditions into the state of electron-nucleus plasma. On this stage, the effect of the Coulomb barrier becomes insignificant, and the rapid transmutation of elements and isotopes occurs.

For the verification of this hypothesis, an experimental setup was constructed. The initial conditions for the formation of a collapse were ensured by the specially organized coherent action of the beam of electrons (a coherent electron driver) on a solid target. In experiments, the total energy of the beam did not exceed 1 kJ.

The setup allowed us to perform about 4000 successful experiments on controlled nucleosynthesis for 1999–2002 with the use of various targets made of light, medium, or heavy elements in the range of atomic masses $10 < A < 210$ and in different modes of coherent action of the driver [1].

The analysis of the results of experiments was realized with the use of the most informative analytic methods of measurement (X-ray diffraction spectral microanalysis, Auger electron spectroscopy, laser and secondary ion mass-spectrometry) and relevant devices which are used in the leading institutes of the National Academy of Sciences of Ukraine and meet the modern requirements. The measurements were carried out by skilled scientific researchers who have a great experience of the work with those devices.

During the experiments, we stably registered the process of formation of a stimulated quasipoint electron-nucleus collapse with characteristic mechanical signs (specific breaks of the target and the formation of a macroscopic cavity in it). In the process of formation and evolution of the state of electron-nucleus collapse and on the final stage of its decay, we measured the pointwise X-ray radiation with a spectrum close to the thermal one, the characteristic temperature $T \approx 35$ keV, and the duration of about 10 ns.

In all the experiments (including those where the target was made of one chemical element maximally refined from admixtures), we observed the synthesis of the majority of known light, medium, and heavy elements and isotopes in the range of masses $1 < A < 240$ in the amounts which exceeded the total amount of admixtures by many orders. The typical efficiency of the synthesis depended on the initial chemical composition of a target and equaled $k \approx 10^{14}$–10^{16} (synthesized nuclei per 1 J of the applied energy). For a significant share of synthesized elements, their isotope composition considerably differed (by at least 1.5–3 times) from the natural ratios of the isotopes of these elements.

The characteristic (expected) feature of all the synthesized isotopes was the practically full absence of radioactivity. The numerous verifications with storage gamma- and beta-spectrometers showed that the relative concentration of radioactive nuclei of all the synthesized isotopes was at most 10^{-8}–10^{-12}.

In our opinion, all this is the adequate result of our "force-free" method of formation of the state of self-organized electron-nucleus collapse related to the collective character of nuclear transformations. The energy of a coherent driver stimulating this process is equal to only a small part of the total energy released in the process of transformation of nuclei of the target into nuclei of the synthesized isotopes. In fact, in the zone of self-organized collapse, we are faced with the process of a distinctive "cold repacking" of nucleons which belonged first to nuclei of the target. This process terminates in the final configuration which corresponds to newly synthesized isotopes. Since the process is adiabatic and the amount of the embedded "excessive" energy is small (in the framework of the traditional way to solve the problem of transmutation, a more higher energy is embedded with the use of high-energy accelerators for overcoming the Coulomb barrier by a pair of interacting nuclei), created nuclei arise in the ground state with minimum energy. It is obvious that this is one of the main reasons for the absence of radioactivity in them.

The evolution of the collapse state terminates by its natural decay in 20–30 ns, which results in the output of synthesized isotopes from the collapse zone. They are registered near this zone and on the surface and in the volume of remote accumulating screens.

In all the experiments performed under optimal conditions, we registered the mass spectra of the long-lived isotopes of unknown superheavy elements whose masses correspond to the interval $270 \leq A \leq 480$ [1–3]. In each specific experiment, 10–20 types of superhigh masses was registered. The number of nuclei of these isotopes is about 10^{14}–10^{15} in every experiment and depends mainly on the chemical composition of the target (the largest number of types of the synthesized transuranium nuclei was derived with targets made of Pb). The upper boundary of atomic masses of the registered isotopes (the maximum value of $A \approx 480$) was limited by the technical parameters of a measuring installation [an ion microprobe IMS 4f (CAMECA)]. In fact, this boundary can be essentially higher [2]. Numerous additional verifications within the method of backward Coulomb scattering of alpha-particles by the nuclei of atoms situated on the target surface near the collapse zone confirmed the presence of these superhigh masses [3]. On the repeated measurement on the same targets in 1–2 months, we measured the same amount of these unknown masses, which corroborates their stability and the absence of radioactivity.

These results contradict the hypothesis well known in the literature, according to which all the transuranium isotopes outside the boundary of the hypothetical "island of stability" ($A \approx 298$) must be normally unstable and possess a very small lifetime (much less than 1 ms). These ideas are based to a great extent on the extrapolation of the fact that all the earlier known transuranium elements are unstable. It is worth noting that all these elements, without exception, were derived within the "force" method in the very small amount (sometimes at most a few nuclei) in the collisions of heavy nuclei speeded up on an accelerator up to an energy of 10–30 MeV/nucleon, which brings in, by itself, a lot of the "excessive" energy into the synthesized nucleus (3–10 GeV). Such a process proceeds not long and can be a reason for the instability. Thus, the extrapolation of these experiments to those, which are carried out with the adiabatic process without use of "force" methods, is incorrect. Whereas the synthesis of transuranium nuclei on the basis of their pairwise interaction is always accompanied by the deficit of neutrons, which leads to the instability of nuclei, the multinuclear collapse has no such problem.

In the additional studies of the stimulated collapse in radioactive targets, we observed the phenomena of transmutation of radioactive nuclei into stable nuclei of the other types (so to say, the "passivation" of a radioactive substance). Such a phenomenon is completely consistent with the conception of "repacking" of the nucleons of radioactive nuclei in the collapse zone into more stable formations in the process of adiabatic nuclear transformation.

References

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