CONCEPTION OF THE ARTIFICIALLY INITIATED COLLAPSE OF THE SUBSTANCE AND KEY RESULTS OF THE FIRST STAGE OF ITS EXPERIMENTAL IMPLEMENTATION

S. V. ADAMENKO
PROTON-21 ELECTRODYNAMICS LABORATORY

KYIV, 2004

Abstract

Briefly described below is the author's conception of shock coherent collective cascaded cumulative mechanism of particles acceleration through initiating the self-developing collapse of a converging solitary shell-wave of extreme density of energy and substance. Also provided is some part of experimental data obtained in course of practical implementation of that concept. This preprint is aimed at preliminary discussion of the composition and content of collected works describing the experimental and theoretical results obtained in the Electrodynamics Laboratory of Proton-21 company in Kyiv, Ukraine. This work has been carried out within the commercial project called Luch, which is developed on our initiative and aims at the creation of new, efficient and environmentally safe nuclear technologies for neutralizing the radioactivity and synthesizing stable isotopes of chemical elements, including superheavy ones.

Contents

1 Introduction

In the recent decades, there have been impressive results obtained in main areas of development of modern physics. Discoveries that shape new ideas of the matter self-organization in the nature have been made in various areas of the modern natural science, physics. Discoveries which shape new ideas of the matter self-organization in the nature have been made in various areas of the modern natural science, which determine both the depth of our knowledge of the Nature and the level of technical and technological development of our civilization.

Generally known are revolutionary changes in technical and informational support for the most sophisticated experiments in the *analysis* of structure the very basic objects of the material world, that is, nuclei, nucleons, and quarks, and interactions between those objects.

At the same time, there do exist real grounds for statements being made about crisis phenomena in modern physics. Here we should mention, first of all, those tasks which require for their solution the discovery of *synthesis* mechanisms at the nucleus and nucleon levels. In particular, far from being solved are the key theoretical and practical problems of controlled nuclear fusion and synthesis of superheavy nuclei, as well as the related in our view area of astrophysics, which aims at revealing and recreating in laboratory conditions the physical mechanisms of birth of chemical elements and their nuclei. As an illustration for the above, we can use the lack of convincing explanations for the following:

- relative concentrations of stable isotopes being to high precision the same everywhere in the nature;
- energy parameters of supernovae explosions and spreading of the shells they shed;
- the presence and significant prevalence of iron meteorites in nature, coupled with the complete absence of their analogues consisting of other metals, including those metals with prevalence in natural conditions comparable with that of iron,

as well as the lack of explanations for a number of other important natural phenomena related to the mutual transformations of energy and matter.

As a very special case, there are problems in nuclear physics raised by the creation and use, in most cases unavoidable as yet, of nuclear power plants. Among the most urgent problems, there is utilization or, preferably, neutralization of the radioactive waste collected, which can also be considered as a specific problem of nuclei synthesis and fission, with the limitation in terms of the minimum nuclear stability of the process products.

2 Principle of dynamic harmonization in the systems and the idea of shock coherent acceleration

The above circumstances have been urging us for many years to look for general universal algorithms of synthesis and self-organization in multi-unit stable systems of different physical nature and purpose, as well as to critically analyze the methods and means used in order to solve the problem of the energy-efficient synthesis of nuclei.

Gradually we came to believe that whatever different approaches are used, they all have a fundamental common flaw preventing them from the creation of conditions optimal for the synthesis (the main of those flaws being striving for high temperatures as an end in itself); on the other hand, they are missing something very important that would be able to act as an optimal detonator and catalyst for the desired process.

Research and development done in 1972–1982 in the area of optimization of eigenvalues and phase trajectories of multiply-connected dynamical systems [1, 2] have led us to the conclusion that this problem of the stability theory has some essential formal features which are common with a seemingly far from the control theory physical problem of the efficient carrying out of controlled nuclear reactions, including the problem of the inertial nuclear fusion.

Logical analysis of the said commonality had helped us understand the key role played by *external disturbances of certain kind* (first of all, those regularly occurring and catastrophic ones) in the evolutionary synthesis (or, in other words, self-organization) of multiply-connected, multiple-unit stable systems of any physical nature, including atomic nuclei as stable assemblies of nucleons.

As a result of that analysis, a working hypothesis was developed claiming the existence and decisive role in self-organization of multiply-connected structures of a general universal law which can be named as *the principle of regularization of disturbances and dynamic harmonization of systems* (or, to keep it short, the dynamic harmonization principle).

Let $\bar{x}^i \triangleq [x_1^i, x_2^i, ..., x_l^i]$ be an l-dimensional state vector of the i-th element.

Then $X_k \triangleq [\bar{x}_k^1, \bar{x}_k^2, ..., \bar{x}_k^m]$ is a state vector of the system which consists of m interacting elements.

The dynamic equation for that system is

$$X_{k+1} = F[X_k, \tilde{U}(X_k), \lambda\vec{\psi}_k], \tag{1}$$

where $\tilde{U}(X_k)$ is a vector-function of changing structure of the self-organizing system; $\vec{\psi}_k$ is a vector of the dominating disturbance in the system state space; λ is the disturbance intensity parameter.

Let $\omega^i(X_k), i = 1, ..., m \cdot l$ be eigenfunctions of the system (1), i.e. if $\lambda \equiv 0$ then

$$\forall i, \omega^i(X_{k+1}) = \sigma^i \cdot \omega^i(X_k), \tag{2}$$

where σ^i are eigenvalues of the system (1).

$\tilde{U}(X_k) \to U^*(X_k)$, $U^*(X_k) \in \mathfrak{A}$,, where $\mathfrak{A}$ is a set of functions for the system's possible structures; $U^*(X_k)$ is a vector-function of the structure of system (1) being optimal for a given $\vec{\psi}_k$, such that if

$$X^*_{k+1} = F[X^*_k, U^*(X^*_k), \lambda\vec{\psi}_k], \text{ then } J \triangleq \sum_{k=0}^{\infty}\sum_{i=1}^{m\cdot l} \left\{\sigma^i \omega^i (X^*_k)\right\}^2 \to \min \tag{3}$$

Without claiming mathematical rigor, the principle can be put in the following short form. Any set of elements of whatever nature, which has fundamental properties of limited inertness and limited sensitivity, as well as the ability to establish links affecting the speed at which components of the set elements' state vector change over time, when affected by the common dominating coherent disturbance, will create, within the available evolutionary degrees of freedom, such matrix (network) of links between its elements which would provide simultaneously (in a self-consistent way) both the maximum stability reserve for the system being formed, and optimal trajectories of transient processes in the system's eigenfunction space (using the criterion of minimum consumption of disturbance energy), or, equivalently, *the minimum possible inertness of the system's proper disturbed motion in the direction of the dominating disturbance vector in the same space*. In terms of the problem of linear dynamic system synthesis it probably comes to minimizing the functional (3) for trajectories of the optimally organized system.

If this hypothesis is true, then for efficient formation of the required system based on the set of original elements, i.e. particles, it is expedient to use own mechanisms of self-organization of the original set which we want to reform, i.e. its internal energy, using an adequate external action (*reforming disturbance*) to initiate the self-transformation in the system in the required direction, thus adding the reforming potential of the external action to the evolutionary potential of the system itself (Figs. 1, 2).

Looking from this angle at the problem of initiating of self-sustaining exoergic reactions of nuclear synthesis, we can single out what is probably the most important factor in this process: the decrease in average and/or total mass of the participating nucleons (mass defect).

The only thing known for sure about the physical nature of mass of any material object (nucleon, nucleus, atom, etc.) is that it is a measure of inertness of that object.

Following the above logic, a solution to the problem of obtaining a negative mass defect and corresponding energy release should be found in the area of choosing an initiating mechanism (a driver) whose action would stimulate the system being reformed, which is in general case an electron-nucleus or electron-nucleon megasystem — the local volume of the target source matter, precisely and first of all, to decrease the average and/or total inertness (i.e., mass) of all particles taking the impact.

It is obvious that if the system motion is *non-accelerated*, then energy absorption in the system will not depend on the velocities or masses of the particles making it up. Hence, a conclusion can be made that in terms of the dynamic harmonization principle, spending the energy of an external impact (driver) for the original particles to reach *high final velocity or energy* only would mean a failure to use the evolu-

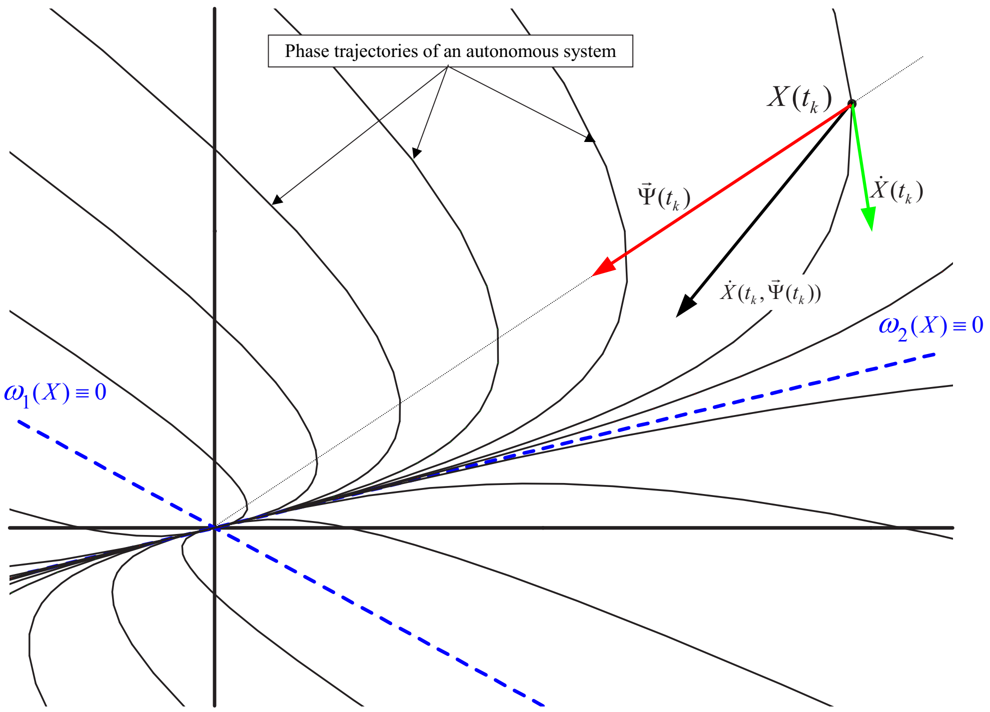

Figure 1. *Non-optimized system.*

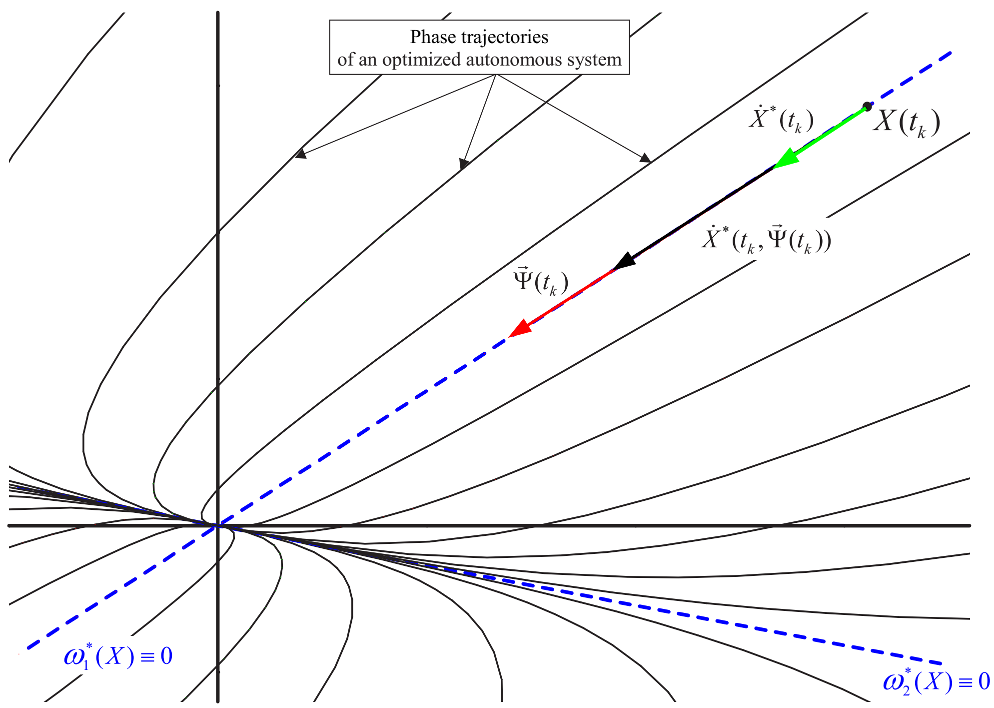

Figure 2. *Optimized system.*

tionary potential of the system for its nuclear transmutation, i.e., inefficient way of action.

We can thus summarize: efficient activation of the nuclear transmutation in the original nuclear system should be stimulated by the intensive coherent acceleration of original components (i.e. nuclei) participating in that transmutation, accompanied with extreme shock "overload" they can tolerate.

The above reasoning had in due time led the author to the conclusion that successful initiation of the self-organizing *exoergic* nuclear process is about creating the driver for the *collective coherent shock superacceleration of particles*.

So, a concept of the driver alternative to purely thermodynamic, or "heating", arrangements and methods was born as a result of considerations being very far from both the theory and practice of nuclear synthesis.

3 Construction development and experimental testing of the driver

Practical need for implementation of the above idea appeared many years later, when in 1996 a group of researchers started working, on their on initiative, on the driver construction for the inertial nuclear synthesis. The initial intention was to create the driver based on self-focusing of the subrelativistic electron micro-beam to the current densities of $10^{10} \dots 10^{11}$ A/cm^2 in the focus, using the scheme shown in Fig. 3. It was a priori assumed that it would be possible to provide conditions where the said current density will be reachable and sufficient for required heating of matter of the target placed at the beam focus (area A in Fig. 3) [3–11] to the energies of tens of keV, as well as for confinement and supercompression of the created dense plasma by the beam's own magnetic field.

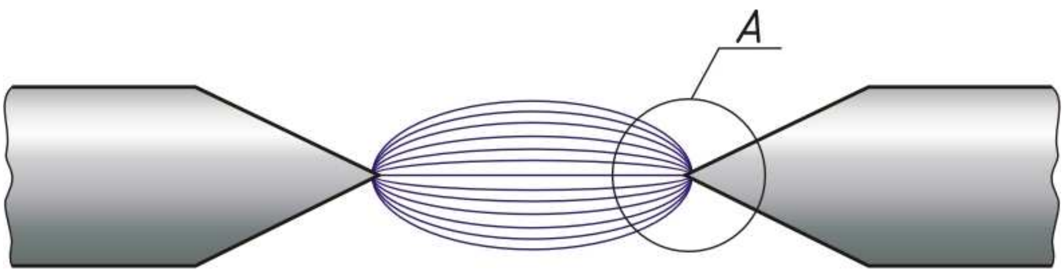

Figure 3. *Driver construction for self-focusing of the subrelativistic electron micro-beam to the current densities of* $10^{10} \dots 10^{11}$ *A/cm*^{2} *in the focus.*

It seemed almost obvious that a self-focusing electron beam would be able to initiate the required self-organizing nuclear process. Thus, the work started in 1997 on the problem later called Luch Project.

In 1999, the project participants had made a decision on the establishment of the specialized research and technological entity, Electrodynamics Research Laboratory, for carrying out the crucial experiments on superfocusing of energy in the high-current electron micro-beam in order to reach the conditions required for the nuclear transmutation of matter, and to develop on that basis a fundamentally new technology for neutralizing radioactivity.

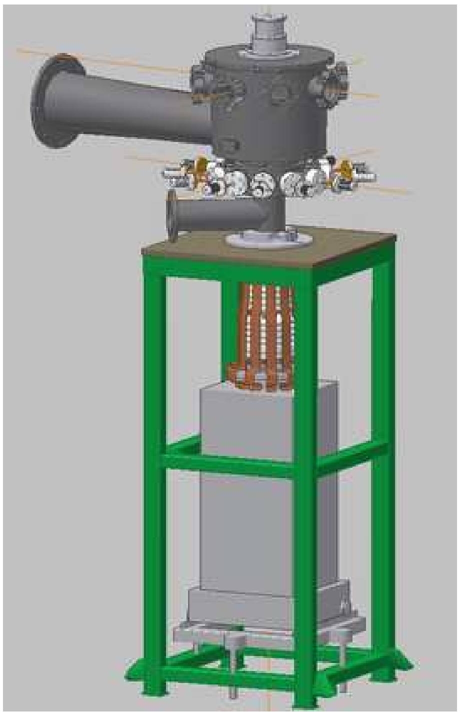

Figure 4. *Experimental assembly for self-focusing of the subrelativistic electron microbeam.*

In December 1999, experiments started using the experimental assembly created by the group (Fig. 4), with a total energy reserve of 2.5 kJ, maximum beam current of up to 30 … 50 kA, maximum energy of electrons of up to 500 keV, and total duration of the beam current impulse of about 30 ns.

Experiments were carried out using copper cylindrical targets. The arrangement is shown in Fig. 3. It was expected to see the formation of a thin axial channel in the target (Fig. 5), which would be the evidence of the required beam focusing and, consequently, energy density in the target volume.

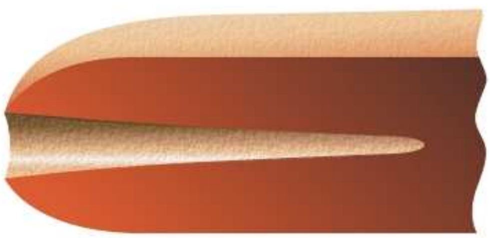

Figure 5. *Model of the longitudinal section of the target after the experiment, with a thin axial channel.*

During three months of permanent experiments, all our attempts remained unsuccessful. There was no observable indication of energy superconcentration and channel formation in the target.

Life had created a situation where a non-standard decision had to be made.

Such decision was made following the logic of the above principle of dynamic harmonization in the systems. In accordance with that, to get the substance's own evolutionary potential involved in the process, it was necessary to create general synchronous and cophasal dominating shock impact, which would simultaneously create extreme overload through superintensive acceleration for all potential reactants, i.e. particles of the original substance, such overload to stimulate formation of links structure between interacting particles, which would, due to the increase in the specific or integral binding energy of the system, decrease the system's inertness in the subspace of disturbed degrees of freedom, or, in other words, it would bring to the minimum part of the eigenvalues of the system (2), which are characteristic of the particles inertness in the three-dimensional physical space.

It can be easily assumed that the best external disturbance providing the general dominating impact on the set of particles, nuclear reactions involving which should provide the free energy release, there should be *a self-collapsing, self-condensing, and self-accelerating isoentropic cylindrical or spherical solitary wave-shell of the extreme density of energy and matter, scanning the target volume from its surface to the point of the wave collapse* (Fig. 6).

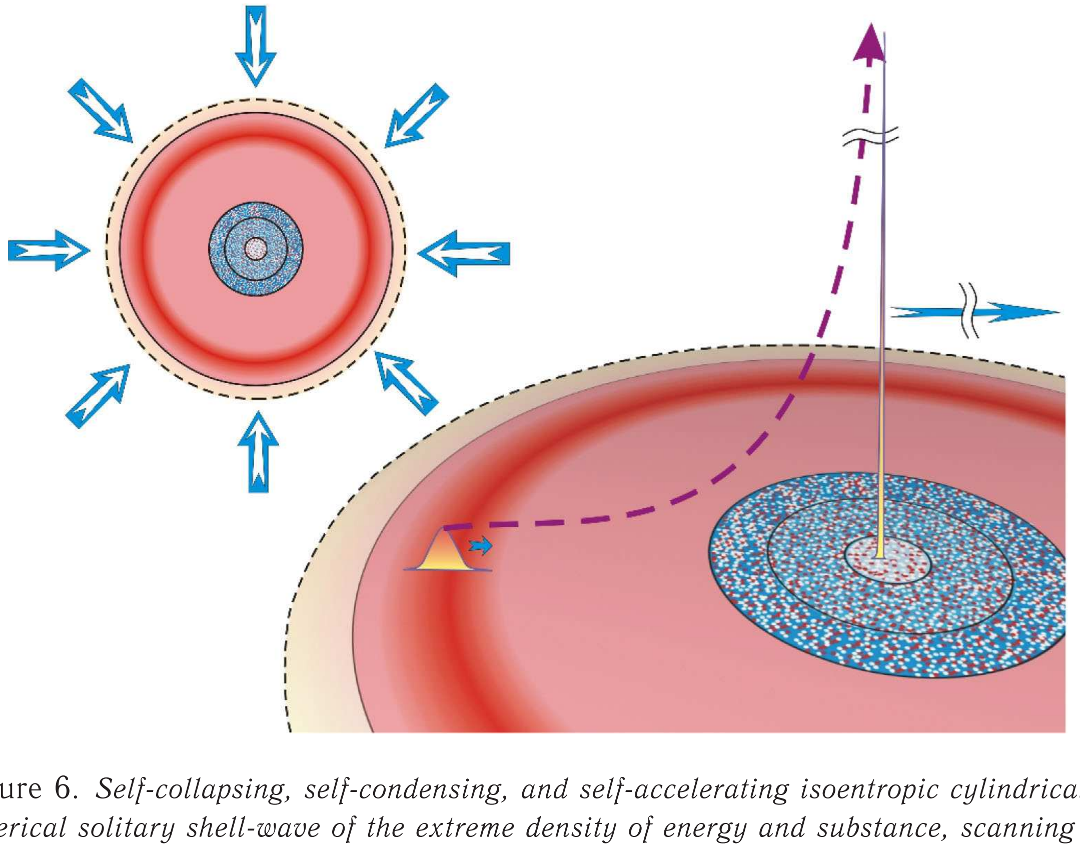

Figure 6. *Self-collapsing, self-condensing, and self-accelerating isoentropic cylindrical or spherical solitary shell-wave of the extreme density of energy and substance, scanning the target volume from its surface to the point of the wave collapse.*

Adequate mathematical description of the conditions of that shell-wave creation and dynamics appears to be an extremely complicated problem, taking into account the fact that even at the initial stage, the matter within the wave volume may be in the extreme state of the electron-nuclei plasma, and at further stages of the evolution, analysis of energy considerations in so complex macroscopic system of both corpuscular and wave nature should take into account really complex quantum-mechanical effects, as well as collective multi-particle interactions in the superdense electron-nuclei and electron-nucleon plasma, those effects resulting in possible creation of the mass defect in the wave-shell as an integral macroscopic system, a kind of a “quasi-megaatom”. Finding a solution to this problem is probably a task for the future, although we have been already making some attempts to consider the problem.

Fortunately, despite the lack of a complete theoretical model, it has been in our view possible in our experiments to initiate a collapsing solitary wave of the extreme density of energy and substance, as well as to observe the consequences of its self-development and collapse.

It happened after we radically changed the arrangement, or construction, of the relativistic vacuum diode serving as energy concentrator in our experiments, in order to excite in the thin near-surface layer of the target anode a converging wave of the extreme density of energy and substance through the creation of high-charge ions of the substance of target surface layer and coherent collective acceleration of those ions towards the target energy focus. The new arrangement is shown in Fig. 7.

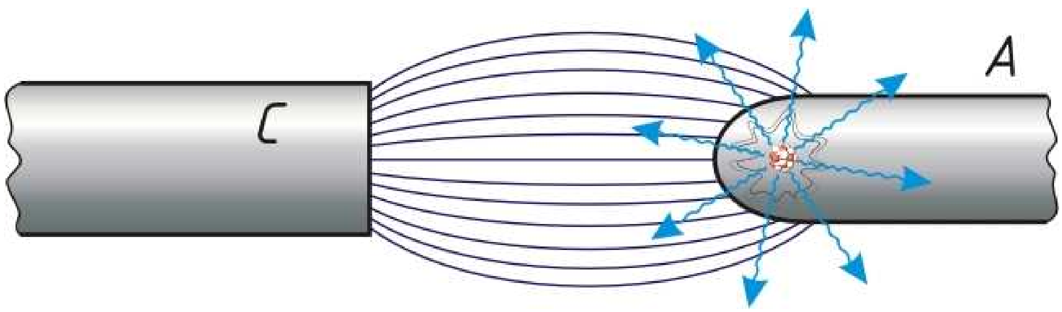

Figure 7. *Schematic arrangement of the electron beam self-focusing on the surface of the target anode, which excites a soliton-like density impulse converging to the axis of symmetry in its near-surface layer.*

The very first experiment using the new arrangement, carried out on February 24, 2000, proved a success, resulting in the explosion of the cylindrical target from inside with the creation of a crater changing into an axial channel (Fig. 8).

The nature of the effect denoted that the maximum energy density was reached precisely in the focus, on the axis of the cylindrical target, and was an indirect evidence that the intended process occurred.

4 Artificially initiated collapse and laboratory nucleosynthesis

Shortly after the first successful experiment, when looking under the microscope at another exploded target, we could not but noticed on the chemically pure surface of the copper-made accumulating screen, which surrounded the bed of the concentrator target made of the same copper, a macroscopic area (around 1 mm long) of solidified

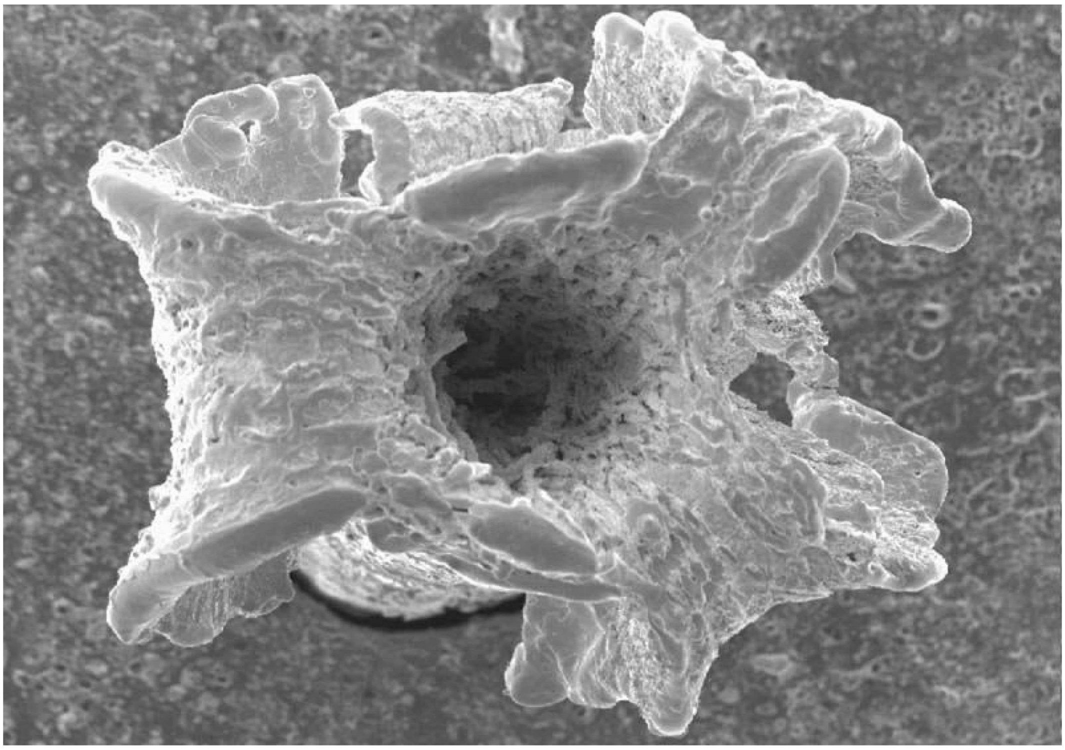

Figure 8. *Cylindrical monolithic target after the experiment which ended with the target explosion from inside and creation of the crater changing into an axial channel.*

silver-and-white "lava" (Fig. 9), which had obviously flowed out of the exploded "volcano" with a tubular crater, and left its traces, some drops, on the surface of one of the "petals" of the exploded tube which formerly was a monolithic target rod.

X-ray electron probe microanalysis of element composition of that "lava" showed that it consists of zinc for 71%.

It has been obvious that we see *products of artificial nucleosynthesis on the macroscopic scale, occurring in the focal volume of the exploding concentrator target*.

Now we have serious grounds to say that we have succeeded in implementing, and learning how to reliably reproduce in laboratory conditions, a microscopic analogue of the natural physical phenomenon which accounts for the explosive nucleosynthesis and seems to be an energy source for supernova flares, as well as possibly for pulsars and gamma-ray bursts.

This is probably the first time that an explosive physical process has been controllably initiated of the nuclear transmutation of macroscopic amounts of matter, with the creation (birth) of a wide range of stable isotopes of light, middle, heavy, and superheavy (transuranium) chemical elements. This process is self-sufficient in energy terms. The energy required to trigger the process is tens of thousands times lower then the whole "energy cycle" of the process itself. The resulting products of the process (i.e., the isotopes of chemical elements being born) are stable, irrespective of the activity of the target substance. The discovered physical process, which can be controllably reproduced, can become an efficient way of neutralizing the artificially created radioactivity.

Figure 9. *Copper target after the experiment, with traces of solidified silver-and-white "lava" on its "petals", which had flowed out of the target center.*

The energy source for the process self-development is, to our belief, the detonative collective (multi-particle) dynamical transmutation of nuclei of the target source matter into new nuclei — both traditional and superheavy ones — for which the integral weighted average binding energy per nucleon exceeds the initial energy, which occurs within the volume of a collapsing spherical solitary wave of the extreme energy and substance density.

Radiophysical measurements data give us grounds to assume that the energy efficiency for the implemented process of nuclear "afterburning" of the substance may reach the level of $20\,\mathrm{GJ{\cdot}g^{-1}}$.

This process has become feasible due to the fact that in 2000–2003, Proton-21 Electrodynamics Laboratory has been using a fundamentally new method and device for shock compression of matter (international patent application filed with a priority date of August 14, 2002).

Unfortunately, it would be difficult to simply list, not to say to describe in detail, all experimental facts and phenomena reliably registered within the said period, which deserve attention and reveal fundamentally new and previously unknown aspects of mutual transformations of energy and substance, as well as new manifestations of properties present in the corpuscular and wave forms of existence of matter.

We will therefore briefly discuss below only that part of the most important results for interpretation of which there have been practically no doubts left.

5 Studies of the element and isotope composition

Numerous studies of the element and isotope composition of surface of the exploded target and accumulating screen, conducted using various methods, have shown the presence, in different amounts, of all elements of Mendeleev periodic table among the target ejections [12, 13]. Most of chemical elements found in accumulating screens and remnants of the target either were not found in the materials of which targets and screens were initially made, or they were present in those materials in concentrations and amounts several orders lower than in the resulting ones. In addition, for most of the created elements, their isotopic composition has been significantly different from natural conditions.

Studies of the near-surface layer (0.25 micrometer thick) of fifty same-type samples which contained the laboratory nucleosynthesis products using analytical chemistry methods have demonstrated the presence of lanthanides, namely terbium (Tb) and europium (Eu), in mass concentrations four orders higher than the detection limit of the method used, while there was no indication of those elements in the original substance.

It should be noted that experiments were made in a vacuum of 10^{-4} mm Hg; furthermore, used in the experiments were chemically pure materials, for which all impurities contained in the volume under high energy impact were taken into account when processing the analysis results. Therefore, the origin of macroscopic amounts of a number of chemical elements found, including rare and rare-earth elements (Figs. 11—13), most of those with a “shifted” isotopic composition (Figs. 14—16), cannot be explained by anything but nuclear synthesis.

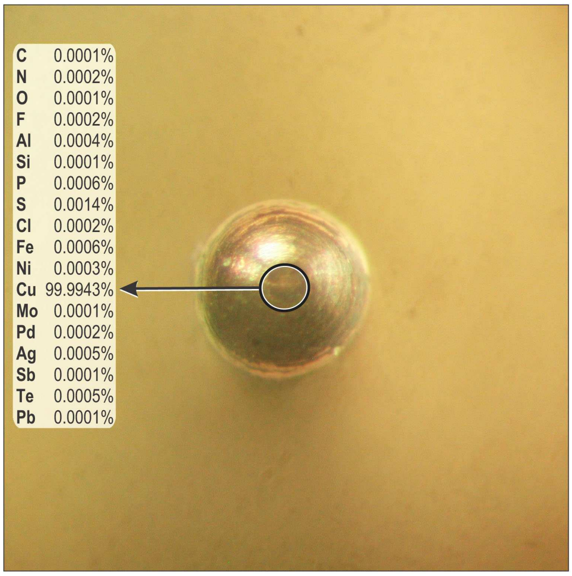

Figure 10. *Target prior to the experiment. Material of the target is copper (Cu 99.99 %). The method of investigation is glow-discharge mass-spectrometry. (VG–9000 device, analyzed mass range — up to 250,* $M/\Delta M = 7000\ldots9000$*).*

Statistical treatment of the data across all experiments has allowed us to estimate the number of nucleons in the substance of the target that participate in the nuclear transmutation. This number is $10^{20} - 10^{21}$ nucleons per 1 kJ of energy input.

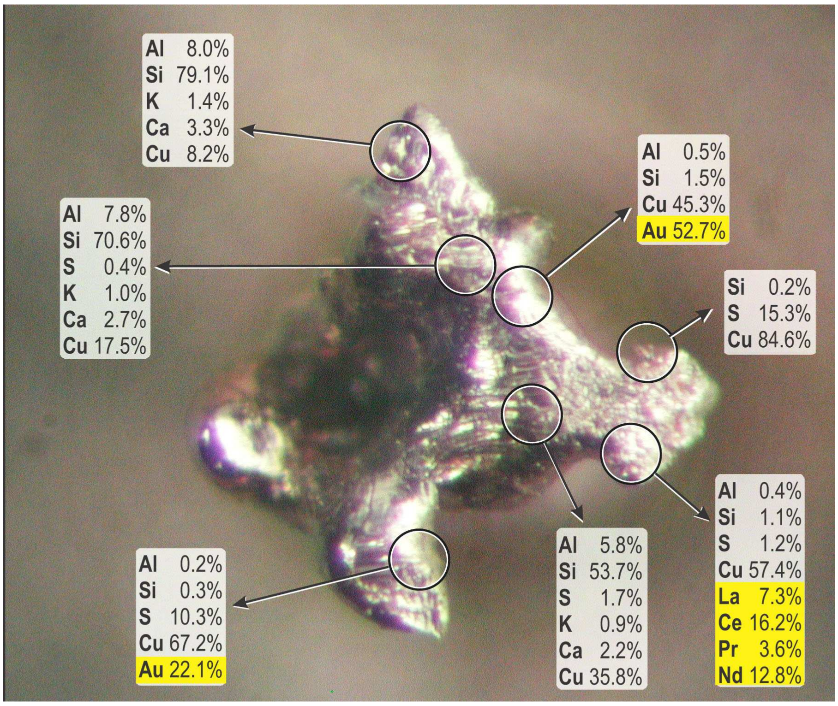

Figure 11. *Target after experiment No. 2107. Material of both the target and the accumulating screen is copper (Cu 99.99%). The method of investigation is X-ray electron probe microanalysis (REMMA102 device, element detection range: from Na to U).*

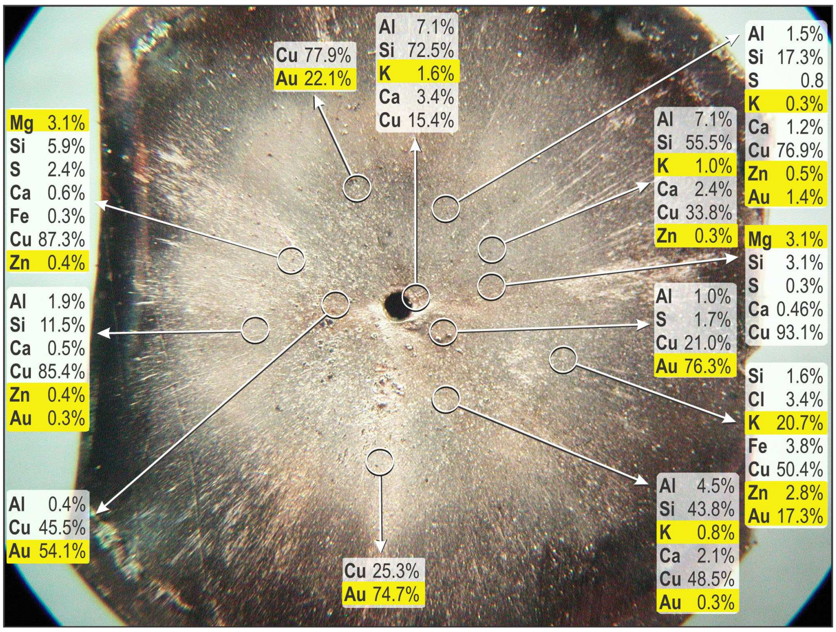

Figure 12. *Accumulating screen after experiment No. 2107. Material of both the target and the accumulating screen is copper (Cu 99.99%). The method of investigation is X-ray electron probe microanalysis (REMMA102 device, element detection range: from Na to U).*

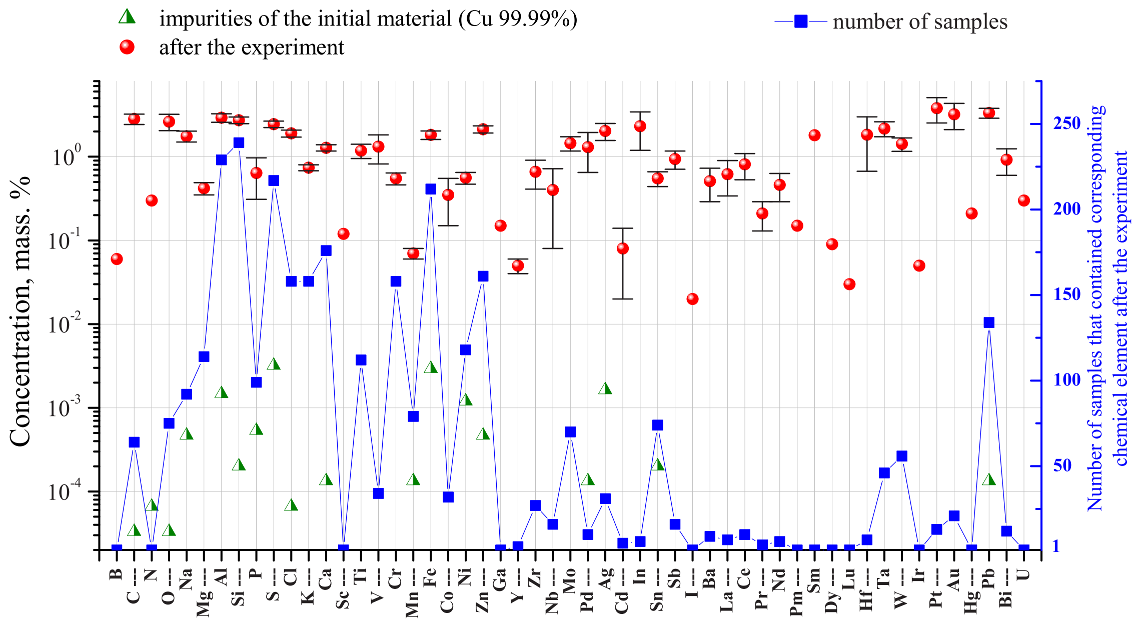

Figure 13. *Results of local analyses of the element composition in 277 copper (Cu mass. 99.99 %) accumulating screens, each of them was used in the experiment with copper target of the same purity. The method of investigation is X-ray electron probe microanalysis (REMMA102 device, element detection range: from B to U).*

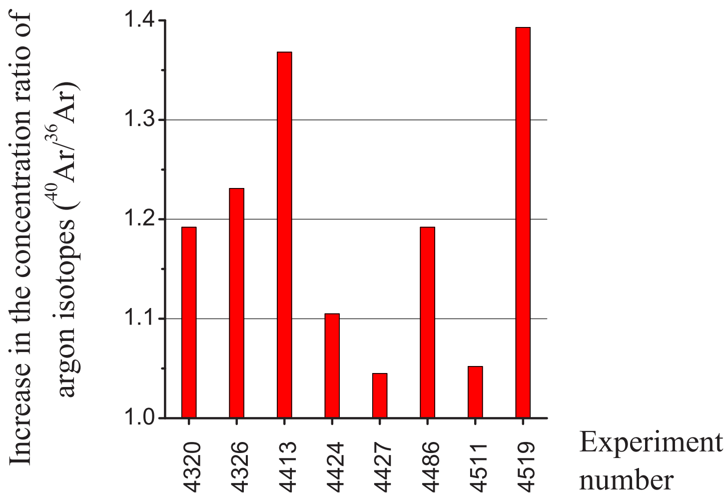

Figure 14. *Increase in the ratio $^{40}Ar/^{36}Ar$ in the vacuum chamber in comparison to that for the atmosphere. The method of investigation is mass-spectrometry (MI–1201IG).*

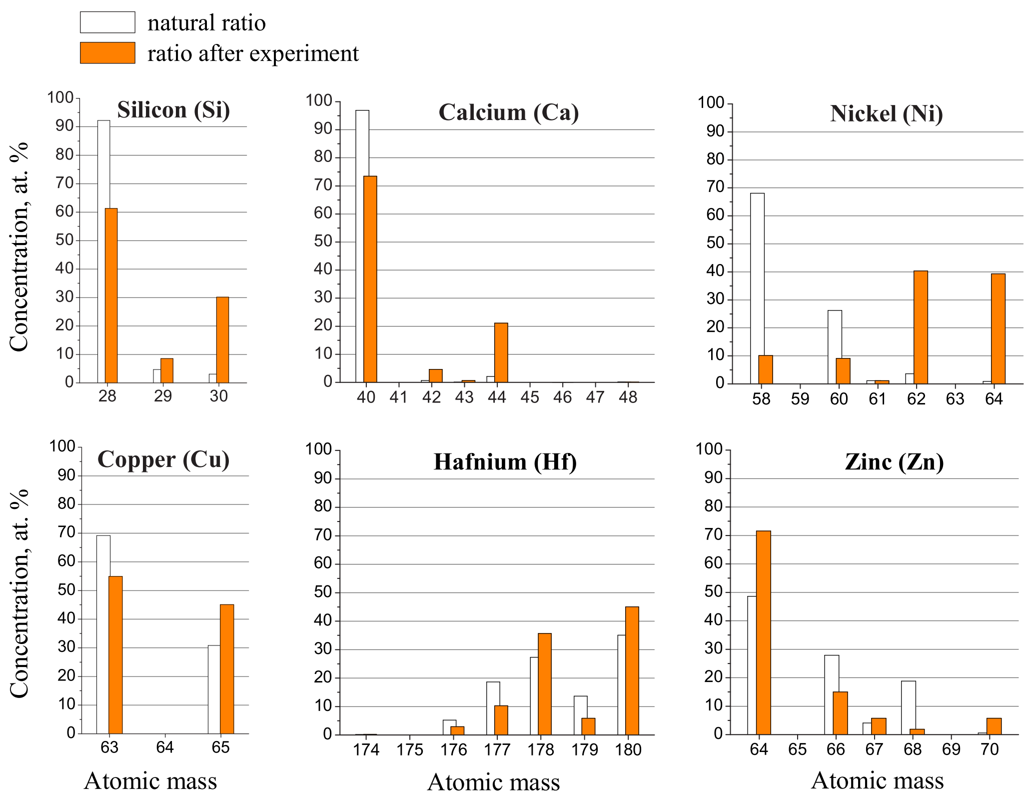

Figure 15. *Examples of anomalous isotopic ratios for some chemical elements detected on the surface of the accumulating screens. The methods of investigation are secondary ion mass-spectrometry and laser mass-spectrometry.*

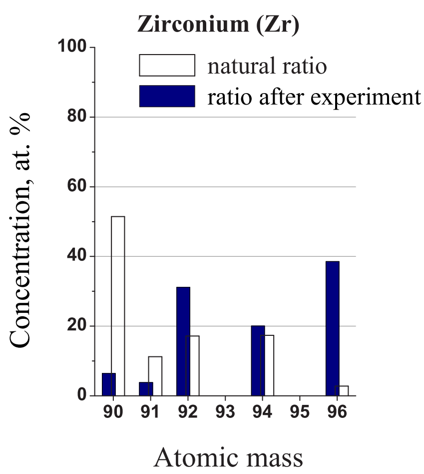

Figure 16. *Anomalous isotopic ratio for zirconium (Zr). The method of investigation is thermal-ionization mass spectrometry (MAT-262 device).*

6 Neutralization of the radioactive cobalt isotope (^{60}Co)

Alongside with the experiments with non-radioactive targets, a series of experiments was conducted with radioactive isotope of cobalt ^{60}Co (half-life of 5.5 year).

Activity of the targets was detected by Ge(Li)-detectors with the volume of 160 cm^3 and resolution of 2.2 keV at two gamma-lines with energies of 1173 keV and 1333 keV.

The tightness of the vacuum chamber and position of the detector remained the same over the course of the experiment.

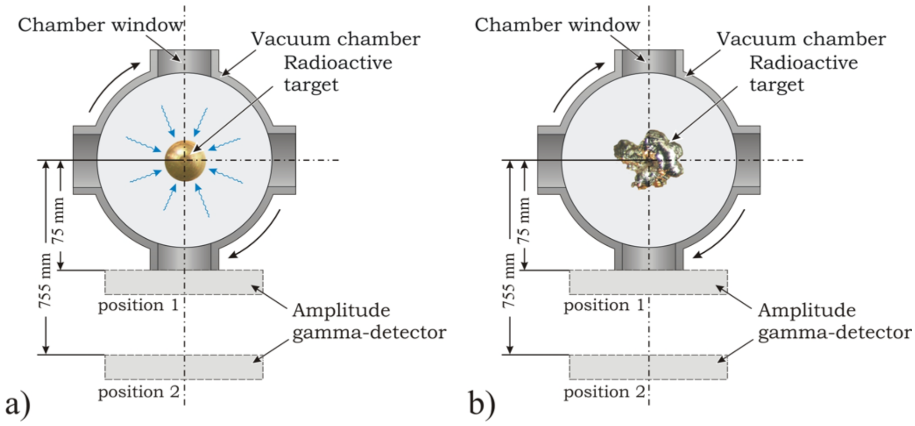

Figure 17. *Scheme of the experiment on the gamma-activity neutralization in the target, depicting the initial state of the sample (a) and its state after the driver action (b).*

Experiment was conducted in a caprolon-made cylindrical vacuum chamber with four windows for measurements (Fig. 17). The target containing ^{60}Co was placed in its center. The average activity before and after the experiment at two distances between the target and the fixed detector (position 1 and position 2, with respective distances of 75 mm and 755 mm) was calculated from four measurements, the chamber turned by 90° after each measurement.

The residual activity calculations considered the factors of target dispersion in the chamber, as well as changes in gamma-quanta absorption by the chamber walls due to the redistribution of activity in the chamber.

On average, as a result of impacting the target, the intensity of ^{60}Co spectral lines decreased by the equivalent of about 10^{18} nuclei transmuted in the target, with no lines of other radioactive elements appearing (see Table 1).

Table 1. *Decrease in the gamma-activity of ^{60}Co after the experiment.*

Sample No.	Decrease in the gamma-activity, %	Sample No.	Decrease in the gamma-activity, %	Sample No.	Decrease in the gamma-activity, %
2397	48	2479	2	2588	47
2398	11	2481	23	2600	33
2425	22	2534	30	2769	29
2426	17	2558	23	2770	36

7 On the circumstances in which superheavy elements were found

Analyzing the data being gathered on the element and isotopic composition of the laboratory nucleosynthesis products, we noticed the presence of elements in the transmuted matter with atomic masses exceeding 2, 3, 5 and more times that of the elements originally contained in the targets, as well as the fact that the weighted average concentration of neutrons in heavy nuclei being products can increase by 10–20 % compared with nuclei of the original substance. Thus, facts said that in this process, there is no problem of neutron deficiency for the nuclei being born to be stable. Late, those assumptions found their theoretical basis [14].

This provided us with grounds to suppose that using heavy elements for targets, such as Au, W, or Pb, accordingly it would be possible to find among products of the synthesis superheavy elements with atomic masses up to 10^3 and more. In addition, the same statistical data directly proved that the most prevailing in the synthesis products are the most stable nuclei.

Hence, it followed that if superheavy nuclei can exist in natural conditions, then they can be found in some amounts among the laboratory nucleosynthesis products, first of all when using heavy elements for targets.

First evidences of the presence of superheavy nuclei were obtained when studying accumulating screens using a CAMECA IMS 4f secondary ion microprobe (Fig. 18). For most of the registered peaks within the range of masses from 210 to 480 (which is the limit of the device's dynamic range), it was not possible to interpret them other than as masses of atomic ions of SHE. Further multiple measurements of accumulating screens using different mass-spectrometric methods confirmed the existence of peaks of masses in the heavy area, which could not be interpreted as clusters or chemical compounds (Fig. 19).

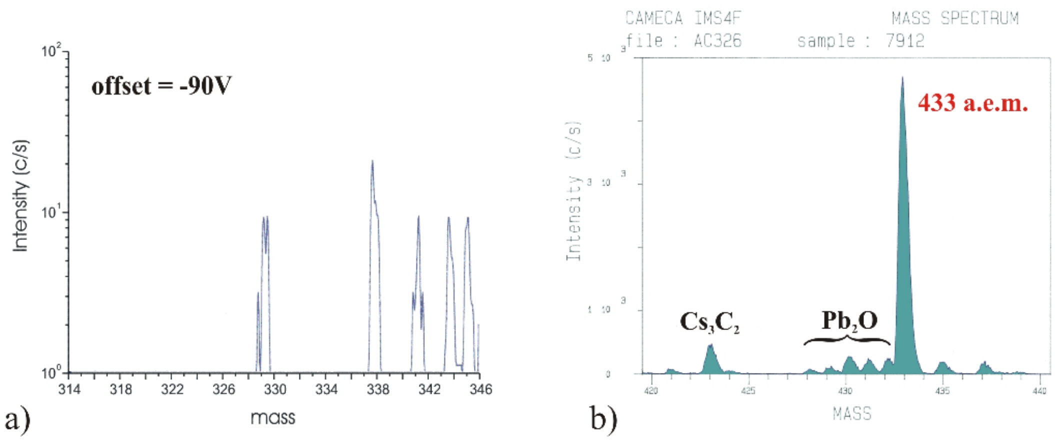

Figure 18. *Unidentifiable masses of chemical elements in the range of atomic masses from 326 to 346 (a), and near 433 (b). Investigation method is secondary ion mass spectrometry (IMS-4f device, analyzed mass range - up to 500).*

As an argument for the presence of SHE on the accumulating screens surface, there have also been the results obtained using instruments which allow to directly study the electron shell of the atom. The X-ray electron probe microanalysis

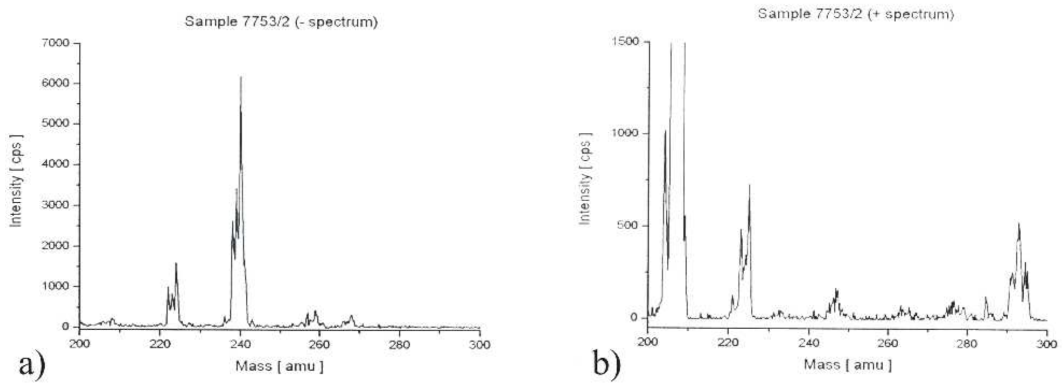

Figure 19. *Secondary-ion mass spectrometry (SIMS, analyzed mass range — up to 300). The mass spectrum is given for negative ions (a) and positive ions (b).*

(XEPMA), X-ray fluorescent (XRF), and Auger spectral studies have indicated the presence of peaks in the spectra of some samples which do nor belong to the known chemical elements, nor are they artefacts of the analysis (Figs. 20, 21). Those peaks are supposed to belong to SHE (Table 2).

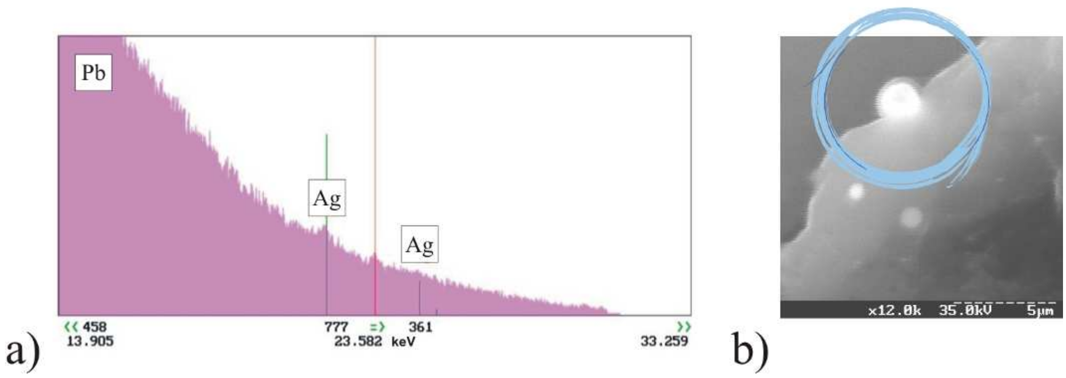

Figure 20. *Unidentifiable X-ray peak with the energy of 23.582 keV; estimated charge is 118–119 (a); photograph of the location of that peak (b).*

The presence of SHE on accumulating screens is also confirmed by purely nuclear investigation methods: Rutherford backscattering of α-particles [15] and nitrogen ions ^{14}N on SHE nuclei in near-surface layers of accumulating screens and *the registration of α-particles with energies of up to 25 MeV resulting from the decay of superheavy nuclei under the impact of copper or oxygen ions with energies of 10–30 keV* (Fig. 23) [16]. With regard to the last method mentioned, we currently have no other interpretation of the results obtained using this method, other than interpreting them as the induced α-decay of superheavy nuclei.

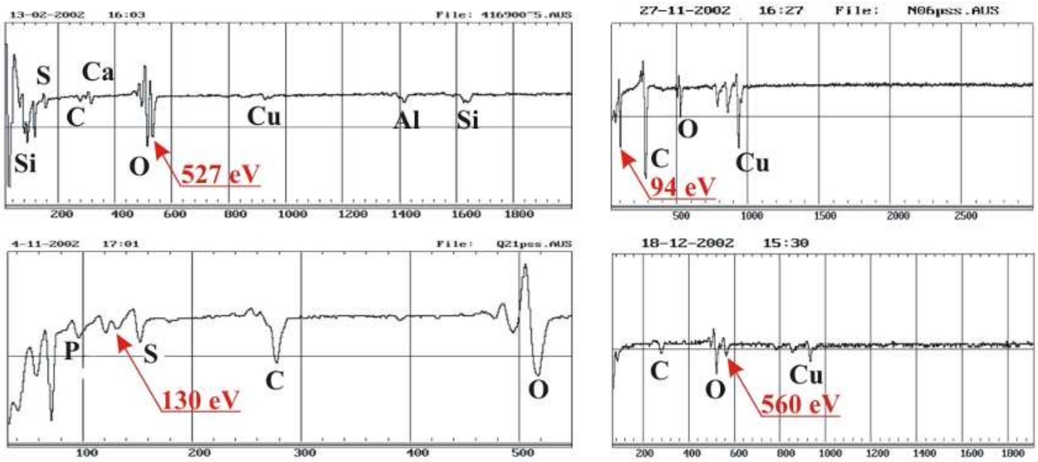

Figure 21. *Unidentifiable Auger-peaks of chemical elements with energies of 527, 94, 130, and 560 eV.*

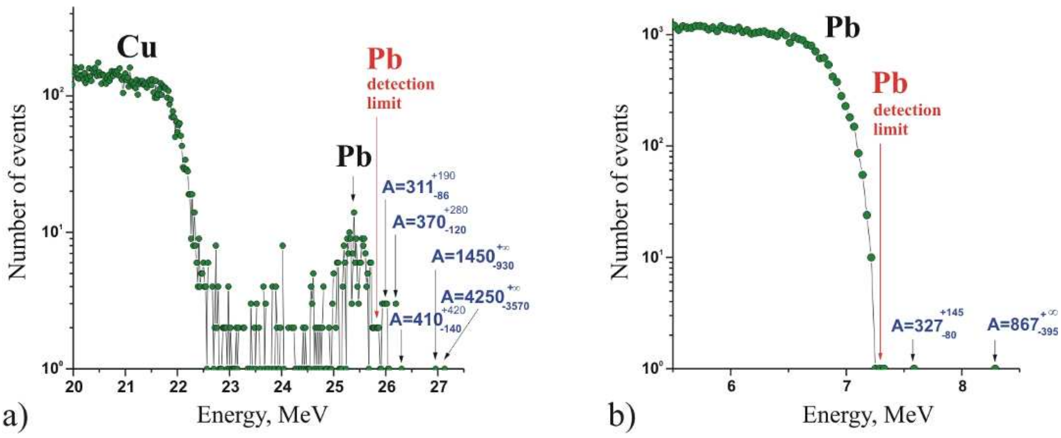

Figure 22. *Rutherford backscattering of α-particles accelerated to the energy of 27.6 MeV, at the angle of 135° (a), and that of nitrogen ions (^{14}N) with the initial energy of 8.7 MeV, at the angle of 150° (b).*

Table 2. *Unidentifiable peaks of characteristic X-ray radiation.*

Peak energy, eV	Method of analysis	Typical element environment	Expected serial number of the element by L_α	by M_α	Number of occurencies	Peak height†
20000	XEPMA	Pb, Cu, Au, Fe, Ni	109–110	198–202	1	4.6
21300	XRF with X-ray tube	Cu, Pb, Ag, Cd, Sn, In	112–113	204–208	3	2.8
22600	XEPMA	Pb, Cu, Fe, Ti, Ca, K, Si, Zn	115–117	209–214	1	4.7
23600	XEPMA	Al, Cu, Pb, Ag	117–118	213–218	2	4.2
24600	XEPMA	Al, Si, Ca, Ti, Fe, Cu, Pb	119–121	218–222	1	3.1
26300	XEPMA	Cu, Ag	123–125	224–229	1	3.9
26700	XEPMA	Cu, Al	124–125	226–231	1	3.5
28900	XEPMA	Ag, Pb, Bi, Sn, Cu	128–129	234–239	5	5.6
36600	XRF with ^{241}Am	Ag, Ba, Nd	141–143	260–267	1	3.2
38100	XRF with ^{241}Am	Ag, Ba, Nd	144–145	265–272	1	5.1
51950	XRF with ^{241}Am	Pb, Cu, Au, Fe, Ni	162–164	306–314	1	5.9

†maximum, in the units of mean square background fluctuation

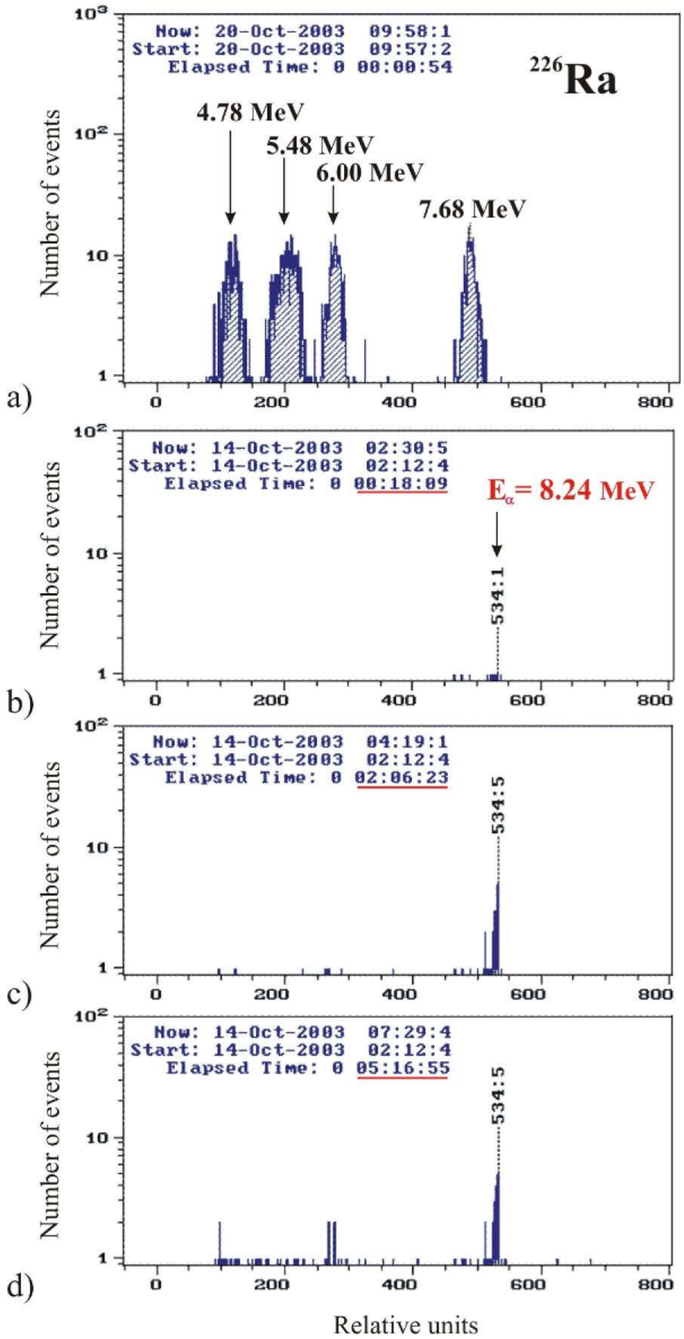

Figure 23. *Alpha-particles energy spectrum. Calibration source is ^{226}Ra (Sample Alpha Spectrum Source) (a). Complete dynamics of alpha lines accumulation for the sample; accumulation time is 18 minutes (b), 2 hours 6 minutes (c), and 5 hours 16 minutes (d).*

8 On the first results of registration of high-energy particles and investigation of the composition of dense plasma in the exploding target using etched track detectors

The density of *plasma tracks* registered at distances of about 10 cm from the "hot spot" reaches the levels of $10^8/\mathrm{cm}^2$ or more, with absolute packing of tracks virtually isotropic for weak micrometer-scale tracks looking like etching pits. These tracks are mostly formed by ions of the target matter with energies near to the track formation threshold of 10 keV/nucleon. The lower estimate for the total number of track-forming particles is $10^{11} \ldots 10^{12}$. Detailed track analysis of the composition of plasma particles beams has been hindered by the lack of a complete set of calibration date.

Tracks of ions with speeds corresponding to energies of *up to 500 keV/nucleon and more* have been registered anisotropically, as streams, with the fastest long-run ions being hydrogen nuclei — protons and/or deuterons. They are those particles that account for contrast images in pinhole cameras (Fig. 24, 25). There have been groups of those particles registered with energies in excess of 1 MeV, with absolute track density in detectors in excess of $10^8/\mathrm{cm}^2$.

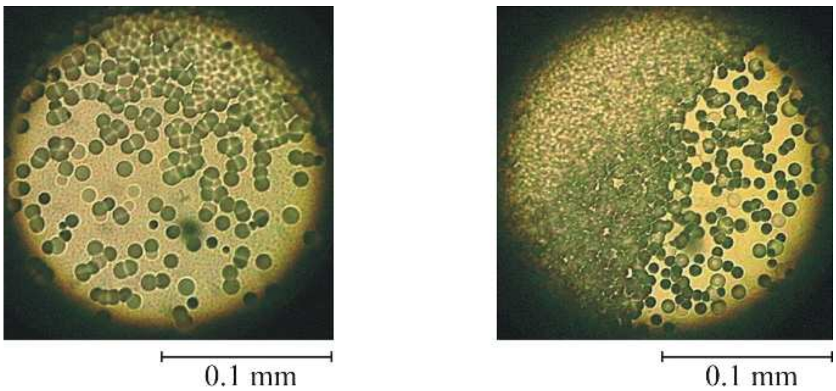

Figure 24. *Pattern of the detector filling in the ion pinhole camera with tracks of 1-MeV protons and deuterons, with absolute track density in excess of* $10^8/cm^2$.

There have been also registered *localized pools of tracks* on the detectors which were shadowed from the direct plasma streams. Those are either chaotic α-tracks with densities up to $100/\mathrm{mm}^2$, or centered "families" of tracks. We have noticed the appearance of giant track clusters with a clearly seen center of spreading, with numbers of tracks > 100. Those clusters contain α-particles, lithium nuclei, and possibly heavier nuclei with energies of up to MeV/nucleon (Figs. 26, 27).

The appearance of both fast proton-deuteron beams and nuclear fission, the latter registered by detectors as centered clusters is an example of *anomalous nuclear physical phenomena*. In their totality, those phenomena provide an evidence of the existence of anomalous nuclear processes related to the target collapse in the experiments carried out by Proton-21 Electrodynamics Laboratory.

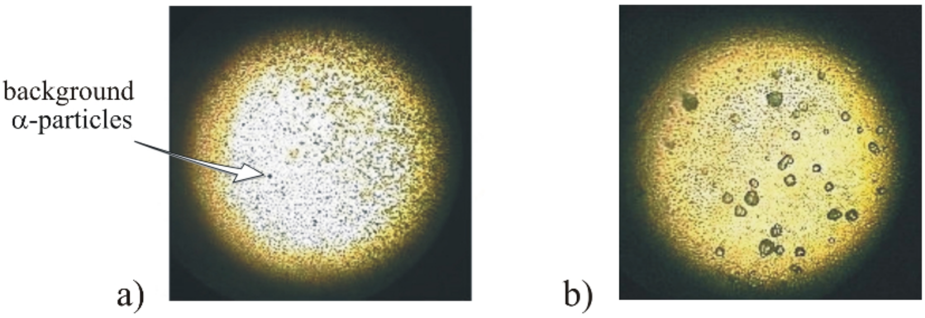

Figure 25. *Pattern of the detector filling with tracks at the distance of 10 cm from the discharge area with small (plasma-produced) and pronounced large tracks of ion jets (a), and tracks of particularly large plasma particles (b).*

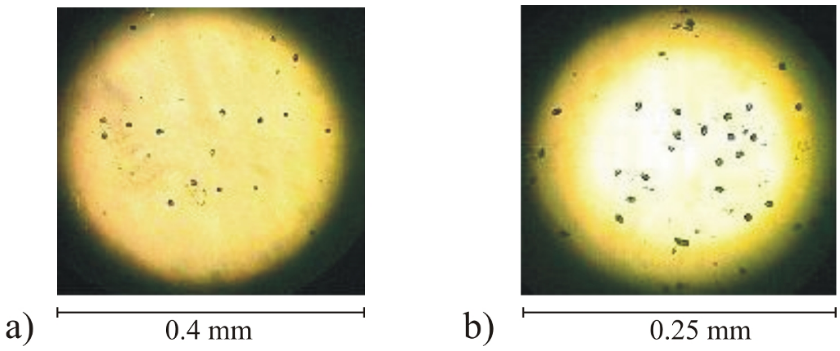

Figure 26. *Pattern of the detector filling with tracks of α-particles after it has been exposed in three experiments (a), and after it has been exposed for 30 seconds to the ^{239}Pu source with the intensity of 10^4 impulses/min (b).*

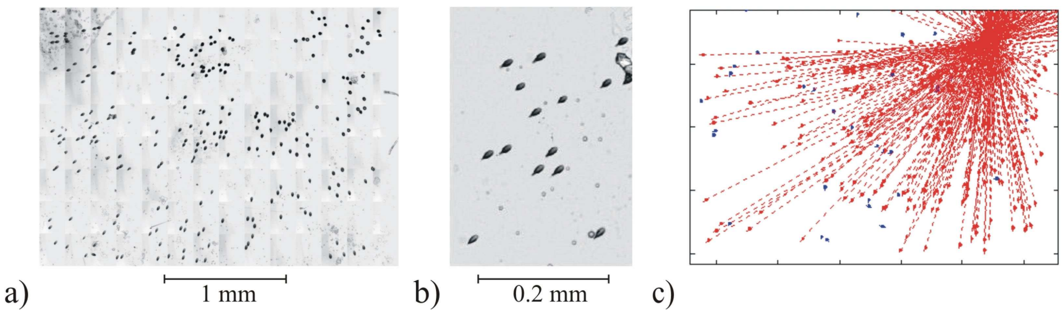

Figure 27. *Pattern of the filling of the detector by tracks with a "giant" cluster of 276 tracks (a); an individual fragment of that pattern (b); the track directions diagram (c).*

9 Some results of investigation of the X-ray radiation in the collapse area

To estimate the size, intensity, and energy spectrum of the quasi-point source of X-ray quanta, we used X-rays of a metal microchannel plate with thickness of 8 mm (ca. 60,000 square cells) (Figs. 28, 29), and GaAs detectors equipped with filter sets.

Estimation of plasma parameters in the hot spot:

- plasma temperature $T_e \approx 38\,\text{keV}$,
- ion concentration in the hot spot $n_i \geq 8.7 \cdot 10^{26}$,
- electron concentration in the hot spot $n_e \geq 2.5 \cdot 10^{28}$,
- electron thermal velocity $v_{Te} \approx 10^{10}\,\text{cm/s}$,
- average distance between nuclei $r_i \leq 6.5 \times 10^{-10}\,\text{cm}$.

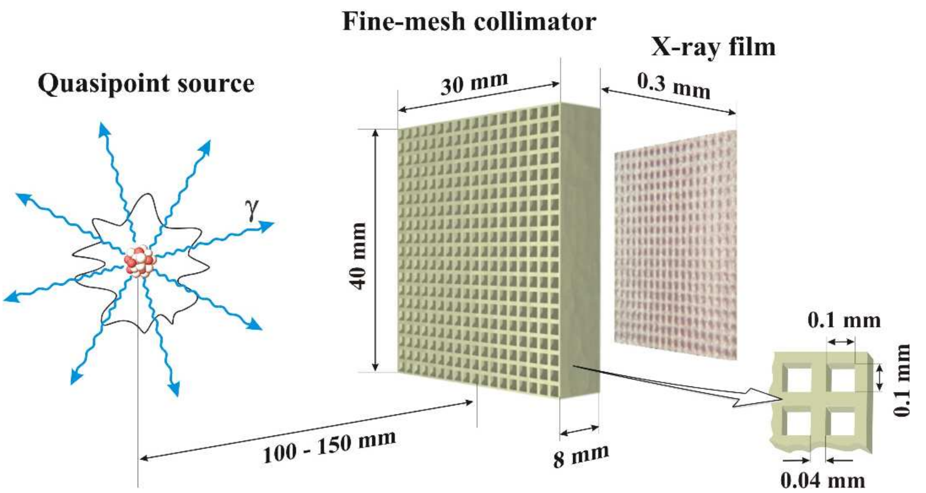

Figure 28. *Scheme of the fine-mesh collimator setup.*

X-ray parameters for the collapse area demonstrate good correlation with same parameters of some astrophysical objects.

Results of the comparison of spectral density distribution in X-ray and gamma ranges for the exploding target, or the collapse area, and that for such astrophysical

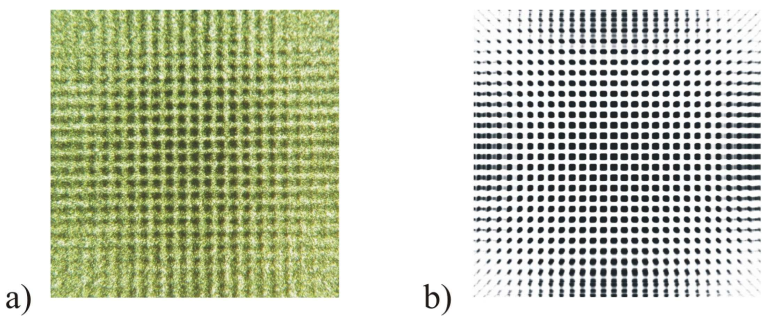

Figure 29. *Image in X-rays of a metal microchannel plate (a) and computer simulation of the X-ray quanta passage through a fine-mesh collimator (b).*

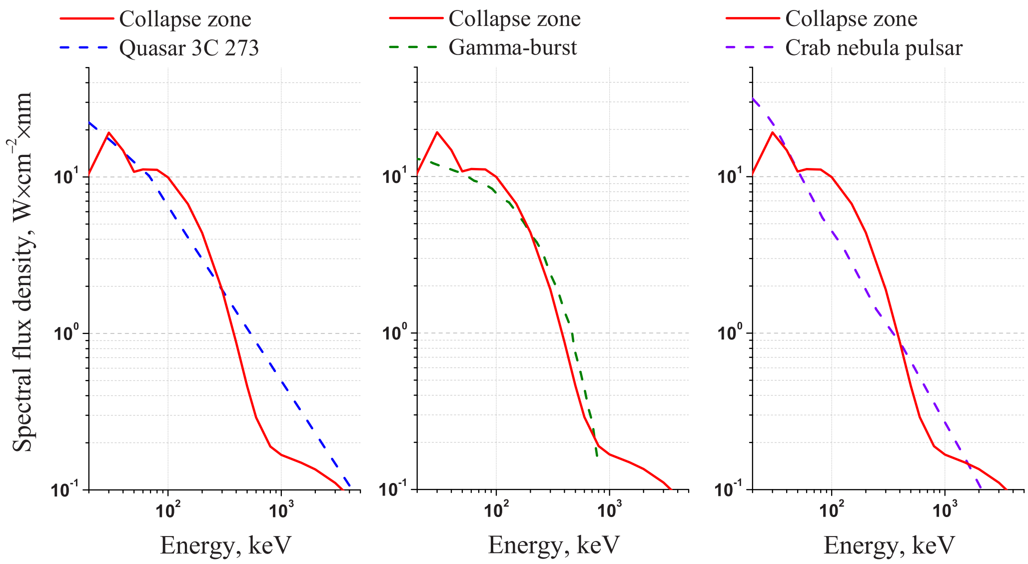

Figure 30. *Spectral density distribution for the shock compression area of the target and that for some astrophysical objects (logarithmic scale).*

Table 3. *Comparison of Spectral density distribution for the shock compression area of the target and that for some astrophysical objects.*

Object	Energy range, keV	Correlation coefficient
Quasar 3C 273	10 . . . 4000	0.94
Pulsar in the Crab nebula	10 . . . 4000	0.92
Gamma radiation bursts in the Universe	20 . . . 800	0.99
Supernova SN1987	10 . . . 700	−0.23
The Sun	200 . . . 5000	−0.96

objects as the Sun, the pulsar in the Crab nebula, quasar 3 273, Supernova SN1987, and short-term gamma radiation bursts in the Universe, are shown in Fig. 30.

The distributions are shown in the logarithmic scale and stretched along the ordinate axis, with stretching ratio selected in such a way that each distribution could be conveniently compared with that for the quasi-point source. Spectral density distribution for the collapse area of the target is an average across approximately 2.5 thousand measurements. Correlation coefficients for the distributions in question are shown in Table 3.

10 Energy estimations for light-emitting components of the plasma bunch

A plasma bunch created in the target shock compression area is a source of the intense optical radiation.

Spectrum of that optical radiation was registered using specialized spectrum analyzers, calibrated against a deuterium standard (in the high-frequency area) and a tungsten calibration lamp.

Time signal was measured using a fast-response photoelectric multiplier and digital oscilloscope.

Parameters were registered at a distance of $\sim 6\,\text{m}$ from the hot spot.

Results of measurements and estimates of the plasma bunch optical radiation parameters in a typical experiment are as follows:

- total output of the light energy within the wavelength range of $300 \ldots 700\,\text{nm}$ amounts to $\sim 14\,\text{J}$ per impulse;
- duration of the light burst amounts, based on the duration of the registered signal, to $\sim 60\,\text{ns}$;
- size of the plasma bunch, diameter $3\,\text{cm}$, was calculated based on the duration of radiation and average velocity of ions.

Shown in Fig. 31 is a typical spectrum of optical radiation for the plasma bunch created.

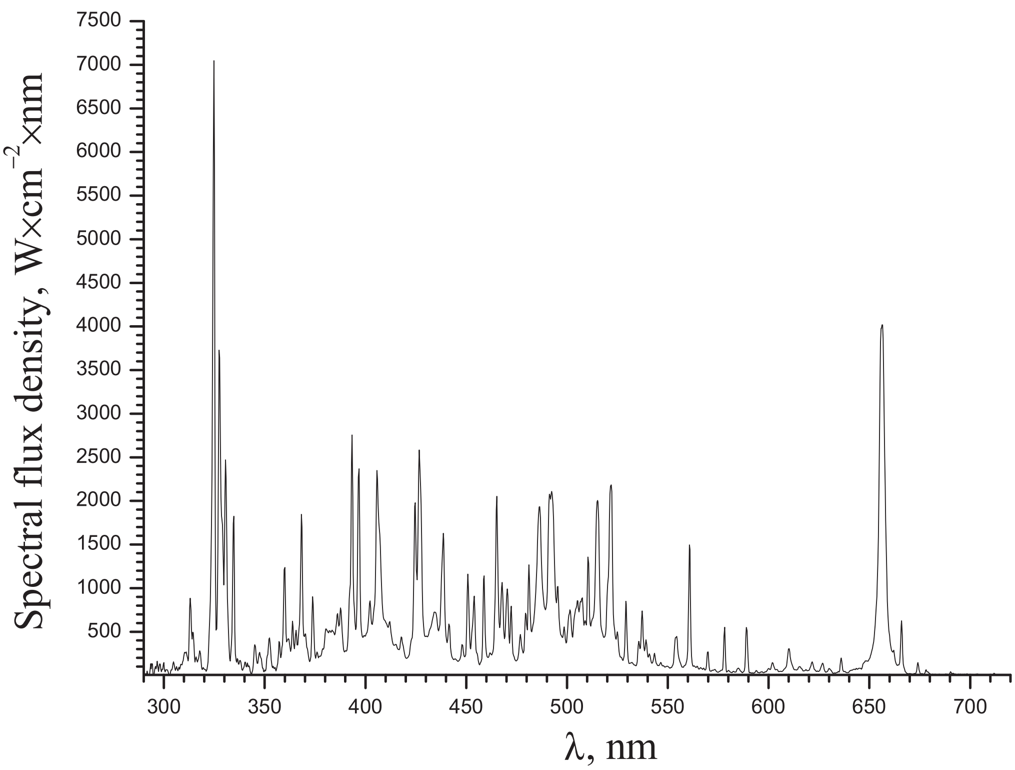

Figure 31. *Typical optical radiation spectrum of a plasma bunch in the area of the target shock compression (experiment No. 3981).*

Estimations of the ion and electron component of the plasma bunch radiation for a typical working experiment:

- ion average energy and velocity: 9.48 keV and 1.6×10^7 cm·s^{-1}, calculated using formulae for the Doppler broadening;
- number of radiating atoms: 8.03×10^{17}, calculated using the curves of the integral absorption for spectral lines (“growth curves”); for some spectral lines, the intensity was normalized to the effective cross-section area of the plasma bunch and radiation duration;
- energy of the ionic component: ~ 750.89 J, obtained through analysis of the Gaussian components in spectral lines of separate ions of different chemical elements;
- total number of electrons in the plasma bunch: 10^{18};
- energy of the electron component: ~ 60 J.

The kinetic energy of particles in the plasma bunch which emit radiation in the optical range is thus ~ 810 J. It should be reemphasized that the total energy of the driver input in the target is 300 J at most.

Present within the spectrum of the plasma bunch are spectral lines of ions of Fe, Ni, and other chemical elements, which were not contained in the original composition of the target material, but which compete, in terms of energy and numbers of emitting atoms, with the basic elements of that material (Pb, Cu).

In the experiment where the energy parameters of the initial electromagnetic impact were the same, but conditions had not been created for triggering of the cumulative process of energy self-concentration in the target (so called imitation mode), plasma radiation parameters differ significantly in the corpuscular component energy with the total output of the corpuscular energy being ~ 12 J, or two orders lower.

11 On the key results of investigation of an exotic product of the nuclear transmutation of matter

This exotic product is a half-part of a thick-walled iron shell (hollow iron sphere). Its birth conditions, electronic photograph, and results of investigation of element composition are shown in Fig. 33.

At the end of March, 2002, in course of the comprehensive studies of local chemical irregularities on the accumulating screen surface of sample No. 4908 (experiment No. 2500) using electron probe analytical methods, including X-ray electron probe microanalysis (REMMA-102 device) and Auger electronic spectroscopy (JAMP-10S device), a macroscopic particle was found incorporated into the surface of the copper accumulating screen, which is pictured in Fig. 32.

Morphologically, the particle is a segment of a broken solid sphere, with a hemispherical cavity approximately 36 micrometers in diameter located in its central part. The particle in question had incorporated into copper at the distance of several millimeters from the center of the target explosive destruction area, and has the external diameter of ~ 92 micrometers. As one can see in the figure, the direction of that

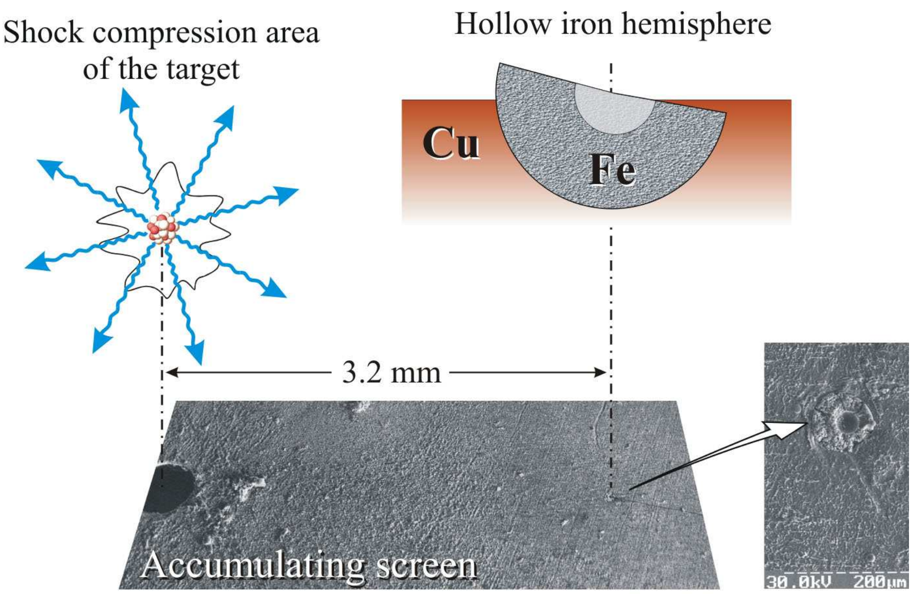

Figure 32. *Scheme of iron particle incorporation into the copper accumulating screen.*

particle incorporation is the same as the radial direction of spreading of the target material.

Use of local probing analytical methods allowed us to find that the said particle consists of iron for more than 93 %. Use of low-loss electrons and absorbed electrons, forming the image based in particular on the chemical composition, has demonstrated a high degree of homogeneity in the chemical composition of the spherical iron particle. Analysis of the isotope composition of iron on its surface has shown a deviation from the natural distribution of isotopes (Fig. 33).

We calculated the total number of foreign atoms, i.e. those which were not part of the target nor the accumulating screen, on the accumulating screen surface of sample No. 4908 using a specially developed technique. In this method, the number of atoms is calculated on the accumulating screen surface in the raster mode, as well as n the mode where impurity atoms are counted in local chemical irregularities on the surface of the analyzed sample. Results of that calculation show the presence of 5.68^{16} foreign atoms, which is 2 orders lower than the calculation results for the majority of typical accumulating screens.

Spectrum analysis of the characteristic X-ray radiation obtained near the location of the said hemispherical iron particle has shown the existence of a peak at the energy of 30.1 keV, which cannot be identified in any way. The standard procedure for analyzing this peak, where the presence or absence of a weak peak is detected against background fluctuations, would involve the "3σ" statistical criterion described in a number of books, including [17].

According to this criterion, the characteristic X-ray radiation peak shall be deemed as significant if its height is in excess of three σ, or root-mean-square fluctuation of the background.

Calculations of the said criterion for the 30.1 keV peak produced the result of 4.67σ. Therefore, we have grounds to speak of a reliably registered line which is not present in the catalogs of characteristic X-ray spectral data. Extrapolation of energy

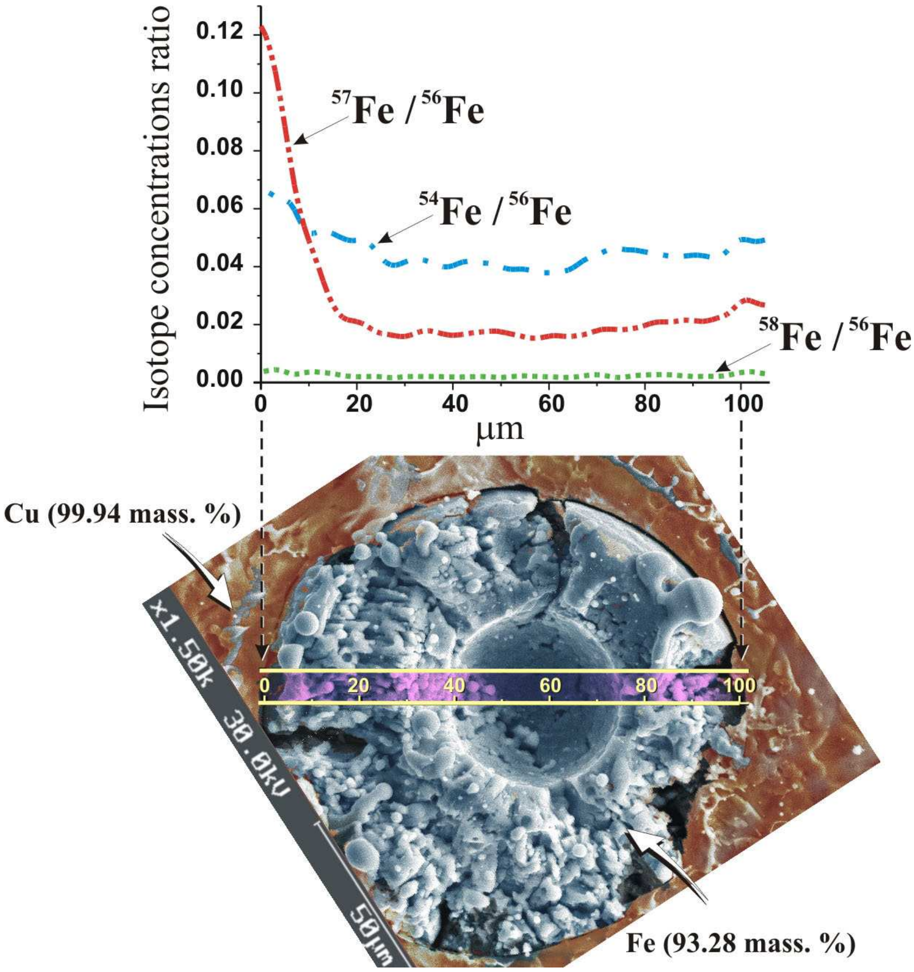

Figure 33. *Isotope composition of iron on the surface of the hollow hemisphere.*

for that peak using Moseley's law produces for the $L_{\alpha 1}$ line an estimated nuclear charge of $Z = 134$.

In author's view, the iron hemisphere observed is a direct material evidence to support the proposed concept of collapse of the target (or, in general case, any material object), with the key role played in that process by a superdense collapsing concentric shell-wave scanning through the target volume and determines both the instantaneous (current) energy parameters of that process, and the final energy balance.

12 The most probable scenario of the process initiation and evolution

Based on the above data, as well as on the assumptions of the conceptual physical model used as a foundation for the developed method of shock compression of matter, and a substantial amount of experimental data analyzed during 4 years, we can describe the most probable scenario of the process initiation and evolution as follows.

It is possible to conventionally divide the process into 5 stages:

Stage 1. As a result of collective interaction of the shock high-current relativistic electron beam with the surface of the target anode which acts as an energy-concentrating lens, in the near-surface layer of the target a solitary shell-wave of highly ionized, extremely dense plasma, particles of which, through the collective acceleration mechanism, acquire momentum of ordered motion to the target energy focus; the matter and energy are transferred by the wave isoentropically, and that transfer is not accompanied by significant heating of the target volume scanned. While the wave is moving, its wavelength decreases, while its velocity, steepness of the leading edge (density difference), and amplitude (maximum density) increase up to the values where at the leading edge of the shell-wave preconditions are created for the nuclear transmutation of the matter.

Stage 2. The nuclear transmutation of the target matter, which has started within the wave volume, results in a mass defect and, consequently, in an increased potential and kinetic energy of the shell-wave, and further avalanche-like growth of both its leading edge velocity and matter density in the wave. Detonative nuclear combustion starts within the wave volume, that combustion being supported by the combination of, firstly, the mass defect in the shell-wave as an integral megaatomic quantum-mechanical system, and, secondly, the mass defect (binding energy) in the transmuted nuclei "evaporated" by the wave's trailing edge and forming a "cold" matter which has undergone nuclear transmutation, with a solid-state density, i.e. the "ashes" of the nuclear combustion.

Here the nucleon composition of the nuclei evaporated by the trailing edge of the collapsing wave, which is scanning the target volume layer by layer, is determined by the current (instant) density of energy and substance in the shell-wave volume, while the binding energy and nucleon composition of the nuclei being born are determined by way of compromise between the possibility arising out of the instant density of energy and substance in the wave, and the *necessity to maximize* its stability, based on the current relation between the mass (the inertness) and free energy of the virtual collapsing shell.

The mechanism of self-preservation and self-development of the shell-wave works in such a way that the composition of nuclei being the transmutation products can vary within broad limits depending on the current quantum-mechanical and nuclear physical parameters and the energetics of the shell-wave itself. If the process in the wave reaches the boundary of the active existence area (energy self-sufficiency of the wave), then evaporated at its trailing edge are the nuclei with the maximum specific binding energy, both per nucleon and per neutron. Those include first of all the nuclei of *stable isotopes* of Mn, Fe, Ni and some other chemical elements.

The 2^{nd} stage of the process ends when the shell-wave parameters (density, neutron concentration, etc.) reach the levels where evaporation of the "energy-efficient" classical nuclei by the wave trailing edge becomes impossible due to the crossing of matter density threshold in the wave, and evaporation of "energy-consuming" heavy and superheavy nuclei starts.

Stage 3. In this stage, further increase of density and nuclear transmutation of the matter continues in the volume of the shell wave and at its trailing edge. The energy accumulated by the wave is spent for the creation ("evaporation") of the "energy-consuming" nuclei by the trailing edge, with simultaneous increase of substance density in the wave, until the critical threshold is achieved where conditions appeas for the transition into the next (second) stage of the detonative nuclear combustion.

Stage 4. Another stage of the detonative nuclear combustion. Further transition of the shell-wave towards the collapse stage is accompanied by the accumulation of both potential and kinetic energy by the wave at the expense of transmutation of the original target nuclei into "energy-efficient" superheavy nuclei. Binding energy within the wave volume reaches its maximum. The leading edge of the wave, the internal surface of the collapsing shell, shrinks to the single point, and the wave finally collapses.

Stage 5. The final stage of the collapse of shell-wave, which degenerates into a microscopic spherical superdense bunch of electron-nucleus plasma (a megaatom). The accumulated energy of the shell wave is spent for reaching reach the extreme density of energy and substance within the volume of the megaatom formed, and following clusterization of the "boiling" electron-nucleon bunch into light, middleweight, and heavy nuclei.
End of scenario.

13 Conclusions

The above features of the discovered phenomenon denote its fundamental difference from other nuclear physical processes of artificial origin.

It necessitates the most urgent earliest organization of a broad range of both theoretical and experimental research aimed first of all at finding peculiarities of interaction between the products of the nuclear reactions and the substance, as well as determining the spectrum and intensity of the particle beams.

Listed among the priority tasks should also be:

- the isolation of necessary amounts of unknown chemical elements and isotopes found among the products of the artificially initiated collapse, and investigation of their physical and chemical properties;
- analysis of the total energy balance of the process at all stages as a function of controlled initial conditions, in order to maximize the fraction of the target volume which is undergoing a complete nuclear transmutation, in order to neutralize the activity;
- studying of possible applications of the radiation produced in the process for improving consumer properties of materials.

Illustrative material used in this publication includes materials from the website of the Proton-21 Electrodynamics Laboratory,
http://proton21.org.ua

References

[1] S. V. Adamenko. Pro problemu vyboru kvadratychnykh funktsionaliv i zadachu optymalnoho syntezu liniynykh system z holonomnymy zvyazkamy, *Avtomatyka*, No. 2, 1976, pp. 54–61.

[2] S. V. Adamenko. Niekotorye zadachi i metody sinteza sistem uprvleniya s obratnoy sviazyu. *Preprint*, Kyiv, 1976.

[3] S. V. Adamenko, V. V. Dolgopolov, Y. V. Kirichenko, V. A. Stratiyenko. Fokusirovka skompensirovannogo nieodnorodnogo puchka elektronov. *Radiofizika i elektronika*, V. 3, No. 1, Kharkiv, Institute for Radioelectronics of the National Academy of Sciences of Ukraine, 1998, pp. 94–95.

[4] S. Adamenko, E. Bulyak, V. Stratienko, N. Tolmachev. Effect of auto-focusing of the electron beam in the relativistic vacuum diode. in *Proceedings of the 1999 Particle Accelerator Conference*, New York, 1999, p.3271

[5] S. Adamenko, E. Bulyak, V. Stratienko, N. Tolmachev. Limits of plasma focusing of high current electron beams. in *Proceedings of the 1999 Particle Accelerator Conference*, New York, 1999, p.3269

[6] V. I. Vysotskii, S. V. Adamenko, V. A. Stratienko, N. G. Tolmachev. Creating and using of superdense micro-beams of subrelativistic electrons. *Intern. Symposium on New Vision on Laser-Beam Interaction*, Tokyo, Japan, October 11–15, 1999, Program and Abstracts, p.15, report 1214

[7] V. I. Vysotskii, S. V. Adamenko, V. A. Stratienko, N. G. Tolmachev. Creating and using of superdense micro-beams of subrelativistic electrons. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, V. 455, Issue: 1, November 21, 2000, pp. 123–127

[8] S. Adamenko, V. Dolgopolov, I. Paschenko, V. Stratienko, N. Tolmachev. Kinetics of transporting of high-current relativistic compensated electron beam. *13th International Conference on High-power Particle Beams*, Nagaoka, Japan, June 25–30, 2000

[9] S. Adamenko, V. Dolgopolov, V. Stratienko, N. Tolmachev. Focalizing of high current electron beam by ion counter flux. *13th International Conference on High-power Particle Beams*, Nagaoka, Japan, June 25–30, 2000

[10] S. V. Adamenko, P. A. Bereznyak, I. M. Mixajlovskij, V. A. Stratienko, N. G. Tolmachev, A. S. Adamenko, T. N. Mazilova. Initsiirovanie elektricheskogo vakuumnogo razryada uskorennymi nanochastitsami. *Pis'ma v ZhTF*. 2001. v. 27. n. 16. pp. 15–20

[11] V. I. Vysotskii, S. V. Adamenko, V. A. Stratienko. Optimization of plasma pinch stimulated by focusing action of powerful nanosecond annular laser pulse on a target. *Intern. Pulse Power Conf. (PPPS-2001)*, Laser Produced Plasmas 4.5 Session, Las Vegas, USA, 17–22 June, 2001

[12] S. V. Adamenko, A. S. Adamenko. Isotopic composition peculiarities in products of nucleosynthesis in extremely dense matter. in *Proceedings of Int. Symp. New Projects and Lines of Research in Nuclear Physics*, 24-26 Oct. Messina, Italy, p. 33–44 (2002)

[13] S. V. Adamenko. Isotopic and elemental composition analyses of the laboratory nucleosynthesis products. *VIII International Conference Nucleus-Nucleus Collisions*, June 17–21, 2003, Moscow, Russia, p. 237

[14] S. V. Adamenko, V. I. Vysotskii. Mechanism of synthesis of superheavy nuclei via the process of controlled electron-nuclear collapse. *FoPL*, v. 17, **3**, 2004

[15] S. V. Adamenko, A. A. Shvedov. Superheavy nuclei research. in *Proceedings of Int. Symp. New Projects and Lines of Research in Nuclear Physics*, 24-26 Oct. Messina, Italy, p. 355–361 (2002)

[16] S. V. Adamenko, A. S. Adamenko, M. V. Vasilchenko, A. V. Zhabrovec, M. N. Fedorovich, O. P. Gavrikov, A. A. Shvedov. Issledovanie kulonovskogo vozbuzhdeniia raspadnykh mod metastabil'nykh sostoianij sverkhtiazhelykh atomnykh iader. *Conference in the Kyiv Institute for Nuclear Research*, January, 2004

[17] J. I. Goldstein, et al. Scanning Electron Microscopy and X-ray Microanalysis, Plenum Press, New York and London, 1981