FULL-RANGE NUCLEOSYNTHESIS IN THE LABORATORY

Stable Superheavy Elements: Experimental Results and Theoretical Descriptions

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Abstract

The problem of supercompression of a solid target to a collapsed state is considered. The basic principles of construction and the parameters of an experimental setup ensuring such a supercompression are described. The model and method of creation and evolution of superheavy nuclear clusters with $250<A<500$ and $A>3,000$ to 5,000 in the controlled collapse zone and in the volume of a remote accumulating screen are discussed. The evolution of such clusters in a remote screen results in the synthesis of isotopes with $1<A<500$ and with anomalous spatial distribution. These phenomena were interpreted on the basis of the idea of the formation of a self-organizing and self-supporting collapse of the electron-nucleus plasma under the action of a coherent driver up to a state close to that of the nuclear substance.

Introduction

The investigation of extreme states of substances under extremely strong compression is one of the most important trends of fundamental science. Especially important and interesting is the search for ways to form superdense states of substances with parameters close to those which occur in such astrophysical objects as white dwarfs and neutron stars, but in a terrestrial laboratory. Various theoretical models predict the anomalous properties of both the process of supercompression and the synthesized superdense substance, including the possibility of releasing a great deal of energy accompanying the process of self-supporting compression of a substance, the neutralization of radioactive nuclei, and the formation of superheavy quasistable nuclei.

The problems of forming an extreme state of a substance and its use in applied nuclear physics, power engineering, and radiation ecology are the priority directions of a specialized laboratory for electrodynamical studies within the "Proton-21" firm, which was established in Kiev in 1999.

Electrodynamics Laboratory "Proton-21" is a scientific research company that carries out electrodynamics and nuclear research without nuclear reactors. Some departments of the Laboratory are responsible for experimental research, others develop theory and provide data analysis for the experiments. Scientific institutions capable of handling radioactive materials are engaged in the process of testing the reduction of radioactivity. Many highly qualified specialists from the National Academy of Sciences of Ukraine and leading universities of Ukraine participate in our work. The Laboratory staff exceeds 120 persons.

1. Facilities, Methods, and the Main Results of Experiments

In the course of creating the experimental basis for the laboratory, the best available methods for extremely strong compression of substances were employed. At the same time, while designing the experimental setup, a special emphasis was placed on realizing scientific ideas developed by the creative staff and the laboratory administration.[1] We posed the problem of creating a setup which is able to ensure a high concentration of energy by a coherent driver in a solid target with a size of at most 10 to 100 μm at the first stage of the impulse process. At this stage, the effect of the Coulomb barrier becomes insignificant, and the rapid transmutation of elements and isotopes occurs. At the second stage, the further self-supporting compression of this region up to the state of collapse on the subangstrom-scale and the attainment of the superdense state of substance occurs.

In the experimental setup, an impulse electron beam with a total energy of at most 1 kJ was used as a coherent driver in each cycle of supercompression. Both the compressed target and the system of a driver ensuring the supercompression were in a vacuum system, which guarantees maximum purity, control over experiments, and their reproducibility.

The first results concerning the supercompression of a substance were obtained on February 24, 2000.[1-4]

The optimized structure of the experimental setup allows us to perform at least ten different experiments on the supercom-

Electrodynamics Laboratory "Proton-21," located in Kiev.

pression of different targets in one day. At present, the total number of experiments that have been done exceeds 5,000. Various testing equipment was used in the process of each experiment. As a target material, we used practically every chemical element from which one can manufacture a solid target. The majority of the targets under study were produced from chemically pure elements, such as Cu (purity of 99.99%), Al (99.99%), Ta (99.97%), Pb (99.75%), and Ag (99.99%).

The understanding of the physical essence of the processes running during every experiment allows us to reliably predict (with a probability of almost 100%) the results of experiments for all variations in the operation modes of the setup and in the characteristics of targets under study.

The results of action of a coherent driver in the experimental setup were investigated with the use of several independent systems of detection:

- After every experiment, the chemical, isotope, radiometric, and structural analyses of the materials of a target, walls of the shell, and special accumulating screens with different forms, materials, and structures, which were positioned in the vacuum region of the experimental setup, were carried out;

- We measured the spectra of electromagnetic radiation from the collapse zone in the microwave, visible, and γ-ranges;

- We analyzed in real time the products emitted from the collapse zone (electrons, positrons, ions, charged and neutral nuclear particles and clusters).

In the implementation of the element and isotope analyses, the following methods based on relevant facilities were used:

- Electron probe microanalysis (EPMA)—analyzer REMMA 102 (Ukraine);

- Auger-electron spectroscopy (AES)—Auger spectroscope JAMP-10S (JEON, Japan);

- Secondary ion mass-spectrometry (SIMS)—SIMS analyzer IMS 4f (CAMECA, France)
- Laser mass-spectrometry (LMS);

- Integral thermal ion mass-spectrometry (TIMS)—thermal ion mass-spectroscope “Finnigan MAT-262”;

- Glow discharge mass-spectrometer VG 9000 (Thermo Elemental, UK);

- Rutherford backscattering of accelerated α-particles (RBS).

All together, more than 15,000 element and isotope analyses were performed, including the following: EPMA (more than 600 samples, at least 12,000 analyses), LMS (20, 297), AES (25, 474), SIMS (24, 399), RBS (40, 40), TIMS (13, 280), EPMA+LMS (38, 1227), EPMA+AES (44, 1,522), EPMA+SIMS (21, 619), LMS+AES (1, 29), AES+SIMS (2, 102), EPMA+LMS +AES (4, 164), EPMA+LMS+SIMS (2, 57), EPMA+AES+SIMS (7, 316), and EPMA+LMS+AES+SIMS (1, 43).

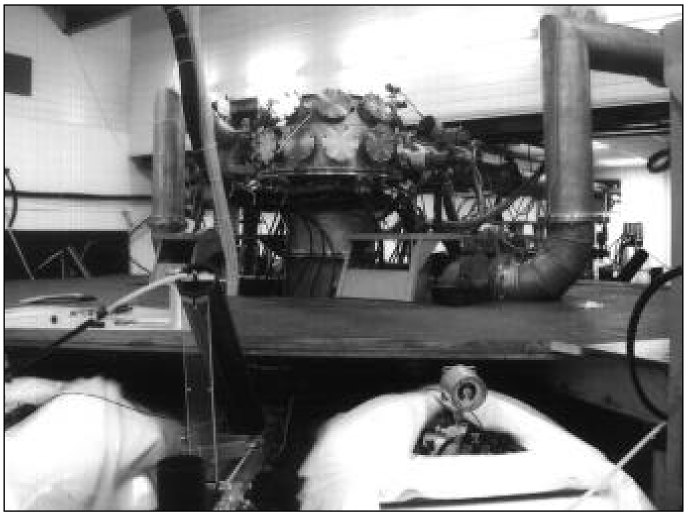
During the experiments with supercompressing a solid target to the collapse state by a special coherent driver, several anomalous phenomena were observed:

- In the process of formation of the collapse and during its subsequent evolution for 100 ns, we registered intense X-ray and γ-radiations in the energy range from 2 to 3 keV to 10 MeV with a maximum near 30 keV. The average radiation spectrum is shown in Figure 1. As one can see, its parameters are very similar to that of pulsars and quasars. On the other hand, this radiation has nonthermal nature and differs from the solar radiation spectrum in principle. The total radiation dose in the range 30 to 100 keV exceeded 50 to 100 krad at a distance of 10 cm from the active region.

- Fusion of light, medium, and heavy chemical elements and isotopes with $1 \leq A \leq 240$ and fusion of superheavy transuranium elements with $250 \leq A \leq 500$ in the area near the collapse zone. The maximum value of $A \approx 480$ was limited by the technical parameters of a measuring installation—an ion microprobe IMS 4f (CAMECA). Some of these results are considered in Section 2.

- All the created elements and isotopes were stable (without α-, β-, and γ-activities);

- Transformation of any radioactive states to stable-nucleus states in the collapse zone. The utilization efficiency of radionuclides per 1 kJ of the driver energy corresponds to the transmutation of about 10^{18} target nuclei (*e.g.*, ^{60}Co) into nonradioactive isotopes of other nuclei. A typical scheme of radioactivity neutralization experiment is



Experimental setup of the second generation.

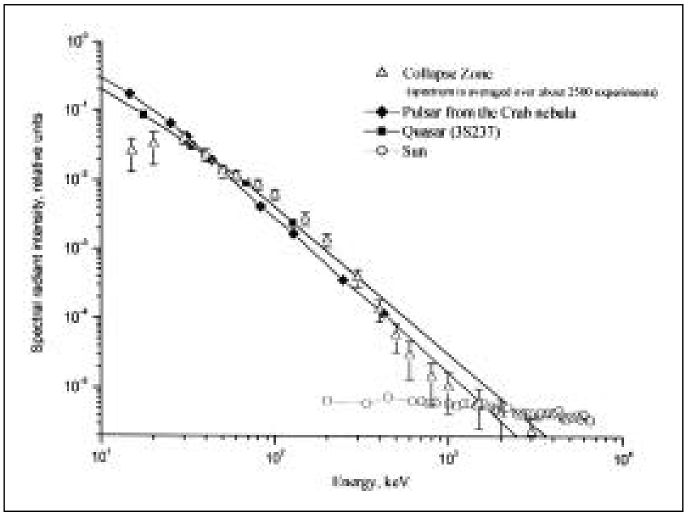


Figure 1. Typical hard radiation spectrum of the collapse zone along with spectra of a pulsar, a quasar, and the Sun.

shown in Figure 2. Table 1 presents the values of radioactivity reduction for ^{60}Co targets.

- Unique spatial distribution of different chemical elements and isotopes with $1 \le A \le 240$ in the volume of an accumulating screen which was made of a chemically pure element, remote from the collapse zone (all the created elements and isotopes were situated in the same thin layer or several thin layers inside the screen). These results and a theoretical analysis of a possible superheavy nuclei evolution scenario are discussed in Sections 3 and 4.

The above results described indicate that the previously unknown physical process, namely the artificially initiated collapse of a part of the target material, was realized at our laboratory for the first time. In every experiment, the collapse is completed by both the full nuclear regeneration of a portion of the initial substance of the target with a mass of 0.5 to 1 mg and the formation of artificially derived chemical elements instead of the initial substance atoms, including the long-lived and stable isotopes of superheavy chemical elements *which are not found on Earth or in nearby space.*

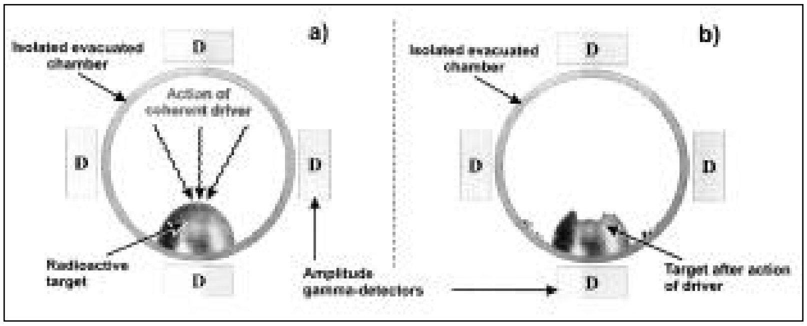


Figure 2. Scheme of the radioactivity neutralization experiment (a: initial condition, b: after experiment). The sealed condition of the vacuum chamber and the position of amplitude detectors remain unchanged during experiment.

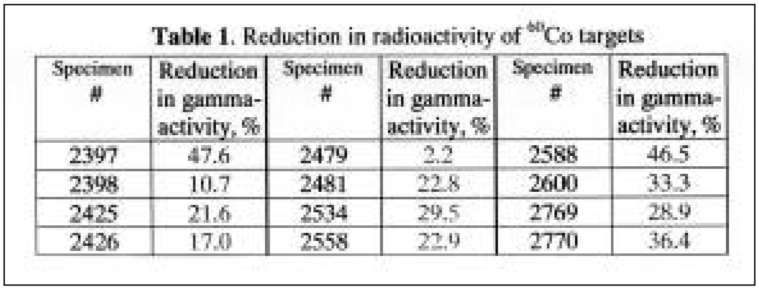


Table 1. Reduction in radioactivity of ^{60}Co targets

Specimen #	Reduction in gamma-activity, %	Specimen #	Reduction in gamma-activity, %	Specimen #	Reduction in gamma-activity, %
2397	47.6	2479	2.2	2588	46.5
2398	10.7	2481	22.8	2600	33.3
2425	21.6	2534	29.5	2769	28.9
2426	17.0	2558	22.9	2770	36.4

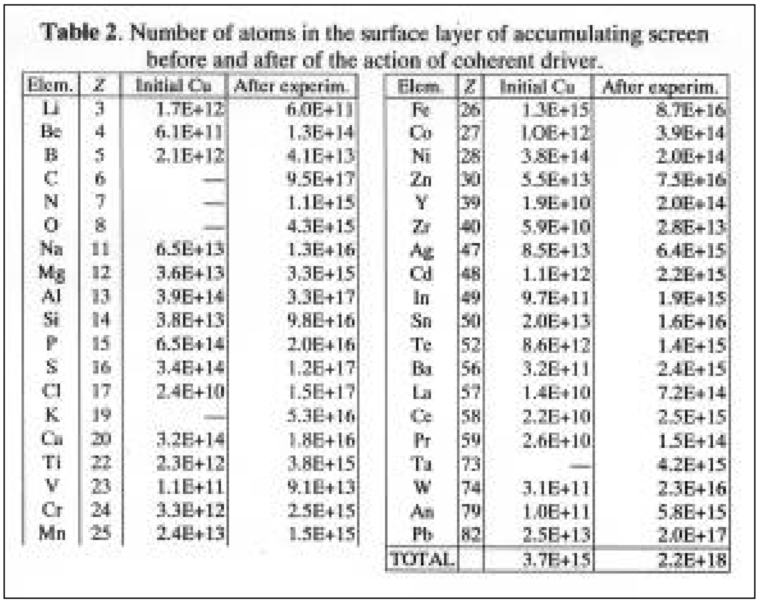


Table 2. Number of atoms in the surface layer of accumulating screen before and after of the action of coherent driver.

Elem.	Z	Initial Cu	After experim.	Elem.	Z	Initial Cu	After experim.
Li	3	1.7E+12	6.0E+11	Fe	26	1.3E+15	8.7E+16
Be	4	6.1E+11	1.3E+14	Co	27	1.OE+12	3.9E+14
B	5	2.1E+12	4.1E+13	Ni	28	3.8E+14	2.0E+14
C	6	—	9.5E+17	Zn	30	5.5E+13	7.5E+16
N	7	—	1.1E+15	Y	39	1.9E+10	2.0E+14
O	8	—	4.3E+15	Zr	40	5.9E+10	2.8E+13
Na	11	6.5E+13	1.3E+16	Ag	47	8.5E+13	6.4E+15
Mg	12	3.6E+13	3.3E+15	Cd	48	1.1E+12	2.2E+15
Al	13	3.9E+14	3.3E+17	In	49	9.7E+11	1.9E+15
Si	14	3.8E+13	9.8E+16	Sn	50	2.0E+13	1.6E+16
P	15	6.5E+14	2.0E+16	Te	52	8.6E+12	1.4E+15
S	16	3.4E+14	1.2E+17	Ba	56	3.2E+11	2.4E+15
Cl	17	2.4E+10	1.5E+17	La	57	1.4E+10	7.2E+14
K	19	—	5.3E+16	Ce	58	2.2E+10	2.5E+15
Ca	20	3.2E+14	1.8E+16	Pr	59	2.6E+10	1.5E+14
Ti	22	2.3E+12	3.8E+15	Ta	73	—	4.2E+15
V	23	1.1E+11	9.1E+13	W	74	3.1E+11	2.3E+16
Cr	24	3.3E+12	2.5E+15	Au	79	1.0E+11	5.8E+15
Mn	25	2.4E+13	1.5E+15	Pb	82	2.5E+13	2.0E+17
				TOTAL		3.7E+15	2.2E+18

These phenomena can be interpreted with a high probability on the basis of the idea of the creation and evolution of a self-organizing and self-supporting collapse state of the electron-nucleus plasma of an initial solid substance to the state of electron-nucleus clusters with a density close to that of the nuclear substance under the action of a coherent driver. During the evolution of such a collapse, the processes of fast fusion and creation of different isotopes (including transuranic ones) must be taking place. After the end of the collapse, synthesized isotopes were detected near the collapse zone on the surface and in the volume of the remote accumulating screen.

In our opinion, all these phenomena are the direct result of our method of forming a state of self-organized electron-nucleus collapse that is 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 initially belonged 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 of accomplishing transmutation, much higher energy is required in using high-energy accelerators to overcome the Coulomb barrier between 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. During the evolution of such a collapse, the processes of fast fusion and creation of different isotopes (including transuranic ones) takes place. After the end of the collapse, synthesized isotopes were detected near the collapse zone on the surface and in the volume of the remote accumulating screen.

It was also inferred that during the evolution of this collapse up to the state of electron-nucleus cluster, the process of emission of superheavy neutral nuclear clusters with $A > 3{,}000$ to 5,000 takes place.

2. Fusion of Light, Medium, and Heavy Chemical Elements and Superheavy Transuranic Nuclei in the Area Near the Collapse Zone

By analyzing the results of all experiments, we found a great number of element and isotope anomalies. The measurements were carried out at the institutes of the National Academy of Sciences of Ukraine, at the Taras Shevchenko Kiev National University, at one of the leading enterprises of the Ministry of Atomic Industry of the Russian Federation, and at the specialized mass-spectrometric laboratory United Metals Inc. (USA).

After every experiment, a great number of different chemical elements with atomic numbers, which are greater and/or smaller than those of initial chemically pure material, were found on the target surface and on the surface and in the volume of accumulating screens. This amount is much greater than that of admixtures in the initial materials of the target and accumulating screens (see Table 2).

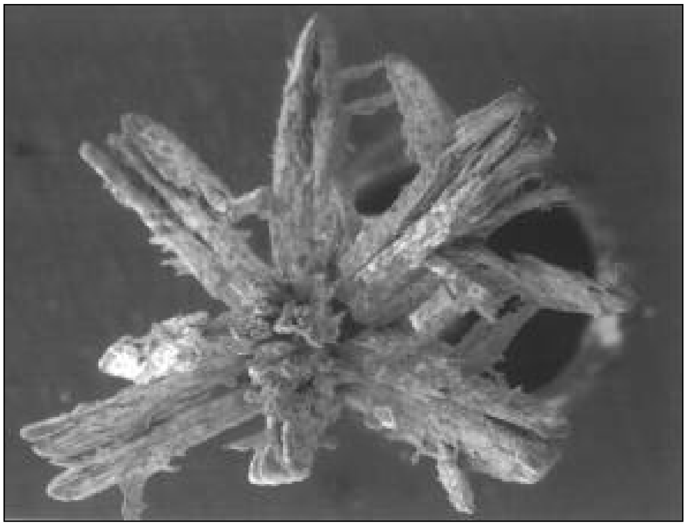
For the majority of the synthesized chemical elements, we observed a significant deviation from the natural isotope ratio. For many elements, this ratio is changed by 5 to 100 times (it can increase or decrease). Figure 3 shows one of the examples of a change in the isotope ratio for certain elements registered after experiments.

While analyzing the samples, we found a lot of nonidentified atomic masses in the transuranic region with $A > 250$.

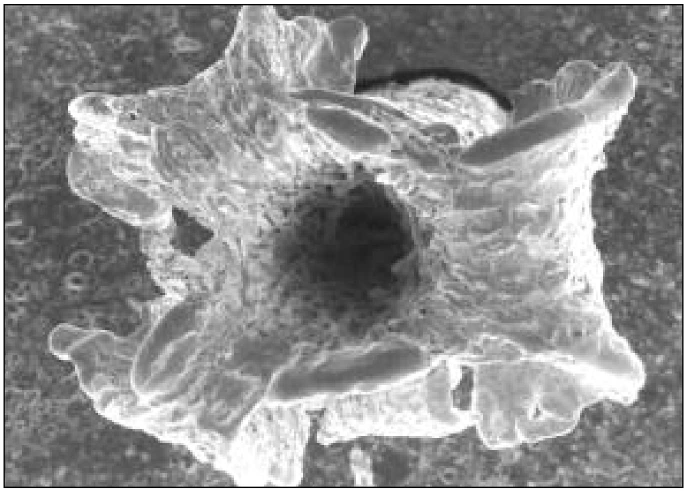
Performing the spectrometry of superheavy masses, we employed special measures that allowed us to prevent the appearance of molecular clusters:

- We carried out a complex study of the same sample on several mass-spectrometers of different types.
- We used a special operation mode, "offset," in a SIMS analyzer IMS 4f which allowed us to separate highly efficiently molecular clusters and monoions (Figure 4).
- While using a mass-spectrometer, we used the operation mode with a high temperature (about 100 eV) at the laser focus on the surface of the samples under study. At this temperature, molecular complexes cannot exist and such a mass-spectrometer will register only monoions.
- The investigation of superhigh masses was performed with the use of Rutherford backscattering of accelerated alpha-particles with an energy of 27.2 MeV derived from a U-120 cyclotron. This method allows one to register only monoions. The results of measurement of the backscattering spectrum are presented in Figure 5.[3]

These precautions enable us to assert that we found unidentified stable atomic masses in the transuranic region with $250<A<500$ in the samples located near the action zone of the coherent driver. After every experiment, about 10 to 20 types of superhigh masses (superheavy nuclei) were found, moreover, a representative number of superheavy nuclei of each type equaled 10^7 to 10^8. The number of formed superheavy nuclei increases when a target made of heavy atoms (*e.g.*, Pb) is used. Most frequently superheavy nuclei with A = 271, 272, 330, 341, 343, 394, 433 are found. The same superheavy nuclei were found in the same samples when repeated measurements were made at intervals of a few months.



Tungsten target after experiment.



Copper target after experiment.

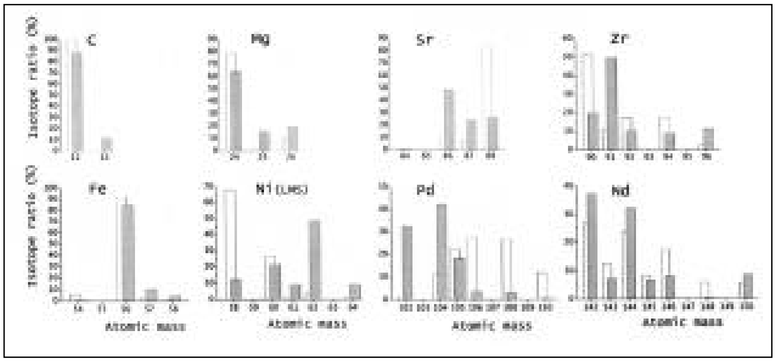


Figure 3. Isotopic composition of some elements measured with LMS (indicated) and SIMS (others). Natural composition is depicted with empty bars, the composition of synthesized elements with hatched bars.

3. Formation of the Unique Spatial Distribution of Created Chemical Elements in the Volume of Distant Accumulating Screens

3.1. Anomalous parameters of motion of unknown superheavy particles

While investigating the spatial distribution of products of the nucleosynthesis in the volume of accumulating screens made of chemically pure materials (mainly Cu), we found alien chemical elements (from H to Pb) in amounts which exceeded their initial total amount in the form of admixtures by several orders of magnitude (Table 2). All these elements were positioned in several thin concentric layers. The first (superficial) layer about 200 Å in thickness contained about 3×10^{18} atoms of all elements, the second was located at a depth $X \approx 0.3$ micron and contained about 10^{18} atoms, and the third was at $X \approx 7$ mm. At the same time, we found a decrease in the concentration of the initial material of a target in the volumes of these layers.

Let us consider in detail the possible mechanisms of the formation of a thin layer (containing different elements and isotopes with the same spatial distribution) in the volume of an accumulating screen made of a chemically pure

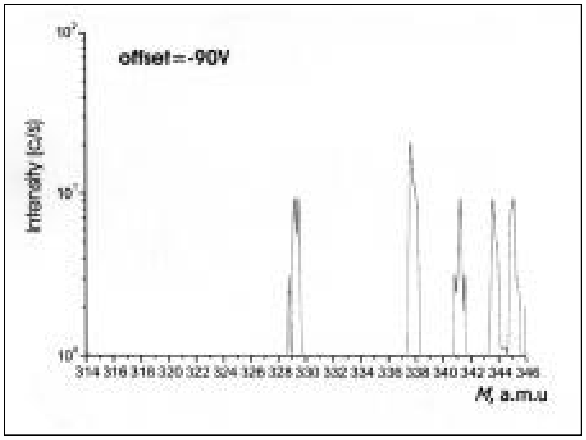


Figure 4. SIMS mass-spectrum of unidentified masses after applying the offset mode.

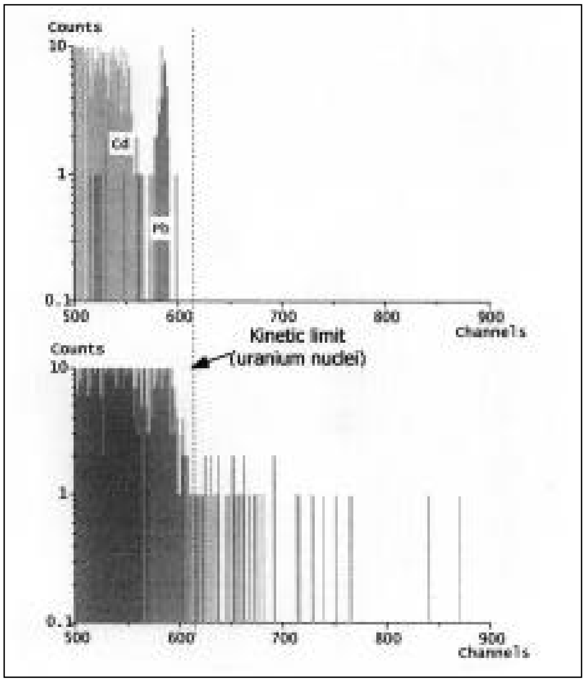


Figure 5. Rutherford backscattering data; initial material (above) and after the impact (below).

element (*e.g.*, Cu), remote from the action zone of a coherent driver.[4] The typical scheme of formation of this layer in experiments is presented in Figure 6.

The presented depth profile (see Figure 7) was typical of all experiments and was obtained by ionic etching of the surface of an accumulating screen with an ion microprobe analyzer CAMECA IMS 4f. It follows from Figure 7 that different chemical elements (*e.g.*, Au, Pr, La, I, Ce, W, and unidentified element ^{156}A) are situated in the same thin layer with relative thickness $\Delta R/R \approx 0.25$ and distance $R = X\cos\theta$ from the surface into the depth of the accumulating screen in the direction outward from the collapse zone. The distance R and thickness ΔR are the same for the whole layer and all chemical elements for a single experiment. For different experiments, the values of R and ΔR may be different, but the ratio $\Delta R/R$ is the same.

The synthesized elements and isotopes were distributed over the layer surface as separate clusters. At the center of the screen, the clusters overlapped. The distributions of clusters of different elements (Al, B, Si, and K) on the layer surface are presented in Figure 8. The general shape of the distributions are the same in all details! This result is possible only if all detected elements were born in each cluster during the nuclear transmutation of unknown particles. It is easy to make sure that such distributions over the surface and radius cannot be a result of the ordinary process of Coulomb deceleration for different fast ions.

For such a Coulomb deceleration, the energy losses dE/dr and the deceleration distance R of an ion with mass M, charge Z, and energy E are

$$dE/dr = -(2\pi n_e M Z^2 e^4/m_e E)\ln(4m_e E/MJ),\ R = \int_E^{E_{min}} dE/(dE/dx) \qquad (1)$$

Here, J is the averaged ionization potential of atoms of the screen.

On the one hand, at the same deceleration distance $R = 0.3$ μm in a copper target, the values of initial energies E are very different for different ions (*e.g.*, we need $E_H \approx 60$ keV for H^+ and $E_{Pb} \approx 60$ MeV for Pb^+). The same dispersion of Ei will hold for ions with different charges. On the other hand, for different ions at the same energy E, the ratio of deceleration distances R_i is also very high (*e.g.*, for H^+ and Pb^+, we have $R_H/R_{Pb} > 20$ to 30).

The total number of alien atoms considerably exceeded that of the starting admixture, therefore, such a unique distribution cannot be created by nonlinear waves of admixtures which are observed sometimes in nonequlibrium processes. In addition, the three-dimensional character of the anomalous distribution of synthesized chemical elements (different elements were located in small coinciding regions on the surfaces of concentration layers) also cannot be explained by the processes of transport or diffusion.

The observed distribution of chemical elements (the fixed values of ΔR and R for different particles in each single experiment) in the layer may appear only in the case of deceleration in the depth of the screen of identical particles with the same charge and energy. But such a distribution is observed for different elements (from H to Pb)! So, in this case we are faced with a paradox!

We suppose that such a distribution of different chemical elements and isotopes is possible only if the following conditions are met:

1) All initial (decelerated and stopped) particles must be the same (identical);

2) For the stability of the charge of particles, their velocities V must be lower relative to the velocity $v_0 = e^2/\hbar = 2.5 \times 10^8$ cm/s of valence electrons;

3) For a large distance of deceleration R at a low velocity $V \ll v_0$, the mass M of an unknown particle must be very large;

4) Different chemical elements and isotopes observed in the screen layer are created by the nuclear transmutation of these identical particles after stopping at R.

What are the nature of these unknown superheavy particles and the mechanism of the fast nuclear transmutation to different final stable nuclei?

3.2. Deceleration of heavy particles by elastic scattering in the screen

We have investigated the possible mechanism of elastic deceleration of these unknown particles and have calculated their parameters.

The equation of motion of the unknown uncharged particles with mass M in the bulk of the screen is the following:

$$M\,dV/dt = F = -(2M_0 V^2 \sigma n) \qquad (2)$$

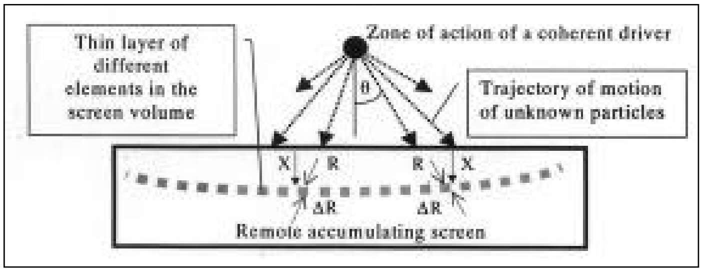


Figure 6. The typical scheme of formation of thin layer in the volume of an accumulating screen.

Here, $F \equiv \Delta p/\Delta t = -(2M_0V^2\sigma n)$ is the mean force of elastic deceleration of the unknown heavy particle in the screen, $\Delta p = -\delta p\,(\Delta t/\delta t) = -(2M_0V^2\sigma n)$, Δt is the decelerating momentum of a particle at $\Delta t >> \delta t$ (during $\Delta N = \Delta t/\delta t$ single collisions with ions of the target with mass M_0), $\delta t = l_1/V = 1/\sigma nV$, $l_1 = 1/\sigma n$ is the interval between two nearest collisions of the unknown heavy particle with ions of the target, and $\delta p \approx 2M_0V(t)$ is the decelerating momentum of a particle at a single collision.

The solution of Equation (2) reads

$$V(t) = V(0)/[1+2M_0\sigma nV(0)t/M] \qquad (3)$$

Deceleration terminates at a time $t=\tau$ when the kinetic energy of the particle, $MV(\tau)^2/2$, becomes equal to the thermal energy $M_0v_T{}^2/2$ of atoms (ions) of the screen.

The duration of deceleration

$$\tau = [(V(0)\surd M)/(v_T\surd M0) - 1]\ M/2M_0\sigma nV(0) \qquad (4)$$

The distance of deceleration is

$$R(\tau) = \int_0^{\tau} V(t)dt = (M/2M_0\sigma n)\ \ln[V(0)\surd M/v_T\surd M0] \qquad (5)$$

The mass of the unknown particle is

$$M = 4R(\tau)M_0n\sigma\ /\ \ln(T/T_0) \qquad (6)$$

Here, $T = E(0) = MV(0)^2/3$ is the initial energy of the unknown particle after leaving the action zone of the coherent driver, and $T_0 = M_0v_T{}^2/3$ is the temperature of the screen.

Let us make numerical estimations. For a screen made of chemically pure cooper ($A_0 \approx 63$ to 65), the concentration and cross-section of elastic scattering are, respectively, $n \approx 8\text{x}10^{22}$ cm^{-3} and $\sigma \approx 10^{-16}$ cm^2. With an experimental value of the distance of deceleration $R(\tau) \approx 0.4$ µm and at T_0=300 K = 0.025 eV, and T = 35 keV, we have the very large mass of the unknown particle: $M \approx 91\ M_0$, $A \approx 91A_0 \approx 5{,}700$.

The initial velocity of these superheavy particles was low relative to the velocity of valence electrons, $v_0 = e^2/\hbar = 2.5\text{x}10^8$ cm/s, and equaled $V(0) = (3T/M)^{1/2} \approx 3.7\text{x}10^6$ cm/s.

The total duration of deceleration of particles equals $\tau \approx 0.8\text{x}10^{-9}$ s.

In a different case (*e.g.*, for a layer situated at a different distance of deceleration $R(\tau) \approx 7$ µm), we have $M \approx 1{,}540M_0$ and $A \approx 1{,}540A_0 \approx 100{,}000$.

The obtained parameters correspond to requirements 1), 2), and 3).

4. A Possible Model of Evolution of Superheavy Neutralized Nuclei

We assume that these superheavy particles are similar to abnormal superheavy neutralized nuclei that were proposed by A. Migdal about twenty years ago.[5,6] Migdal obtained the important result consisting in that the energy *E/A* of the nuclear substance has two minima (the first "ordinary" at $A \approx 60$ and the second "abnormal" at $A_{\max} \geq 2\text{x}10^5$). Migdal suggested that the presence of the second "abnormal" minimum of energy *E/A* was a result of the Fermi condensation of pions in the volume of superheavy nucleus (*e.g.*, during the action of a shock). These minima are separated by a high potential barrier at $Z_0 \approx (\hbar c/e^2)^{3/2} \approx 1{,}600$. The mechanism of suppression of the action of that barrier will be discussed below. If this hypothesis is correct, then superheavy neutralized nuclei in the environment created in the active zone of a coherent driver can absorb "ordinary" nuclei of the target (screen). This transmutation leads

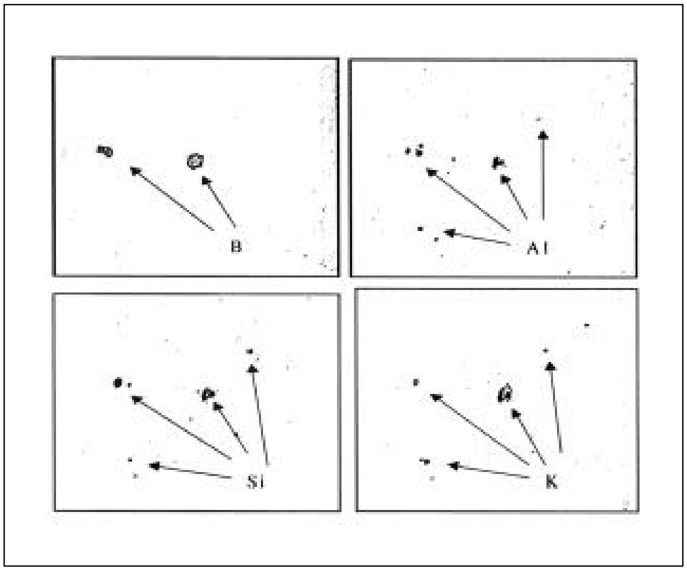


Figure 7. Depth profile of chemical elements in an accumulating screen.

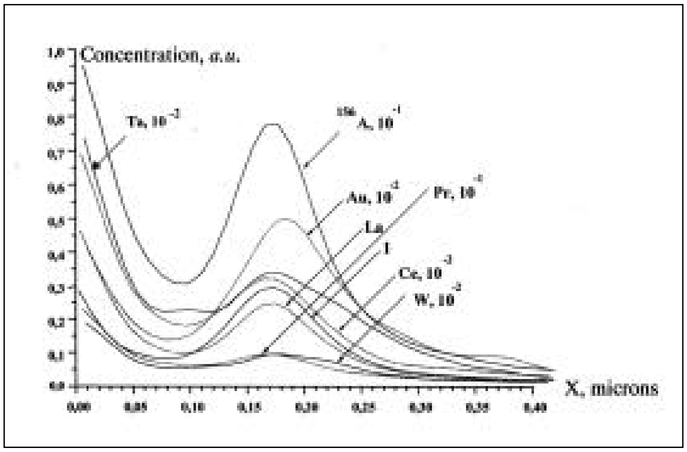


Figure 8. Distribution of clusters of chemical elements B, Al, Si, K on the same very small area on the surface of a thin layer.

to a growth of these superheavy neutralized nuclei by nuclear fusion up to A_{max}.

Very few electrons are outside the volume of these nuclei in a thin skin with thickness about 10^{-12} cm. The probability of such a synthesis is very high due to the high transparency of the Coulomb barrier. During such a fusion, energy is released. There are different channels for the release of the excessive energy (γ-emission, emission of neutrons and nuclear fragments, etc.). One of the channels is connected with the creation of different "normal" nuclei and the emission of these nuclei from the volume of a growing superheavy nucleus. For example, after the absorption of several target nuclei with $A_T \approx 50$ to 200 in a short time, a high binding energy can lead to the emission of several light nuclei with $A_L < A_T$ or one heavy nucleus with $A_H \approx 300$ to $500 > A_T$ (see Figure 9).

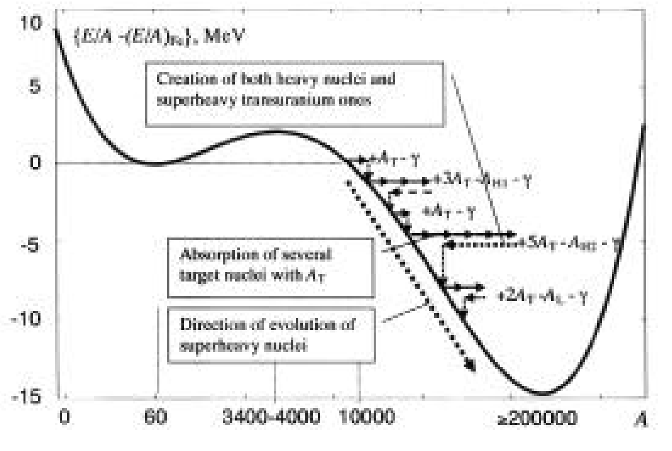


Figure 9. Evolution of superheavy nucleus–absorption of target nuclei and creation of different nuclei (from H up to stable transuranium nuclei).

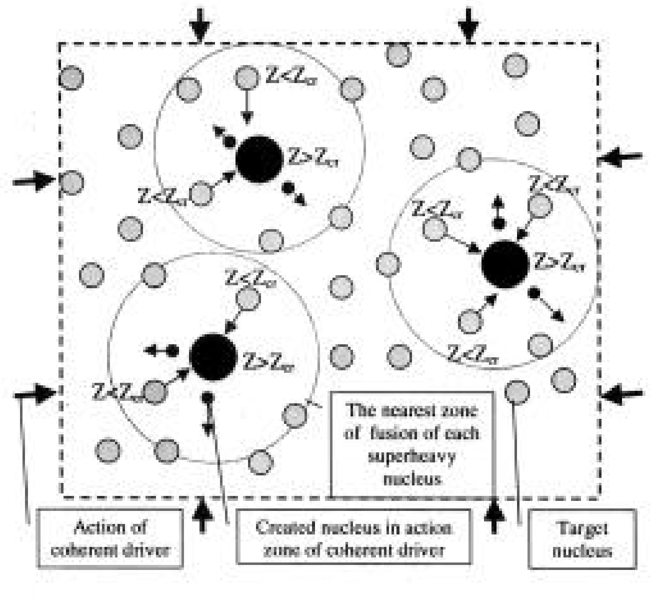


Figure 10. Transmutation of target nuclei ($Z<Z_{cr}$) to different nuclei ($1<A<500$) in zone of collapse.

It is worth mentioning that the electric field of protons in the volume of superheavy nucleus may turn out to be essentially compensated with compressed or degenerated electron gas in the same volume. Hence, the existing backscattering technique for registration and identification of nuclei with $Z > 200$ to 500 appeared to be inefficient. Such nuclei will be detected as ones with much less charge in spite of their very great mass.

The process of nucleus emission competes with other ways for cooling the nuclear substance. In this case, usual even-even nuclei (such as an α-particle and C^{12}, O^{16},..., Pb^{208}) which already exist in the volume of a superheavy nucleus are more likely to emerge and be emitted. In fact, every superheavy nucleus is a "specific microreactor" for the transmutation of "usual" target nuclei to different configurations of nucleons. In this microreactor, the process of transmutation terminates after the utilization of all target nuclei or after the evolution of a superheavy nucleus to the final stable state with A_{max}. How are these superheavy nuclei created?

We have carried out the analysis of the evolution of nuclei in the action zone of the coherent driver. It follows from our calculation that, for some usual (not superheavy) but "critical" nuclei (*e.g.*, at $Z>Z_{cr} \approx 92$) at special parameters of the coherent driver, the process of fast and self-controlling change (decrease) of the energy of nucleons (an increase in the binding energy) takes place. The value Z_{cr} depends on the driver's parameters. For a more intense driver, Z_{cr} will be less. It also follows that the minimum of this energy is changed in time from the initial (usual) value at $A_{opt} \approx 60$ to $A_{opt} \geq 10^4$. All "subcritical" nuclei with $Z<Z_{cr}$ have the stable minimum of energy at $A_{opt} \approx 60$. This effect is connected with self-similar processes in the superdense degenerate electron-nucleon plasma with a suppressed influence of the Coulomb interaction between protons in the volume of a superheavy nucleus.

The coherent driver should start this self-amplifying process of nuclear transformation for "critical" nuclei.

We have calculated the energy change per nucleon (*E/A*) for different relations of the electron and proton concentrations for "critical" nuclei at $30<A<2x10^5$. During the initial phase of the process (at the shift of the minimum of the energy per nucleon *E/A* to $A_{opt} \approx 5{,}000$ to 10,000), the role of pionic condensation is slight but it becomes critical at $A_{opt} \geq 10^5$. The degenerate electron-nucleus plasma initially includes the mixture of all nuclei (usual stable nuclei and growing superheavy ones) and electrons and is prevented from a decay due to the action (pressure) of the coherent driver. The description of such processes will be presented elsewhere.

During such a change of the *E/A* ratio for superheavy nuclei, the process of fusion of target nuclei (the absorption of target nuclei with "subcritical charge" $Z<Z_{cr}$ and the growth of "critical" nuclei with $Z>Z_{cr}$) in the action zone of the coherent driver becomes possible (see Figure 10). This fusion leads to the fast growth of initial "critical" nuclei up to $A \approx 10^4 - 10^5$ during the action time of the coherent driver (about $\Delta t_d \leq 100$ ns) with velocity $(dA/dt)_{collapse} \approx A/\Delta t_d \approx 10^{12} - 10^{13}$ s^{-1}. This velocity is proportional to the concentration of nuclei in the target. This process may lead to the creation of nuclei with $1< A < 300$ to 500. The scheme of creation of these nuclei and the scheme reviewed above during the analysis of the processes occurring in the accumulating screen are the same.

After the termination of the compressing action of a coherent driver, the process of decay of the degenerate electron-nucleus plasma, which includes the mixture of all nuclei (usual stable nuclei of the target, growing superheavy nuclei, and created nuclei) due to nuclear reactions, takes place. Some of these superheavy nuclei hit the remote accumulating screen and are decelerated there.

The growth velocity of these nuclei in the volume of a solid accumulating screen is proportional to the concentration of nuclei n_{screen} and equals $(dA/dt)_{\text{screen}} \approx (n_{\text{screen}}/n_{\text{collapse}})\,(dA/dt)_{\text{collapse}} \approx 10^8\ \text{s}^{-1}$. After the deceleration of these superheavy nuclei in the screen during $\tau \approx 10^{-9}$ s, the process of growth proceeds for a period $T \approx A_{\max}/(dA/dt)_{\text{screen}} \geq 10^{-3}$ s.

We suppose that the above scenario gives rather adequate general description for all the abnormal results obtained in our experiments.

Summary

The results which were obtained experimentally at the "Proton-21" laboratory indicate that a physical process previously unknown in science, namely the physical process of artificial initiation of the collapse of a part of the target material, was realized for the first time. In every experiment, the collapse is completed by both the full nuclear regeneration of a portion of the initial substance with a mass of 0.5 to 1 mg and the formation of artificially derived chemical elements instead of the initial atoms of a target, including the long-lived and stable isotopes of superheavy chemical elements, which are not otherwise found on Earth or in nearby space.

One of the proofs of the artificial origin of elements produced in the laboratory setup in the range of atomic masses of natural isotopes $A \leq 240$ is a significant (sometimes by tens and hundreds of times) change in the natural isotope ratio which dominates the entire substance of the solar system. One more confirmation of both the collective self-compression and the formation of a collapse is presented by the discovered effect of transmutation of any kind of radioactive nuclei into nonradioactive ones. In this case, similarly to nature, the products of laboratory nucleosynthesis contain practically no α-, β-, or γ-active isotopes, which opens the possibility of using the discovered physical phenomenon for the reprocessing of radioactive and toxic wastes.

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