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# Natural Nucleosynthesis

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*Abstract:* **The possibility of generating strong and ultrastrong magnetic fields in condensed ionized media in the presence of unidirectional motion of an ensemble of free electrons with a density > $10^{21}$ e/cm$^3$ is demonstrated. It is shown that atomic and nuclear matter in strong and ultrastrong magnetic fields is transformed into a new state of matter - into transatom, in which atomic electrons and nuclear protons and neutrons are bound in pairs into orthobosons with a spin equal to unity S = 1ħ. Examples of radiationless, low-energy nuclear reactions of transatoms, including those without the Coulomb barrier between identical atomic nuclei, are presented. The mechanism of natural nucleosynthesis, based on the results of the low-energy nuclear reactions registered in various experiments in many laboratories of the world and on the creation of the theory of those reactions, at different stages of the development of the Universe, stars and planets is presented.**

*Keywords:* **low energy nuclear reactions, multinuclear reactions, nuclear reactions without a Coulomb barrier, resonant interference exchange interaction, electron pairing, strong magnetic fields, quantum physics, nucleosynthesis**

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## 1. INTRODUCTION

In 1989-1992 of the last century, low-energy nuclear reactions: cold nuclear fusion reactions and low-energy transmutation reactions of chemical elements were discovered [1-3]. It turned out that nuclear reactions with the transformation of some chemical elements into other chemical elements can occur in ionized, weakly excited condensed media with low, only ~ 1 eV/atom in the reaction region excitation energy. This phenomenon was called: low-energy transmutation of chemical elements (hereinafter referred to as Transmutation).

The methods of the experiments on transmutation are extremely diverse and they are radically different from the methods of nuclear physics. Transmutation reactions were detected and subsequently reproduced in a glow gas discharge [4-6]; at industrial, electronic, zone melting of zirconium ingots in a vacuum furnace [7]; at explosions of metal targets irradiated by a powerful electron pulse [8,9]; at explosions in liquid dielectric media of metal foils through which a powerful electric current pulse was passed [10,11]; when a lead-copper melt was exposed to a pulsed current [12]; at the passage of electric current in water-mineral media [3]; at ultrasonic treatment of aqueous salt solutions [13]; at irradiation of condensed gases with braking gamma quanta [14-16]; in growing biological structures [17-19] and in many other cases [1-3]. The results of transmutation experiments, despite their diversity, are qualitatively similar to each other.

Transmutation reactions are carried out for all chemical elements, starting with hydrogen, and they occur, as a rule, with the participation of a large number of atomic nuclei, both in the input and output channels of reactions. Experiments show that all chemical elements can be synthesized in transmutation reactions. At that, the reaction products − isotopes of chemical elements − are stable, i.e. non-radioactive.

The appearance of "extraneous" chemical elements under "soft" physical conditions in relatively simple experiments led, almost immediately, their authors to the idea of a low-energy natural synthesis of chemical elements in the Universe.

## 2. LOW-ENERGY TRANSMUTATION OF ATOMIC NUCLEI OF CHEMICAL ELEMENTS

− A necessary condition for starting the transmutation reactions of atomic nuclei of chemical elements is the presence of atoms in a strong magnetic field $B > 30$ *T*.

− A sufficient condition for transmutation reactions is the presence of unidirectional motion of an ensemble of free electrons with a density of $\rho > 10^{21}$ el/cm$^3$ in ionized condensed media. The ensemble of such electrons exactly generates strong magnetic fields $B > 30$ *T*.

Both of these processes are characterized by the pairing of both atomic and free electrons into orthobosons with a spin equal to the unit $S = 1\hbar$. The pairing of electrons is associated with the fundamental manifestation, in strong magnetic fields, of an additional, exchange Coulomb interaction between them, and the appearance of new oscillation quantum numbers of electrons.

Analysis of experiments on the transmutation of chemical elements and their results showed that they occur in strong, over 30 *T*, magnetic fields. It turned out that atomic and nuclear matter is transformed into a new state of matter in strong and ultrastrong magnetic fields: spin electron nuclide condensate. A characteristic feature of such a condensate is that it contains paired electrons and paired protons and neutrons (fermions with a spin equal to $s = 1\hbar/2$) in a bound state, in the state of orthobosons, when the total spin of each pair is equal to unit $S = 1\hbar$.

### 2.1. Magnetic fields in condensed matter

Magnetic fields begin to originate in ionized, gaseous and liquid media as a result of unidirectional flows of free electrons with a density of more than $10^{21}$ cm$^{-3}$ passing through them [20]. These magnetic fields originate to the magnetic moments of $\mu_e$ electrons, which are

parallel to each other in a unidirectional flow. Due to the helicity property of electrons $\mathbf{p}_e\uparrow\uparrow\boldsymbol{\mu}_e$ ($\mathbf{s}_e\downarrow\uparrow\mathbf{p}_e$), the magnetic moments of electrons that move in one direction are mainly directed parallel to their pulses $\mathbf{p}_e$. Thus, an ensemble of electrons moving in one direction generates, in accordance with the Landau formula (1) [21], a seed magnetic field $\mathbf{B}_{\mu 0}$. The direction of the field $\mathbf{B}_{\mu 0}$ coincides, on the average, with the direction of motion of the electrons.

$$\mathbf{B}_{\mu(S)}=\mu_0\sum_i\frac{3\mathbf{n}_i(\boldsymbol{\mu}_e\cdot\mathbf{n}_i)-\boldsymbol{\mu}_e}{r_i^3}, \quad (1)$$

where $\mu_0 = 1.26\cdot10^{-6}$ Gn/m is the magnetic constant; $\mu_e = 9.29\cdot10^{-24}$ J/T = $5.79\cdot10^{-5}$ eV/T, $r_i$ is the distance from the electron to the point at which the field $\mathbf{B}_\mu$ is calculated; $\mathbf{n}_i$ is a unit vector in the direction $r_i$, $i$ – is the number of electrons with parallel spins. The formula (1) shows that the magnetic moment of the electron $\boldsymbol{\mu}_e$ creates a magnetic field equal to 30 T at a distance of 0.092 nanometers along its direction axis (the diameter of hydrogen atom is 0.106 nm).

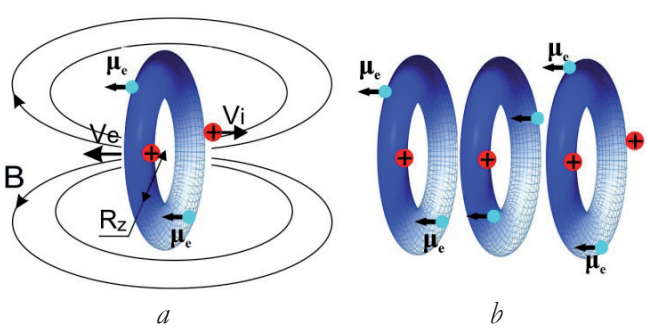
Due to its nature, the field $\mathbf{B}_{\mu 0}$ generated by the sum of magnetic moments of the electrons is spatially inhomogeneous and anisotropic field. Therefore, free electrons that move in a changing field $\partial\mathbf{B}_{\mu 0}/\partial t$ and have an antiparallel orientation of magnetic moments will change the direction of the latter, $\mathbf{B}_{\mu 0}\uparrow\downarrow\boldsymbol{\mu}_e \rightarrow \mathbf{B}_{\mu 0}\uparrow\uparrow\boldsymbol{\mu}_e$. Thus, the number of free electrons in a state with magnetic moments parallel to the field increases, until the moment when most of the electrons enter this state. Consequently, the seed magnetic field will increase until saturation of $\mathbf{B}_\mu$.

The magnetic moments of the electrons are parallel to each other and antiparallel to their spins $\mathbf{s}_e\downarrow\uparrow\boldsymbol{\mu}_e$. Consequently, the spins of the electrons also become parallel. A magnetic, spin plasma is formed.

Since the electron spins in the spin plasma are parallel, then, in addition to the magnetic field, the electrons generate an exchange, self-consistent field with a negative potential in the plasma volume [22,23]. Electrons with parallel spins are attracted to each other due to the exchange interaction. The Coulomb repulsion of electrons at densities of ~ $10^{21}$ см$^{-3}$ is compensated by their attraction to positively charged ions, since the Debye radius, i.e. the distance over which the action of the electric field of a single charge in a quasi-neutral medium extends, has an atom size of ~ $10^{-8}$ см.

The electrons with parallel spins are forced, in the negative potential of the exchange field, to pair into orthobosons with spin S = 1ħ in order to comply with the Pauli principle. Such pairing is carried out due to the appearance of new – oscillation quantum numbers in the electrons in the magnetic field $n_b$ [24]. An orthoboson pair of electrons is a toroidal, annular current of radius $R_Z$ which rotates around an oncoming flow of positive ions that moves at a speed $V_i$ (**Fig. 1***a*). The orthoboson has external and internal strong magnetic fields $B_\mu$ of more than 30 T and a strong electric field. External magnetic fields connect orthobosons into electronic orthoboson "solenoids" – "capsules" (Fig. 1*b*). "Capsules" can have a different number of orthobosons. They can fly out the condensed matter. Then the "capsules" are registered as unknown, as "strange" particles [7,10,20].

Consequently, the electrons, which move in the local regions of ionized, gas or liquid plasma unidirectionally and have a density of ≥$10^{21}$ см$^{-3}$, the pairing of electrons into orthobosons S = 1ħ will be carried out automatically. Electronic orthobosons generate strong magnetic fields $B > 30\ T$ in condensed matter.




*a* *b*

**Fig. 1.** *a – orthoboson;, b – "capsule" – orthoboson "solenoid".*

### 2.2. Transatoms. Spin nuclide electron condensate

The atoms turn into transatoms in the internal, strong magnetic fields of the "capsules" $B_\mu$ > 30 T [24]. The electrons are also paired into orthobosons in the transatom.

In the absence of a strong magnetic field **B,** firstly, the Coulomb repulsion forces between atomic electrons do not have a dedicated direction. Their average values for the spatial *x, y* and *z* components are zero: $\overline{Fx}=0, \overline{Fy}=0, \overline{Fz}=0$. The electron moves around the nucleus not in a plane, but along a trajectory that resembles a "thread in a clue" [25].

Therefore, secondly, despite the fact that the orbital moments for *p, d, f* - electronic states are different from zero ($\ell \neq 0$), the average values of the orbital and orbital magnetic moments for the *x, y* and *z* components are zero: $\overline{\ell x}=0, \overline{\ell y}=0, \overline{\ell z}=0$ and $\overline{\mu_{\ell x}}=0, \overline{\mu_{\ell y}}=0, \overline{\mu_{\ell z}}=0$. As a result, the magnetic field created by the orbital motion of the electron is reset to zero, $B_i = 0$.

In a strong magnetic field, each electron breaks its **ℓ + s** and **j + j** bonds throughout the atom, not only on the outer, but also on the inner orbitals. The spin *s* and orbital **ℓ** moments of each individual electron independently interact with the external magnetic field **B**. The magnetic field **B**, which has a constant orientation, rigidly aligns the electronic orbitals **ℓ** with respect to its direction in accordance with their magnetic quantum numbers $m_\ell$.

The average values of the orbital moments for the *x, y* and *z* components cease to be zero: $\overline{\ell x}\neq 0, \overline{\ell y}\neq 0, \overline{\ell z}\neq 0$. The orbital moments of electrons "freeze" into the magnetic field. An atom from an "amorphous" state is transformed into an ordered, magnetic "crystal" (**Fig. 2***a*). Fig. 2*a* for the sodium atom shows the directions of the orbital moments **ℓ** and the spins **s** of the electrons. The values of magnetic $m_\ell = -1, 0, +1$ and spin $m_s = \pm 1/2$ quantum numbers are given. Yellow circles are S-states ℓ = 0. Fig. 2*b* shows the fine splitting of the internal, electronic levels in the sodium atom. Electronic states with equal

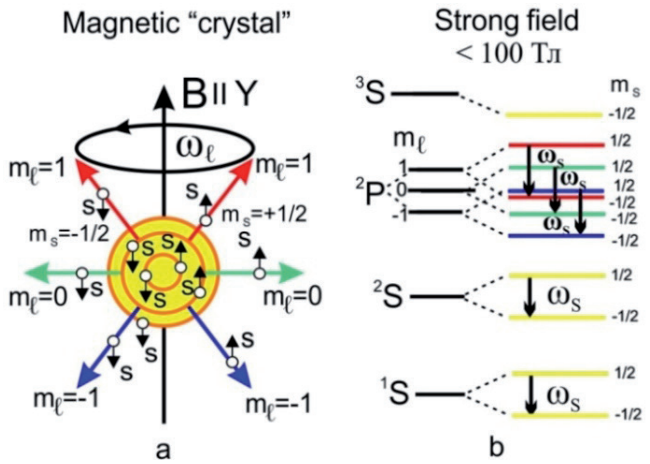



**Fig. 2.** *a – "frozen" orbitals of the sodium atom, b – the splitting of internal levels in the sodium atom.*

orbital ℓ and magnetic $m_\ell$ quantum numbers are split into two spin levels with $m_s = \pm 1/2$. The frequency $\omega_s$ of transitions between them is equal to:

$\omega_s = 2\cdot\mu_e B/\hbar$.

The frequency $\omega_s$ does not depend on the orbital moment of the electron ℓ and on the charge of the nucleus *Z*! All atoms in a strong magnetic field become an "active medium".

In accordance with the orientation, orbital angular momentum **ℓ** of each electron and the resulting orbital magnetic moment $\boldsymbol{\mu}_\ell = -\mu_e \boldsymbol{\ell}/\hbar$ (**Fig. 3***a*) independently precess around the direction of the vector of the external magnetic field with the same Larmor frequency:

$\omega_\ell = \mu_e B/\hbar$.

The orbital magnetic moment $\boldsymbol{\mu}_\ell$ generates its own magnetic field $\mathbf{B}_\ell$ (2) that rotates with the same frequency $\omega_\ell$ (Fig. 3*a*). The magnetic field is a directional, inhomogeneous, anisotropic field.

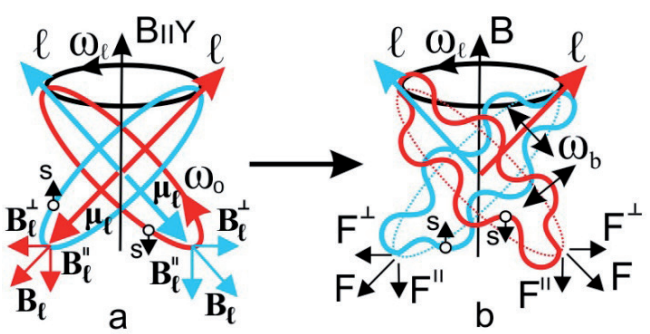



**Fig. 3.** *a –the formation of magnetic fields; b–the occurrence of oscillations.*

The field $\mathbf{B}_\ell$ is decomposed into components $\mathbf{B}_\ell^{\parallel}$ and $\mathbf{B}_\ell^{\perp}$ (Fig. 3*a*).

$$\mathbf{B}_\ell = \mu_0 \frac{3\mathbf{n}(\boldsymbol{\mu}_\ell \cdot \mathbf{n}) - \boldsymbol{\mu}_\ell}{r^3}. \quad (2)$$

Fig. 3*a* schematically shows two orbitals with equal orbital moments $\ell$ and their projections $m_\ell$ on the *Y* axis parallel to **B**, but with different directions of electron spins $s = \pm 1\hbar/2$. In accordance with the principle of least action, the orbitals of the electrons line up relative to each other with a shift of 180° so that the Coulomb repulsion forces between the electrons become minimal. The spins and magnetic moments of the electrons $\boldsymbol{\mu}_\mathbf{e}$ do not precess around **B**, since they are oriented only in two ways: $m_S = -1/2$ along the field and $m_S = +1/2$ against the field. Electronic orbitals with equal quantum numbers $\ell$ and $m_\ell$ precess around *B* synchronously with the frequency $\omega_\ell$ (Fig. 3*a*). The orbital magnetic moments of the two orbitals $\boldsymbol{\mu}_\ell$ form a double magnetic field $2\mathbf{B}_\ell$, which maximum values create the effect of rotation of the field $2\mathbf{B}_\ell^{\perp}$ with a double frequency of $2\omega_\ell$. Thus, the magnetic field $2\mathbf{B}_\ell^{\perp}$ perpendicular to field **B**, and created by two orbitals, stimulates atomic transitions between levels $m_s = 1/2 \rightarrow m_s = -1/2$ (Fig. 2*b*).

This is intraatomic electronic magnetic resonance (IEMR).

In the absence of a strong magnetic field, the transitions $m_s = 1/2 \rightarrow m_s = -1/2$ are forbidden by virtue of the Pauli principle, since the states $m_S = -1/2$ are already occupied by electrons. But this is not the case in a strong magnetic field **B**, because the electrons in the field **B** have additional, oscillation quantum numbers $n_b = 1, 2, 3...$ In a strong magnetic field, the average values of the Coulomb repulsive forces **F** between atomic electrons for *x, y* and *z* components cease to be zero: $\overline{Fx} \neq 0, \overline{Fy} \neq 0, \overline{Fz} \neq 0$. The electrons move in their orbitals, which directions are rigidly connected to each other. These orbitals precess around the field **B**, but they are rigidly bound to its direction. Therefore, the powerful Coulomb repulsive forces between neighboring electrons, which in the absence of the **B** field would force the electron orbitals to rotate freely around the nucleus like "threads in a clue", now they cause the electrons to oscillate around the "frozen" orbitals (Fig. 3*b*) [24,26]. The frequency of these oscillations $\omega_b$ is connected to the rotation frequency of the electron in the orbital $\omega_0$ and the precession frequency of its orbital moment $\omega_\ell$ by the following relation [27,28]:

$$\omega_b = n_b \cdot \sqrt{\omega_0^2 + \omega_\ell^2}.$$

Oscillations are a new degree of freedom of the spatial motion of electrons. This new degree of freedom of motion generates a new spatial quantum number $n_b$ for electrons. Thus, the exchange interaction, which attracts a pair of electrons to each other [29], and their antisymmetric coordinate wave function caused by oscillations $n_b^1 = -n_b^2$ ($\mathbf{p}_{e1} = -\mathbf{p}_{e2}$), allow electrons to create an orthoboson with S = 1ħ, by making the transition $m_s = 1/2 \rightarrow m_s = -1/2$. Electrons paired in the state $m_s = -1/2$ have equal orbital $\ell$ and magnetic $m_\ell$ quantum numbers, but they have different oscillatory quantum numbers $n_b$ and $-n_b$.

In the whole atom, in all atoms that create an "active medium", $m_s = 1/2 \rightarrow m_s = -1/2$ forced transitions similar to transitions in quantum laser generators are carried out under the action of identical $\omega_{sb}$ photons.

Electron oscillations are carried out both in the longitudinal and transverse directions of the magnetic field **B** ($F^{\parallel}$ and $F^{\perp}$, Fig. 3*b*). Since the electrons in the pair oscillate in the opposite phase $n_b$ and $-n_b$, this movement allows two electrons in the same energy states to be in nonintersecting spatial regions. Electron trajectories can be represented as nested closed spirals located on the surface of a toroid.

Atoms whose electrons, not necessarily all, are in a paired state are called Transatoms (**Fig. 4**).

Atoms inevitably turn into transatomsin a strong magnetic field > 30 *T*!

Orthobosons are created in the whole atom. They form a spin Bose-Einstein electron

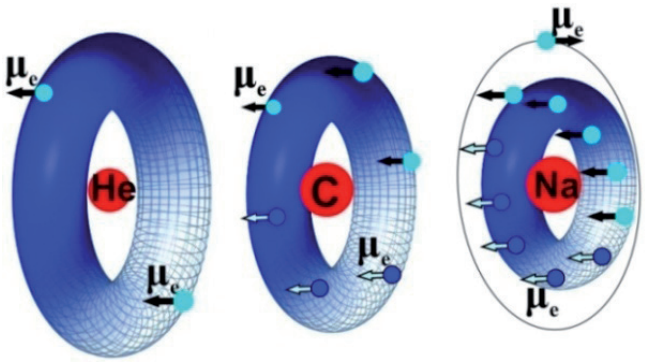



**Fig. 4.** *Examples of transatoms: helium, carbon, sodium.*

condensate. The magnetic moments of the electrons $\mu_e$ in the Bose condensate are directed in one direction, and they generate an ultrastrong directional, inhomogeneous and anisotropic magnetic field $B_S$ ~$10^5$–$10^{10}$ $T$ (1) inside and around the transatom [30].

The internal ultrastrong magnetic field $B_S^0$ that interacts with the magnetic spin and magnetic orbital moments of the nucleons in the nucleus, changes the structure of the nucleus, and turns it into a Transnucleus. In the transnucleus, protons and neutrons in pairs are in the state of nuclear orthobosons when the total spin of each pair is equal to unit $S$ = 1ħ. An intranuclear nucleon magnetic resonance occurs in the nucleus. It is important to note that due to the pairing of protons and neutrons into orthobosons, even-even nuclei with spin equal to zero $I$ = 0, starting with helium $^4$He [31], in an ultrastrong magnetic field acquire mechanical moments, which, apparently, must be either integer $I$ = 1ħ, 2ħ…

The transnucleus with the Bose-Einstein electron condensate surrounding it form a new state of matter: a spin nuclide electron condensate [31,32].

The external ultrastrong magnetic fields $B_S^R$ of transatoms attract them to each other. Electronic Bose condensates of two transatoms are combined into a common Bose condensate. A double transmolecule is formed from the transnuclei. Other transnuclei can join it. A Multinucleus Transmolecule {$X$} is formed, in which multinucleus reactions occur, including those that involve electron orthobosons. Thus, nuclear-electronic (strong-weak) reactions occur, which products are non-radioactive. Such reactions are called low-energy transmutation reactions. Low-energy nuclear reactions can occur with the formation of several nuclei in the output channel of the reaction. Atomic nuclei fly apart after such reactions are carried out. And, if they are not in a strong magnetic field, then the reaction products form ordinary nuclei and ordinary atoms.

### 2.3. Resonant interference exchange interaction

Transmutation reactions are carried out due to resonant interference exchange interaction (RIEX) [33].

A well-known exchange interaction occurs between identical objects: elementary particles, atoms, molecules. The nature of the exchange interaction is related to the indistinguishability of identical objects. The exchange interaction is manifested between identical particles 1 and 2, which are in states $a$ and $b$, when their wave functions $\psi_a(1)$ and $\psi_b(2)$ overlap (**Fig. 5**). The more the wave functions of identical particles overlap, the greater is the exchange interaction. The exchange interaction is characterized by the exchange energy, which is an additional contribution to the total energy of the system. This is expressed in the fact that the energy of interacting identical particles contains an additional interference term, which is not zero due to the identity of the particles. The contribution of the exchange energy to the total energy of the system can be both negative and positive.

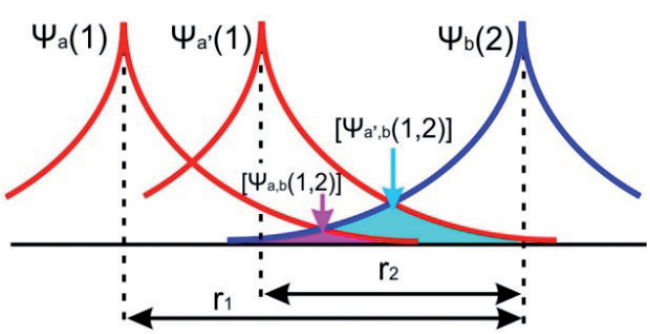



**Fig. 5.** *Overlap of wave functions of identical particles.*

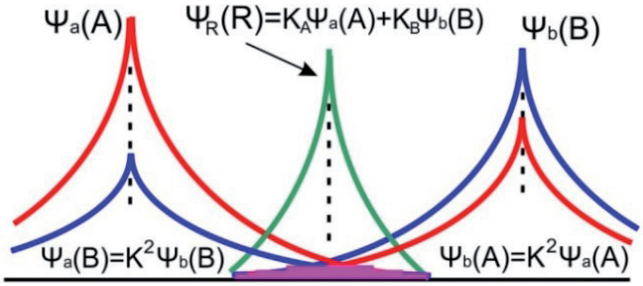



**Fig. 6.** *Overlap of wave functions of "identical" objects A and B during the formation of the R-state.*

It turned out that exchange interaction can occur between non-identical objects if these objects form a composite system that has resonant *R*-states $\psi_R(R)$ [33,34]. The nature of the RIEX-interaction is related to the overlapping and interference of the wave functions of objects in *R*-states. The wave functions of objects, including transnuclei A, B, C, interfere with each other, both in the R-state and "in each other" (**Fig. 6**). The wave functions of resonant *R*-states contain all wave functions of transnuclei A, B, C... Exactly, thanks to the wave functions of *R*-states, the transnuclei are simultaneously "in each other" through exchange interactions with each other. Fig. 6 demonstrates $K_A$ и $K_B$ as coefficients of the presence of wave functions $\psi_a(A)$ and $\psi_b(B)$ in the *R*-state, $K_2 \equiv K_A K_B$ is the generalized coefficient of similarity of the transnuclei A and B to each other.

The *R*-states are excited at the length of wave functions of the transuclei A, B, C... Thus, short-range strong and local weak interactions between transnuclei become "long-range" interactions. In the *R*-states, both the wave functions $\psi_a(A)$, $\psi_b(B)$, $\psi_c(C)$... of all transnuclei that make up the transmolecule, and all known interactions interfere: strong-weak, electromagnetic, inertial-gravitational [35], and also, obviously, still unknown interactions.

The transnuclei A, B, C... form a multinucleus transmolecule $\{X\}$ with its own energy level. Provided the number of nucleons is preserved, there are obviously many other transmolecules $\{Y\}$, $\{Z\}$,.., which consist of other transnuclei, but with their own energy levels. Due to the RIEX-interaction, exothermic, nuclear

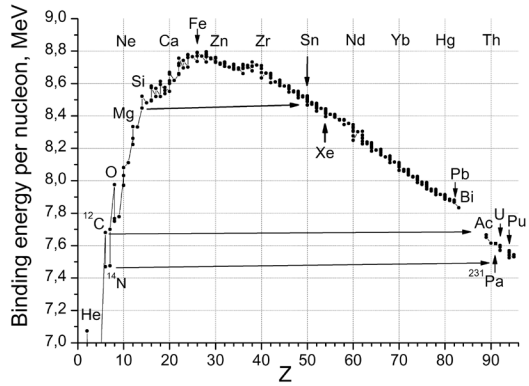



**Fig. 7.** *Coupling energy per nucleon in stable atomic nuclei.*

strong-weak transitions between the energy levels of transmolecules are carried out: $\{X\} \rightarrow \{Y\}$; $\{X\} \rightarrow \{Z\}$... The more these levels overlap, the greater is the probability of transitions between the levels of transmolecules.

In transmutation reactions, the transition to states in which atomic nuclei are nonradioactive is provided by a weak interaction involving electronic orthobosons, since the wave function of an electronic, orthoboson condensate significantly overlaps with the wave functions of transmolecules: $\{X\}$, $\{Y\}$, $\{Z\}$... The transmutation energy is released due to the difference in the nuclear binding energy of the isotopes involved in the reactions, just as in the case of fission of the uranium nucleus or in nuclear reactions of the synthesis of heavy nuclei up to iron from the nuclei of lighter elements (**Fig. 7**). Transmutation reactions can be represented as reactions of nucleon and multi-nucleon transfers between transnuclei [36] with the transformation of protons into neutrons and vice versa, as well as reactions of radiationless fusion and fission of transnuclei.

Thus, due to the RIEX-interaction, multinuclear, radiation-free and low-energy nuclear transmutation reactions occur.

## 3. IDENTICAL PARTICLES

The principle of identity states that it is experimentally impossible to distinguish identical particles. So, if two identical particles 1 and 2 are swapped or change their states *a* and *b*: $\psi_a(1)\psi_b(2) \rightarrow \psi_a(2)\psi_b(1)$, then the

result of the interaction between them will not change. Here $\psi_a(1)=[\psi_a(x_1,y_1,z_1)]S(1)$ and $\psi_b(2)=[\psi_b(x_2,y_2,z_2)]S(2)$ are wave functions of particles, which are the products of their coordinate parts $[\psi_{a,b}(x,y,z)]$ by their spin parts S(1) and S(2), and $\psi_a(1)\psi_b(2)$ and $\psi_a(2)\psi_b(1)$ are wave functions of two particles.

The result of the interaction will not change if the wave function of the particles is represented by a superposition of the wave functions of two states − the eigenstate $\psi_a(1)\psi_b(2)$ and the identical state $\psi_a(2)\psi_b(1)$:

$$\psi^{\pm}(1,2)=1/2\{\psi_a(1)\psi_b(2)\pm\psi_a(2)\psi_b(1)\}. \quad (3)$$

The plus sign in expression (3) describes bosons, i.e. particles with zero or integer spin, s = 0, 1ħ, 2ħ… The bosons obey Bose-Einstein $\psi^{+}(1,2)$ statistics, in which the sign of the wave function does not change when the particles are rearranged. The minus sign describes fermions, i.e. particles with a half-integer spin, s = ħ/2, 3ħ/2... The fermions obey Fermi-Dirac statistics, in which, when the particles are rearranged, the sign of the wave function $\psi^{-}(1,2)$ changes to the opposite sign. Our Visible Universe mainly consists of fermions with a spin s = ħ/2: electrons, protons, neutrons, neutrinos, and quanta of electromagnetic radiation with spin $s_\gamma$ = 1ħ.

The square of the wave function of particles is equal, by definition, to the probability density of their location at a given point in space and at a given time. If expression (3) is squared, then:

$$|\psi^{\pm}(1,2)|^2=1/4\{|\psi_a(1)\psi_b(2)|^2+|\psi_a(2)\psi_b(1)|^2\pm \pm[\psi_a^*(1)\psi_b^*(2)\psi_a(2)\psi_b(1)+\psi_a(1)\psi_b(2)\psi_a^*(2)\psi_b^*(1)]\}. \quad (4)$$

The first two terms in expression (4) are the probability of particles being in the ground state: eigenstate and identical state. The value in the square bracket is the probability of particles being in an exchange state when each particle is simultaneously in two states *a* and *b*.

"**Boson body**". The de Broglie length of the wave function of the particle $\lambda = h/mV$, where h is Planck's constant, $mV$ is the momentum of the particle: the product of its mass m by the velocity $V$. A hydrogen atom with a mass of 1 atomic mass unit at room temperature 300K has a wave function length $\lambda_H$ = 0.145 nm (the diameter of the hydrogen atom is 0.106 nm). The lower the velocity $V$ of a particle, the longer is the length of its wave function $\lambda$, the greater is the distance at which it interacts with other identical particles in an exchange manner.

If we equate the states *a* and *b*, then for the bosons $|\psi^{+}(1,2)|^2=|\psi_a(1)\psi_a(2)|^2$. Bosons can be in the same state, and thus they can form a Bose-Einstein condensate. Consequently, boson particles, boson atoms, boson molecules will be able to concentrate in one place and form a "boson body". With an increase in the mass of the "boson body" and its crystallization, when the bosons bind, the thermal velocity of the "boson body" decreases. Then, we obtain from thermodynamics $V=\sqrt{\frac{3kT}{N\cdot m}}\cdot\left(\frac{3}{2}kT=\frac{N\cdot m\cdot V^2}{2}\right)$, where $k$ is the Boltzmann constant, $T$ is the temperature, $N$ is the number of identical bosons of mass m in the "boson body". Consequently, the "boson body" reduces the velocity of bosons by $1/\sqrt{N}$ times, and increases the lengths of their wave functions $\lambda=\frac{h}{mV}=h\sqrt{\frac{N}{3kT\cdot m}}$ by $\sqrt{N}$ times. The force that attracts other identical bosons is proportional to the number of bosons $N$ that make up the "boson body". It will be recalled that one mole contains $6\cdot10^{23}$ particles. For this reason, the "boson body" will constantly increase its size by means of adding identical bosons to itself.

For fermions at *a* = *b*, $|\psi^{-}(1,2)|^2=0$ (4). Due to the Pauli principle, the fermions cannot be in the same state. But fermions can create boson molecules by combining with both identical and foreign fermions. These boson molecules, in turn, form a "boson body".

When particle 1 in state *a* tends to occupy state *b* of particle 2, $a \rightarrow b$, then the exchange part of the wave function (4) will compensate for its own and identical parts of the state of the two particles until the total wave function

becomes zero $|\psi^{-}(1,2)|^2 = 0$. The particles have disappeared! The particles have mutually annihilated each other without radiation and compensation of electric, baryon and lepton charges. If the reverse process is possible, then the Big Bang can be represented simply as the energy-free birth of pairs of electrons and pairs of protons, without the birth of antiparticles. The generation of exclusively electrons whose spins are antiparallel to magnetic moments and pulses may be related to the property of asymmetry of the Physical Vacuum. The Physical Vacuum generates only particles: electrons and protons, and does not generate antiparticles.

## 4. TRANSMUTATION REACTIONS WITHOUT THE COULOMB BARRIER

Since particles have masses, electric, baryonic, lepton charges, spins, spin magnetic moments, they participate in all fundamental interactions. In particular, identical particles participate in fundamental exchange interactions: exchange strong interaction [F] $-\psi_a^*(1)\psi_b^*(2)[F]\psi_a(2)\psi_b(1)$; exchange electromagnetic interaction [EM] $-\psi_a^*(1)\psi_b^*(2)[EM]\psi_a(2)\psi_b(1)$; exchange weak interaction [W] $-\psi_a^*(1)\psi_b^*(2)[W]\psi_a(2)\psi_b(1)$ and exchange inertial-gravitational interaction [IG] $-\psi_a^*(1)\psi_b^*(2)[IG]\psi_a(2)\psi_b(1)$.

The energy of interaction between particles 1 and 2 in perturbation theory is equal to:

$$E^{\pm}(1,2) = \frac{1}{N_{orm}}\int\{(|\psi_a(1)|^2(F,W,EM,IG)|\psi_b(2)|^2 + |\psi_b(1)|^2(F,W,EM,IG)|\psi_a(2)|^2)\}dV_1dV_2 \pm \pm\frac{2}{N_{orm}}\int[\psi_a^*(1)\psi_b^*(2)\{F,W,EM,IG\}\psi_a^*(2)\psi_b^*(1)]dV_1dV_2; \quad (5)$$

$$E^{\pm}(1,2) = C \pm E_C, \quad (6)$$

where $N_{orm}$ is the normalization integral, and $dV_1 = dx_1dy_1dz_1$, $dV_2 = dx_2dy_2dz_2$. The energy of interaction between particles that are in their own and identical states is the main energy – $C$. In addition, identical particles have an additional exchange energy – $Ec$, i.e. the third term in expression (5). If the distance between the particles is greater than the radius of the strong $F$ and weak $W$ interactions (> 1 fm), then the main energy $C$ has no strong and weak interactions in the first and second terms in (5)! If the states of two particles are equal $a = b$, then for the Coulomb and gravitational interactions, the main energy is equal to their exchange energy $C = Ec$. At the same time, if the formula (6) has a minus sign before the exchange energy $Ec$, then the exchange interaction completely compensates the main interaction $C$!

Thus, two identical particles in strong and ultrastrong magnetic fields, in which the coordinate part of their wave function is antisymmetric $n_b^1 = -n_b^2$ and $a = b$, Coulomb repulsion and gravitational attraction disappear. The paradox is realized: "The Waves extinguish the Wind." In this case, two fermions, for example: protons $p$, have parallel spins, and bosons, for example: deuterons $d$ ($S$ = 1ħ), have antiparallel spins. – The wave function of two bosons must be a symmetric function. Since the coordinate part of two bosons is an antisymmetric function, then the spin part must also be an antisymmetric function.

Two protons begin to oscillate near their nuclear orbitals in a hydrogen transmolecule in the ultrastrong magnetic field of electron orthobosons $B_S^0 \sim 3.5\cdot10^4$ $T$. And, thanks to the exchange interaction, they form a nuclear orthoboson (**Fig. 8**). The exchange Coulomb energy of protons completely compensates for the energy of their Coulomb repulsion.

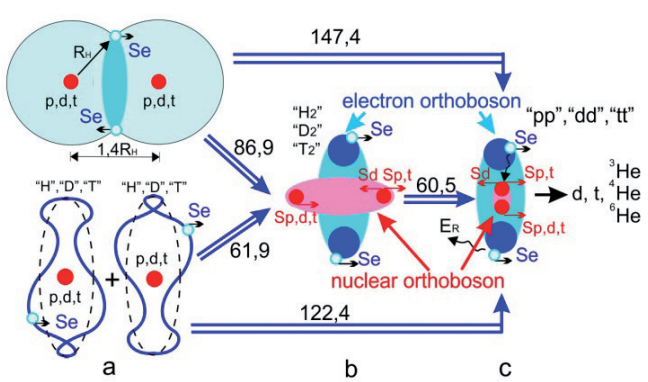



**Fig. 8.** *a –two hydrogen transatoms "H" in a strong magnetic field and a hydrogen molecule; b – the formation of hydrogen transmolecule "$H_2$"; c – thetransmolecule formation "pp" ("dd", "tt").*

This will lead to the convergence of protons up to nuclear distances, the formation of a transmolecule "*pp*", and to the beginning of a nuclear reaction without a Coulomb barrier involving an electron orthoboson $2e^-$ that has a binding energy 326.4 eV (Fig. 8):

$p + p + 2e^- \rightarrow d + \nu_e + e^- + 1.44\ MeV - 326.4\ eV.$

In this reaction, the neutrino spectrum is continuous, unlike the reaction:

$p + p + e^- \rightarrow d + \nu_e + 1.44\ MeV,$

for which the neutrino spectrum is monoenergetic [37].

In a strong magnetic field, hydrogen atoms and molecules are transformed into a transmolecule "*pp*" with a ground state of one electron of 163.2 eV. During the conversion process, vacuum ultraviolet light will be emitted (the numbers in **Fig. 8, 9** are given in eV; the double line is the radiation of two photons) [32]. Such emission lines were observed in the experiment of *R.* Mills [38] on ultraviolet spectroscopy of helium-hydrogen plasma. These lines were recorded during microwave discharge in a mixture of helium with 2% of hydrogen at room temperature and at pressures from 1 to 20 torr. They appear only in a mixture of helium and hydrogen, but are absent in pure helium or hydrogen and in mixtures of hydrogen with other noble gases. This is due to the fact that orthohelium is always generated in an ionized medium in which helium is present. Orthohelium itself has a strong magnetic field due to the parallelism of magnetic moments of the electrons. Calculation (1) shows that the magnetic field in the center of the orthohelium atom is ~ 410 *T,* and at its radius $R_2 = 8.76 \cdot 10^{-11}$ m the magnetic field is equal to ~ 70 *T*. As experiments show, the magnitude of such a field is sufficient to trigger transmutation reactions [14].

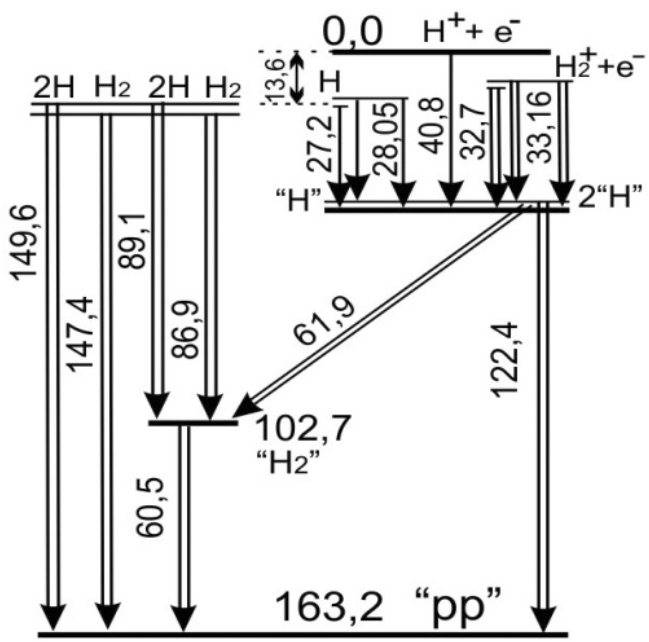



**Fig. 9.** *Scheme of electron transitions in the "pp" transmolecule in He + $H_2$ plasma.*

With the production of deuterium (*D-d*) and tritium (*T-t*), transmolecules "*dd*" and "*tt*" will be formed. They enter into nuclear reactions without the Coulomb barrier, including those with the participation of electron orthobosons. These reactions produce protons, neutrons, tritons, the nuclei $^3$He, $^4$He, $^6$He → $^6$Li (Fig. 8) [39]:

$$\begin{aligned} &d + d \rightarrow t + p + 4.03 MeV, \\ &d + d \rightarrow {}^3He + n + 3.26 MeV, \\ &t + t \rightarrow {}^4He + 2n + 11.3 MeV, \\ &d + d + 2e^- \rightarrow {}^4He + 2e^- + 23.85 MeV, \\ &t + t + 2e^- \rightarrow 2e^- + 12.3 MeV + \\ &+ {}^6He(\beta^-, T_{1/2} = 0.8\,c) \rightarrow \\ &\rightarrow {}^6Li + e^- + \tilde{\nu}_e + 3.5 MeV. \end{aligned} \qquad (7)$$

Helium formed as a result of the Big Bang (7 at.%), and helium produced in reactions (7), in strong magnetic fields, forms transmolecules of beryllium "Be".

Two isotopes of orthohelium $^3$He with the spin of the nucleus $I = \hbar/2$ form a transmolecule "$^6$Be" and a Coulomb-free nuclear reaction begins:

$^3$He + $^3$He → $^4$He + 2p + 12.86 MeV.

A paired Coulomb-free nuclear reaction for two isotopes of helium $^4$He is impossible, since the reaction energy balance is Q < 0. However, two orthohelium $^4$He form a stable

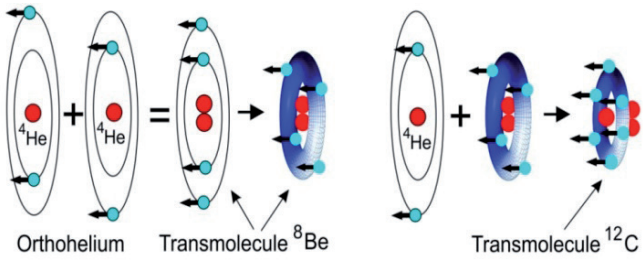



**Fig. 10.** *The formation of transmolecules "$^{8}$Be" (a) u "$^{12}$C".*

transmolecule of beryllium "$^{8}$Be" (**Fig. 10**). The radius of the transmolecule "$^{8}$Be" is equal to $R_{Be} = 4.4 \cdot 10^{-12}$ m, and magnetic fields: in the center $B_S^0$ (Be) = $5.4 \cdot 10^5$ *T* and at a distance of $1.2 \cdot R_{Be}$ from the center $B_S^R$ (Be) = $1.1 \cdot 10^5$ T [30]. The transmolecule "$^{8}$Be" attaches to itself another atom of orthohelium $^{4}$He, and forms a transmolecule of carbon "$^{12}$C". The transmolecule "$^{12}$C" is also stable because it consists of three $^{4}$He nuclei: two paired helium nuclei and one unpaired $^{4}$He. These nuclei cannot unite due to Coulomb repulsion between them. The radius of the transmolecule "$^{12}$C" $R_C = 3.0 \cdot 10^{-12}$ m, and the magnetic fields: in the center $B_S^0(C) = 2.6 \cdot 10^6$ T and at a distance of $1.2 \cdot R_C$ from the center $B_S^R(C) = 5.2 \cdot 10^5$ T.

Subsequently, orthohelium and transmolecules "$^{8}$Be", "$^{12}$C", due to their own ultrastrong magnetic fields, will be attracted to each other, and enter into exchange interaction with their electronic Bose condensates. As a result, multinuclear transmolecules $n \otimes {}^4_2He$ with helium Bose-Einstein condensate will be formed. The creation of such transmolecules leads to multinuclear transmutation reactions without a Coulomb barrier, with the emission of protons, neutrons, alpha particles and with the formation of heavy chemical elements with a nucleus charge $Z \geq 6$ (**Fig. 11**).

$$n \otimes {}^4_2He \rightarrow {}^{4n-1}_{2n-1}A + p + Q,$$

$$n \otimes {}^4_2He \rightarrow {}^{4n-1}_{2n}B + n + Q,$$

$$n \otimes {}^4_2He \rightarrow {}^{4(n-1)}_{2(n-1)}C + {}^4_2He + Q,$$

$$n \otimes {}^4_2He \rightarrow A + B + C + ... + Q,$$

where $Q$ is the energy released as a result of the reaction.

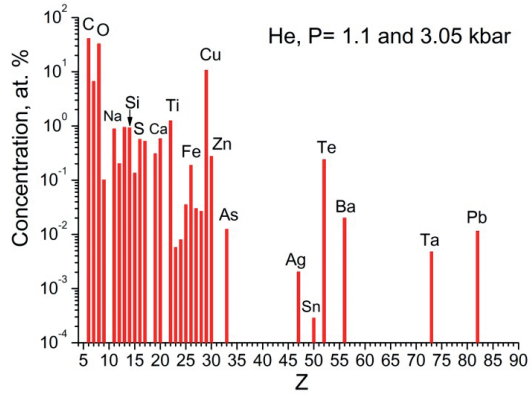



**Fig. 11.** *The element concentrations in two experiments with He.*

Fig. 11 shows the concentrations of chemical elements averaged over 28 measurements of different synthesized structures and microparticles and obtained in two experiments on irradiation with braking gamma rays with $E_{max}$ = 10 MeV of pure helium at pressures of 1.1 and 3.05 kbar. Both irradiations were carried out for 28 hours at an electron current that produces braking radiation, $(1.0\text{-}1.5) \cdot 10^{14}$ $c^{-1}$ [14-16,39,40]. Fig. 11 shows that chemical elements from carbon to lead are produced as a result of irradiation of helium.

Strikingly, similar spectra are obtained in experiments with pure hydrogen and pure deuterium. **Fig. 12** shows the concentrations of chemical elements averaged over 35 measurements and obtained in two experiments with pure hydrogen $H_2$ at pressures of 1 and

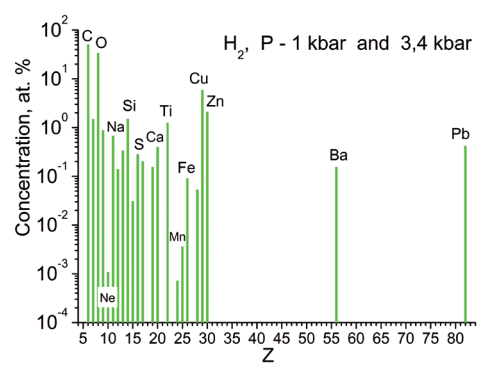



**Fig. 12.** *The element concentrations in two experiments with $H_2$.*

3.4 kbar [15, 40]. Irradiations were carried out for 14 and 62 hours, respectively, at electron current of $(1.2\text{-}1.5)\cdot10^{14}$ $s^{-1}$. **Fig. 13** shows the averaged concentrations of chemical elements obtained in an experiment on irradiating a chamber with deuterium at a pressure of 2.2 kbar [41]. Averaging was carried out over 42 measurements. Irradiation was carried out for 49 hours. The electron current was $(1.2\text{-}1.3)\cdot10^{14}$ $s^{-1}$. We can conclude from the presented results of the experiments that multinuclear reactions, such as in helium, also occur in hydrogen and in deuterium.

In all numerous transmutation experiments, a characteristic feature of the chemical element distributions is the constant presence of a group of light elements with $Z \leq 30$; the presence of a group of medium-mass elements with $30 < Z \leq 70$ and of a group of heavier elements with $Z > 70$. Let us note that the group of elements with $30< Z \leq 70$ is located in the tin region, and the group with $Z >70$ is centered around lead. Both of these chemical elements have "magic", closed shells for protons $Z = 50$ and $Z = 82$, and for lead and for neutrons $N = 126$.

Based on the assumption that the probability of production of new elements decreases with an increase in the number of nuclei in the input channel, it was concluded [39] that a group of elements up to chlorine $Z < 19$ is generated in multinuclear reactions between primary elements − elements of the initial medium. The production of chemical elements from chlorine to zinc ($Z = 30$) is apparently determined by secondary processes. In these processes, both atoms of primary elements and atoms of daughter chemical elements obtained in previous reactions participate in the multinuclear interactions. Elements that belong to other groups with $30 < Z \leq 70$ and with $Z > 70$ are synthesized in multinuclear reactions by daughter chemical elements, starting with carbon (Fig. 7). It is important to note that carbon is in the distribution maximum in the presented experiments.

Carbon is found in the maximum distributions in many other transmutation experiments, including three experiments on the irradiation with braking gamma-quanta of gaseous, pure xenon with $E_{max}$ = 10 MeV at pressures $P$ = 250, 270, 550 bar with an irradiation time of 43, 60 and 72 hours, respectively. **Fig. 14** shows the concentrations of chemical elements averaged over the results of 289 measurements of different structures and microparticles. The detection of radioactive elements in the samples was of particular interest: technetium $_{43}$Tc, francium $_{87}$Fr and actinium $_{89}$Ac [40]. The absence of possible generators in the same samples of such elements as molybdenum, radium, thorium suggests that $_{43}$Tc and $_{89}$Ac are synthesized in condensed xenon in transmutation reactions independently, like

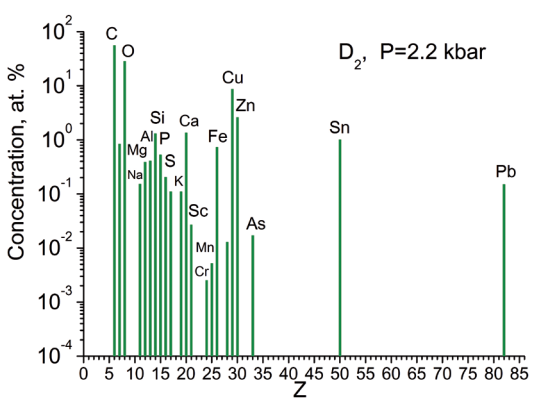



**Fig. 13.** *The element concentrations in experiment with $D_2$.*

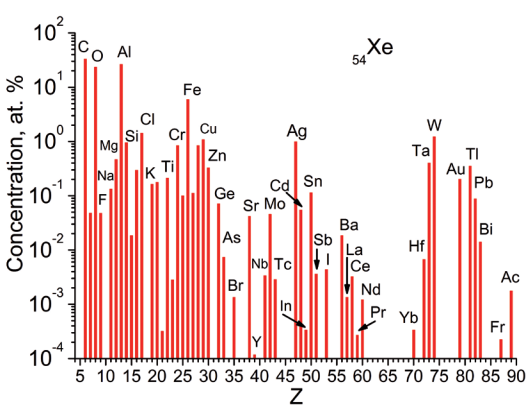



**Fig. 14.** *The element concentrations in experiments with $_{54}$Xe.*

other stable chemical elements. Francium $_{87}$Fr is the alpha decay product of actinium $_{89}$Ac.

It will be noted that transmutation reactions for identical nuclei occur with a larger cross-section compared to non-identical nuclei, since the former lack a Coulomb barrier. It follows from this that the atomic nuclei of identical chemical elements that make up the "boson body" enter more easily into transmutation reactions that lead to a change in the chemical composition of the media. This is important to know in the production of ultra-pure materials.

It clearly follows from the presented experimental results that not only subsequent light chemical elements, but also medium and heavy chemical elements can be synthesized in transmutation reactions in condensed matter that consist of the lightest elements, such as hydrogen, deuterium, helium.

It can be argued according to the results of all numerous experiments on transmutation that all chemical elements of the periodic table are produced in low-energy transmutation reactions (Fig. 14).

## 5. MULTINUCLEAR REACTIONS. UNIVERSAL DISTRIBUTION

Many atoms interact simultaneously during transmutation [11,42,43]

$$\sum_i c_i \, {}^{N_i}_{Z_i}A_i + e^- \sum_i c_i Z_i \rightarrow \sum_j c_j \, {}^{N_j}_{Z_j}B_j + e^- \sum_J c_J Z_J + \\ + l\nu(\tilde{\nu}) + Q,$$

where ${}^{N}_{Z}A$, ${}^{N}_{Z}B$ are nuclides with a charge $Z$ and a number of nucleons $N$; $c_i$, $c_j$ is a number of nuclides ${}^{N_i}_{Z_i}A$, ${}^{N_j}_{Z_j}B_j$ in the input and output reactions, respectively; $e^-$ are atomic electrons; $l\nu(\tilde{\nu}) - l$ – $l$-number of neutrinos and antineutrinos, number of weak transitions that change the charge of nuclides $Z$. Neutrinos and antineutrinos appear in the reaction equations to preserve the lepton charge. At the same time, the conditions for preserving the number of nucleons $\sum_i c_i N_i = \sum_j c_j N_j$, preserving the full charge $\sum_i c_i Z_i \pm l = \sum_j c_j Z_j$ and positive energy balance $Q \geq 0$ must be met. The conclusion about the possibilities of such reactions follows from the consideration of the picture of the binding energy per nucleon in the nuclei of the initial substance (Fig. 7).

It is obvious that if there is a set of chemical elements that transform into each other in the medium, then the quantitative relations between them should be displayed by a certain distribution.

Let's assume that conditions for transmutation processes are always available in the medium, and thus multiple transmutation processes are constantly carried out in it. At the initial stage of the development of transmutation processes, when the number of atoms of the initial, primary chemical elements prevails over the number of atoms of the daughter elements, the nuclide distribution of transmutation products will contain elements from carbon to zinc. The nuclide distribution here should be understood as the distribution of stable nuclides. The distribution of nuclides will begin to change significantly only when the number of daughter atoms increases so much that they begin to enter into transmutation reactions with each other with a greater probability than with the atoms of the original substance. Atomic nuclei of all chemical elements will appear in the products of transmutation. Eventually, multiple, multinuclear transmutation processes will lead to a situation where the number of primary atoms will be comparable or less than the number of atoms of the daughter elements. By this time, the mutual conversion of chemical elements into each other will lead to a certain, quasi-equilibrium distribution.

The distribution would be in equilibrium if the transmutation reactions proceeded without loss of energy. And it is known from statistical physics and thermodynamics that, in a closed system, irreversible processes inevitably end with its transition to an equilibrium state [44]. We have allowed ourselves to apply the laws

of statistical physics and thermodynamics to the transmutation processes on the grounds that transmutation can be represented not as an exchange of energy between particles, but as an exchange between nuclides of portions of nucleons ($E = mc^2$), albeit in a multiparticle interaction. All possible sets of a limited number of stable nuclides can be used as a statistical ensemble.

The energy distribution $E$ for colliding atoms of a gas at temperature $T$ is described by the Maxwell distribution in statistical physics: $f_E = \frac{2\pi}{\sqrt{(\pi kT)^3}}\sqrt{E}\exp\left(-\frac{E}{kT}\right)$. We replace, for transmutation processes, the energy in the Maxwell distribution by the masses of isotopes $M_A$ or by the mass numbers of isotopes $A$: $E \to A$, and $kT$ by the number $G$ that characterize the transmutation process: $kT \to 2G$:

$$f_A = \frac{C}{\sqrt{(2G)^3}}\sqrt{A}\exp\left(-\frac{A}{2G}\right), \quad (8)$$

where $C$ is the normalization coefficient. As the temperature of the system $T$ is a collective parameter of its constituent particles, so the number $G$ determines the collective *energy content* of the system [45]. The greater the energy content of the system, the greater is the $G$ coefficient. The energy content coefficient of a system depends on the total binding energy of its constituent nuclei $G(\varepsilon)$ and it has a maximum value for a system that consists of hydrogen atoms whose binding energy is zero $\varepsilon = 0$. The energy content coefficient is zero $G = 0$ for a system that consists of iron and nickel isotope atoms with a maximum binding energy per nucleon: $^{56}$Fe -8.790MeV, $^{58}$Fe -8.792MeV and $^{62}$Ni -8.794MeV (Fig. 7). The value of the energy content coefficient $G$ of the hydrogen system, apparently, should be determined experimentally. The mass number A varies from 1 to 250, from hydrogen to the isotope californium-250 in the "thermodynamic" distributions that corresponds to formula (8), in **Fig. 15**. The energy content coefficient $G$ in Fig. 15 has three randomly selected values $G = 8$, 12 and 24. These values correspond in the distributions to the maximum values of the mass number Amax, which determines the physical meaning of the coefficient $G$.

In addition, the energy content coefficient of the system $G(\varepsilon,\xi)$ depends on another, independent parameter – on the energy density of a weakly excited medium $\xi$, on its ionization. The energy density of the medium determines how many atoms can simultaneously participate in the transmutation reaction. Thus, the energy content coefficient of the system $G(\varepsilon,\xi) = G(\varepsilon)\cdot G(\xi)$ depends on the internal value – the intranuclear energy and on the external value – the energy density of the medium.

In our case, the transmutation processes are indeed irreversible, but they are carried out in an open system, with the loss of internal energy of the atomic nuclei of the medium during transmutation (it will be recalled: the energy during transmutation is released due to a defect in the masses of isotopes). The loss of energy during transmutation reduces the coefficient of its energy content in the system $G$. It should be

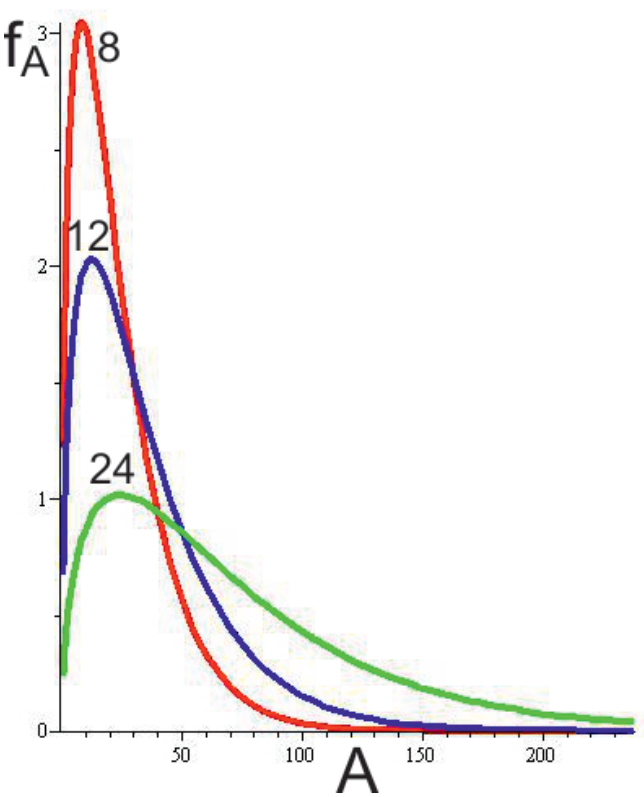



**Fig. 15.** *"Thermodynamic" mass number distributions A for transmutation processes.*

noted that the lost internal energy is converted into kinetic energy of nuclides, thereby increasing the external energy density of the medium ξ. Part of the internal energy is carried away by neutrinos. In part, the internal energy losses will be compensated by the participation of atoms of the initial substance in the reactions, until the moment when the number of the latter decreases to the level of daughter nuclides. In addition, the calculated energy losses of 0.1-10 MeV per one reaction [43] are significantly less than the mass of the reacting nuclides (>> 1 GeV). Thus, multiple transmutation processes are carried out in a quasi-constant medium that slowly decreases in energy and mass. For this reason, the resulting distribution will be quasi-equilibrium. The distribution, conditionally, will change from the distribution described by the line with $A_{max}$ = 24 in Fig. 15 to the distribution described by the line with $A_{max}$ = 12, and further to the distribution described by the line with $A_{max}$ = 8. It should be emphasized that the distributions shown in Fig. 15, do not take into account differences in binding energies per nucleon in stable atomic nuclei, which are shown in Fig. 7.

If the transmutation process takes place without loss of energy, then the final nuclide distribution would be in equilibrium. In addition, if the binding energy per nucleon were the same for all elements, then the equilibrium distribution would be the same, i.e. it would not depend on the initial elemental composition of the substance in which the transmutation processes began. Such a distribution would characterize the process of transmutation as if in a "pure" form. Such a "universal" distribution will be obtained when the transmutation process begins in a hydrogen medium and ends when the chemical elements iron-nickel are in "equilibrium" with other chemical elements.

Obviously, with the implementation of universal distribution, the process of transmutation will not stop. It will lead, due to the constant release of energy, to the beginning of the predominance of iron and nickel in the distribution as nuclides with maximum binding energy (Fig. 7). Thus, the isotopes $^{56}$Fe, $^{58}$Fe, $^{62}$Ni fall out of "equilibrium" with other chemical elements (**Fig. 16**). If, at the same time, the energy content coefficient of the system $G(\varepsilon,\xi)$ remains unchanged $G(\varepsilon,\xi)$ = const without taking into account Fe-Ni falling out of "equilibrium", then the nuclide distribution will remain universal with $A_{max}$ = const. With a decrease in the energy content coefficient $G(\varepsilon,\xi)$, the "universal" distribution will change, as a quasi-equilibrium, from the line with $A_{max}$ = 24 to the distribution described by the line with $A_{max}$ = 8 (Fig. 16). The transmutation process ends when the isotopes $^{56,58}$Fe, $^{62}$Ni with the maximum binding energy per nucleon become significantly greater than other elements. That is why the frozen core of the Earth has an iron-nickel composition, and it constantly increases its size due to transmutation reactions outside the core.

We drew, during processing and analyzing experimental data, attention to the increased yield of some groups of elements in transmutation products. These groups include: Na-Si, K-Ca, Mn-Ni, Cu-Zn, Zr-Mo, Ag-Sb, Ta-W, Pb. We obtained a similar

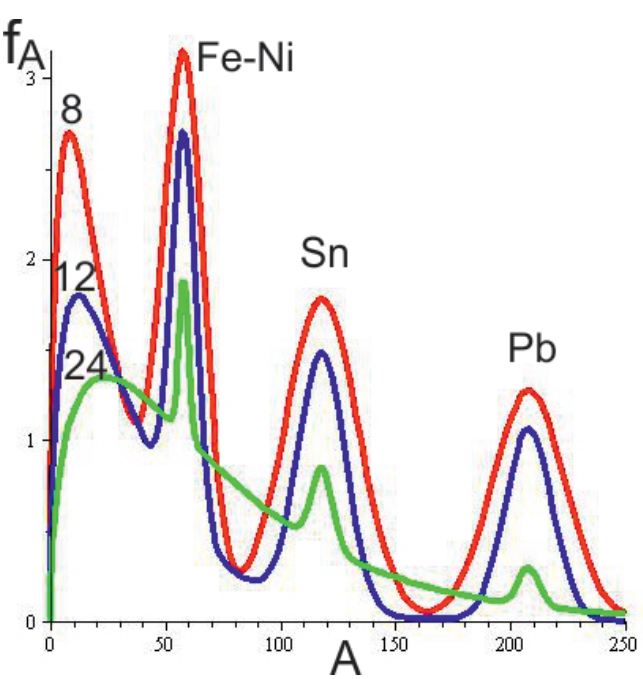



**Fig. 16.** *Quasi-equilibrium, universal distributions with Fe-Ni, Sn and Pb maxima.*

picture when calculating the appearance of elements, with the participation of *N*-molecules of water (**Fig. 17**) and other elements in the transmutation process [43,44]. Fig. 17 shows, for clarity, in order to avoid sharp even-odd fluctuations, the appearance of even-charged elements is presented. It is quite obvious that the increased probability of the appearance of these elements in the products of transmutation is associated with their proximity to the maxima depending on the binding energy of nucleons in nuclei on the atomic number and the number of isotopes of these elements. These maxima are known to be caused by "magic" nuclear shells with the number of protons and neutrons equal to: 2, 8, 20, 28, 50, 82, 126. Indeed, under equal initial conditions in the input channel, the presence of "magic" nuclides in the final spectrum increases the number of combinations of other nuclides in the output channel. A large number of isotopes in a particular element increases the probability of its occurrence purely statistically. Thus, the universal distribution, in addition to the Fe-Ni maximum, will contain peaks caused by "magic" nuclear shells, for example: tin $_{50}$Sn, lead $_{82}$Pb$^{126}$ (Fig. 16).

Note that distributions in Fig. 15 and 16 extend to elements such as thorium, uranium and further to transuranic and superheavy

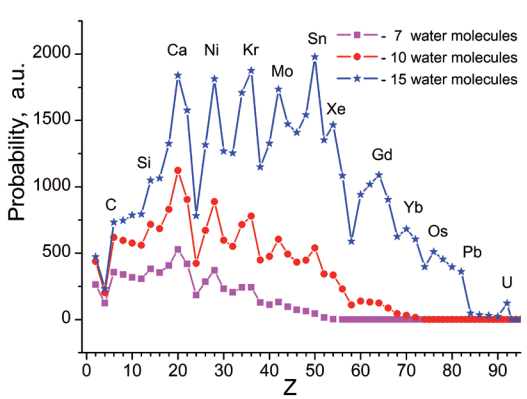



**Fig. 17.** *Calculation of yield of even-charge elements, at participation in transmutation process of 7, 10 and 15 – molecules of water.*

elements. Thus, protactinium $^{231}_{91}Pa$ ($T_{1/2} = 3 \cdot 10^4$ years) was detected in experiments on irradiation with gamma quanta of hydrogen in the presence of palladium in the *X*-ray spectra of reaction products, along with elements such as barium $_{54}$Ba and lead $_{82}$Pb [15].

Consequently, in any matter, regardless of its chemical composition, in which long, multiple transmutation processes occur, a quasi-equilibrium, universal distribution will be realized in its products, defined by expression (8). In addition, maxima associated with the peculiarities of energy dependence will be superimposed on the universal distribution, to varying degrees of intensity connections of nuclides from the mass number. At the same time, the intensity of the Fe-Ni maximum depends both on the duration of the transmutation process and on the chemical composition of the medium in which this process began.

## 6. NATURAL NUCLEOSYNTHESIS

To convert atoms of some chemical elements into atoms of other chemical elements in ionized condensed matter, their presence in strong magnetic fields $B > 30$ *T* is necessary. Magnetic fields are known to be extremely widespread in cosmic plasma: in stars and in the interstellar medium. They manifest themselves in the active regions of stellar and galactic clusters. Magnetic fields cause the pumping of energy into cosmic rays, radio emission, anomalous optical and *X*-ray radiation observed in the active zones of the Universe. Magnetic fields are always accompanied by fast, charged particles, including electrons. As mentioned above, free electrons with a density of $\rho > 10^{21}$ el/cm$^3$, with their unidirectional motion, create strong, and subsequently, due to atomic electron orthobosons, ultrastrong magnetic fields. Thus, the symbiosis of electrons and magnetic fields moving in the cosmic plasma creates conditions for the implementation of low-energy transmutation reactions in all corners of the Universe.

The Universe passes several stages in its development.

When the age of the Universe was $10^{-6} \div 1$ sec, and the temperature was $10^{10} \div 10^{12}$ K, the quark-gluon plasma was in the process of cooling, and electrons, protons and other hadrons were formed. In the era of nuclear fusion, the first lightest nuclei, deuterium and helium, began to be synthesized at the temperatures of the Universe $10^{7} \div 10^{9}$ K and the age of $10 \div 1000$ sec.

After 380000 years, the era of Recombination came in the Universe, when its temperature decreased to ~ 4000 K, and electrons, protons and alpha particles began to form the first neutral hydrogen and helium atoms. At the same time, the Universe entered the stage of Natural nucleosynthesis, which continues to this day.

With the appearance of the first hydrogen, helium atoms and the available free electrons flying away from the center of the Universe, conditions arose for the generation of strong magnetic fields, of the transformation of atoms into transatoms and for the launch of transmutation reactions. In the multinuclear hydrogen and helium transmutation reactions, first of all, chemical elements from carbon to chlorine were synthesized with the maximum operating time of carbon, oxygen, nitrogen (*C, O, N*) (Fig. 11-13). Simultaneously produced chemical elements began to form "boson bodies", namely: organic clusters, in which the chemical synthesis of organic molecules, and, subsequently, biochemical molecules, started with the participation of hydrogen. So, recently a group of scientists identified chemical reactions that could lead to the appearance of life [46]. These chemical reactions occur with the participation of only four chemical elements, which form: ketoacids (derivatives of hydrocarbons that contain *C=O* and *COOH* groups), *HCN* cyanide, ammonia $NH_3$ and carbon dioxide $CO_2$, and the products are aminoacids and nucleic acids − building blocks for proteins and DNA.

In parallel, chemical elements from argon to zinc were being produced in transmutation reactions, and later all other, heavier chemical elements.

Thus, organic and biological planets could already be formed from "boson bodies" in the Universe aged more than 10 million years. Primitive organic life must have appeared obligatory on these organic planets first, and intelligent life must have developed later [47]. It is difficult to imagine the possibilities of a Supreme Intelligence aged more than 12 billion years.

The first stars and galaxies began to be formed after $0.15 \div 1$ billion years of the Universe's development. Low-energy transmutation reactions similar to those carried out in the epoch of Recombination were started againat this stage, when the density of matter and the directional movement of free electrons reaches values sufficient for the generation of magnetic fields and the pairing of electrons in them. The epoch of Stars differs from the epoch of Recombination by the fact that its isotopic composition already contains all chemical elements. The involvement of the transmutation mechanism in nucleosynthesis makes it easy to understand the metallicity of stars and the presence of heavy elements even in the oldest stars, which elemental composition is not associated with supernova explosions, since the synthesis of all elements and their isotopes up to uranium becomes obvious. Thus, the "old" and "new" chemical elements produced in the atmospheres of stars and carried away by the stellar wind participate in the formation of planets.

## 7. PLANETARY NUCLEOSYNTHESIS

Taking into account that the processes of low-energy transmutation take place under fairly "soft" physical conditions and tend to reproduce a quasi-equilibrium universal distribution, the following conclusion can be drawn from the presented material: the process of nucleosynthesis

can be carried out on planets and form their elemental composition [42,43,48-50].

The process of transmutation on the emerging Earth began, apparently, when it was a dense, gas, plasma formation. Now, transmutation processes continue in the magma of the Earth, and the colossal energy released at the same time is observed by us like a volcanic eruption. Experts know that intraplate tectonic activity and volcanism cannot be explained within the framework of plate tectonics. The most common hypothesis that satisfactorily explains volcanism and tectonic activity inside both the oceanic and continental lithosphere is associated with the idea of hot spots and mantle plumes [51]. It is possible that transmutation processes are taking place in these hot spots and mantle plumes.

The fact that nucleosynthesis is determined by transmutation reactions is confirmed by experimental results. So, if we compare the isotope ratios in transmutation products after industrial, electronic melting of zirconium ingots in a vacuum furnace [7] with natural isotope ratios (**Table**) then, on the one hand, their significant difference is striking, for example: for potassium, chromium, copper, zinc, germanium and barium. These elements are highlighted with asterisks (*) in the Table. This circumstance speaks in favor of the existence of the phenomenon of transmutation. On the other hand, there is a fairly good agreement of isotopic ratios of remaining elements with natural, terrestrial elements [42,43]. The difference noted above in isotopic ratios for these elements (K, Cr, Cu, Zn, Ge, Ba) can be explained by the incompleteness of transmutation processes and, as a consequence, the dependence of distributions, including isotopic distributions, on the source element, in this case, on zirconium. The fact that the elements that are products of zirconium transmutation have, in part, a natural, terrestrial isotopic ratio led to the idea of comparing the distribution by mass numbers resulting from the melting of zirconium with the

**Table 1**

Comparison of natural isotope ratio (Nat.,%) with isotope ratio observed in zirconium transmutation products (Zr, %) [7,42].

| Z | A | ТЦ | Ест. | Z | A | ТЦ | Ест. |
|---|---|---|---|---|---|---|---|
| $_{3}$Li | 6 | 6 | 7.5 | $_{31}$Ga | 69 | 66 | 60 |
| | 7 | 94 | 92.5 | | 71 | 34 | 40 |
| $_{5}$B | 10 | 78 | 74 | **$_{32}$Ge*** | **70** | **73** | **20** |
| | 11 | 22 | 26 | | **72** | **12** | **27** |
| $_{12}$Mg | 24 | 76 | 79 | | **73** | **15** | **8** |
| | 25 | 11 | 10 | | **74** | **2** | **36** |
| | 26 | 13 | 11 | $_{34}$Se | 77 | 15 | 7.6 |
| $_{14}$Si | 28 | 89 | 92.2 | | 78 | 16 | 23.5 |
| | 29 | 7 | 4.7 | | 80 | 54 | 44.6 |
| | 30 | 4 | 3.1 | | 82 | 6 | 9.4 |
| **$_{19}$K*** | **39** | **76** | **93** | $_{38}$Sr | 86 | 24 | 10 |
| | **41** | **24** | **7** | | 87 | 7 | 7 |
| $_{22}$Ti | 46 | 8 | 8.2 | | 88 | 69 | 83 |
| | 47 | 8 | 7.4 | **$_{54}$Ba*** | **132** | **11** | **0.1** |
| | 48 | 74 | 73.8 | | **134** | **29** | **2.4** |
| | 49 | 5 | 5.4 | | **135** | **11** | **6.6** |
| | 50 | 5 | 5.2 | | **136** | **9** | **7.8** |
| **$_{24}$Cr*** | **52** | **70** | **83.8** | | **137** | **9** | **11.2** |
| | **53** | **16** | **9.5** | | **138** | **29** | **71.7** |
| | **54** | **14** | **2.4** | $_{63}$Eu | 151 | 56 | 48 |
| **$_{29}$Cu*** | **63** | **48** | **69.2** | | 153 | 44 | 52 |
| | **65** | **52** | **30.8** | | | | |
| **$_{30}$Zn*** | **64** | **49** | **48.6** | | | | |
| | **66** | **17** | **27.9** | | | | |
| | **67** | **14** | **4.1** | | | | |
| | **68** | **20** | **18.8** | | | | |

prevalence of elements by mass in the Earth's crust. **Fig. 18** shows that the distributions are generally similar to each other. Moreover, there is a correlation between groups of elements in

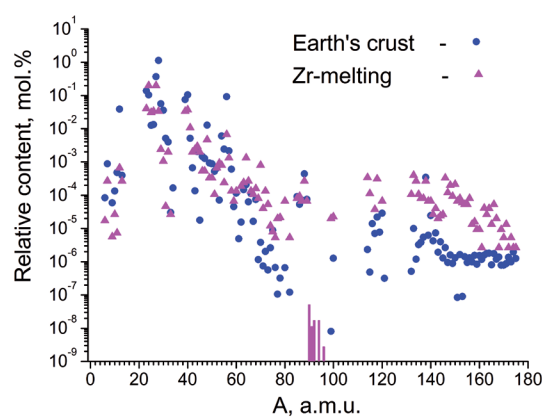



**Fig. 18.** *Comparison of element distribution in case of zirconium transmutation at its melting with element occurrence in the Earth's crust. For orientation, zirconium isotopes with their relative content are emphasized with bold lines* [7,42].

the distributions. The same elements (Ti, Fe) and groups of elements (Na-Si, K-Ca, Ti, Fe, Cu-Zn, Cd-Sb) have maxima in both distributions. Some difference in the distributions compared is due to the incompleteness of the transmutation processes for the case of zirconium melting and the dependence of the distribution on this element. Indeed, the realization of the universal distribution in the case of zirconium transmutation was carried out on the part of heavy masses ($M_{Zr}$ 90 ÷ 96) relative to the estimated maximum distribution in the Mg-Si region ($M$ – 24 ÷ 30).Therefore, heavy masses prevail in the distribution of nuclides during the melting of zirconium, in comparison with the Terrestrial distribution, approximately, from $M$ = 60 to $M$ = 175. These masses are obtained directly from the initial element zirconium. At the same time, the content of light masses has been reduced; approximately, from $M$ = 6 to $M$ = 30. It is known that the synthesis of elements in the Universe begins with hydrogen and helium. And the synthesis of elements on planets starts, including hydrogen and helium, with heavier elements, starting with carbon, nitrogen, oxygen and others.

It is of interest to compare the distribution of elements in the Earth's crust, as a function of the lower concentration level, with the appearance of elements in time during ultrasonic cavitation [13,49] (**Fig. 19, 20**). It should be emphasized once again that a group of light elements from carbon to zinc always appears in all transmutation experiments, regardless of the environment in which this process takes place. Subsequently, first of all, chemical elements of medium masses are synthesized, located around tin-antimony (Sn-Sb), and chemical elements with a heavy mass of lead-bismuth (Pb-Bi). Then all other chemical elements are produced.

An unexpected event in physics is the discovery of two radioactive isotopes in samples

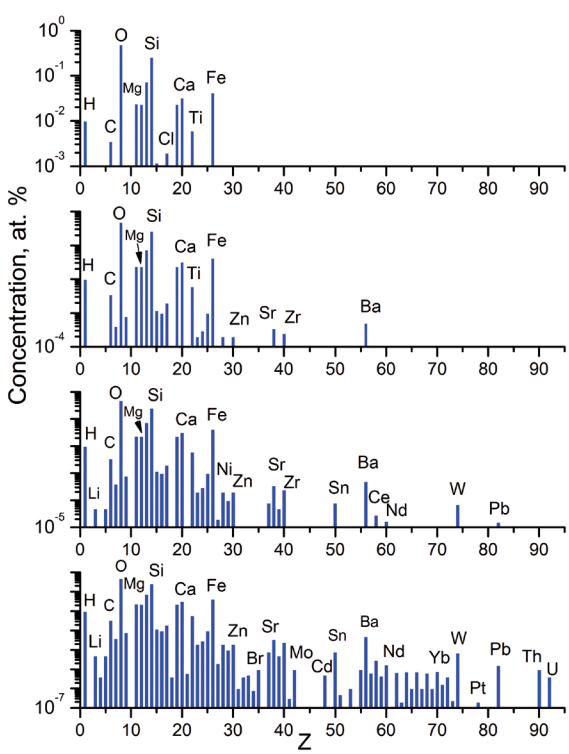



**Fig. 19.** *The occurrence of elements in the Earth's crust as a function of the lower concentration level.*

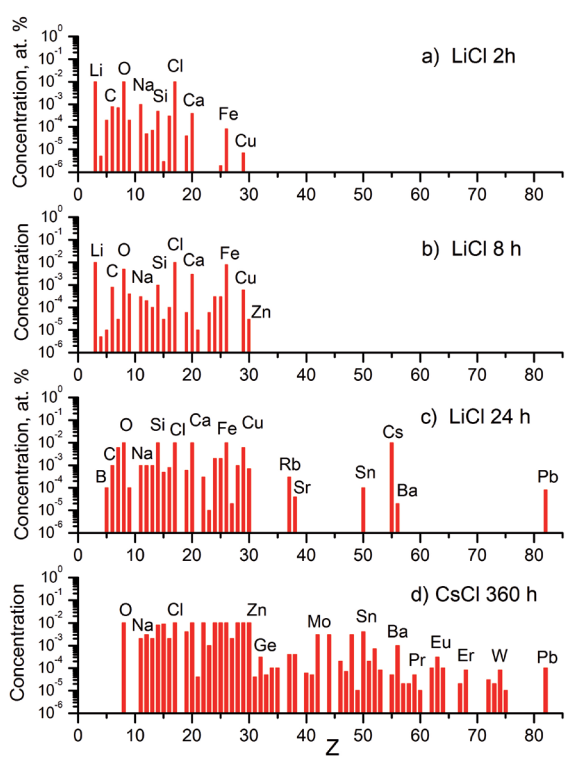



**Fig. 20.** *Ultrasonic solution cavitation LiCl and CsCl* [13,42].

of deep-sea crust that rose from a height of 1500 meters below the Pacific Ocean [52]. These isotopes $_{26}$Fe-60 ($T_{1/2} = 1.5 \cdot 10^5$ years) and $_{94}$Pu-244 ($T_{1/2} = 8 \cdot 10^7$ years) should have decayed long ago, since the age of the Earth is 4.54 billion years ($4.54 \cdot 10^9$ years). Based on the idea of planetary nucleosynthesis, it can be assumed that these isotopes appeared on Earth as a result of low-energy nuclear reactions.

As already mentioned, transmutation reactions occur in ionized condensed matter, mainly in solutions and in melts, when a stream of electrons flows through them. The flow of high-density electrons creates a strong magnetic field sufficient to transform atoms into transatoms and, consequently, they trigger transmutation reactions, i.e. nucleosynthesis. Transmutation reactions that occur in the Earth's mantle stimulate its geological activity.

Therefore, changing Galactic electric, magnetic and even gravitational fields can stimulate transmutation processes on the Earth, both directly interacting with it and indirectly, thanks to the Sun. Because the changes that take place on the Sun, through the Sun-Earth interaction, lead to changes on the Earth. Based on this assumption, we formulated a new doctrine of the geological development of the Earth [49].

1. The geological development of the Earth is a monotonous, evolutionary process, which is superimposed with revolutionary, discontinuous periods.

2. The evolutionary process is determined by internal energy sources: low-energy nuclear reactions, radioactive decays, gravitational compression, etc. Since the energy coming from internal sources is monotonously decreasing, geological processes are monotonously slowing down.

3. Abrupt, including cyclical periods in the development of the Earth are generated by external energy sources that stimulate internal energy sources, geological processes accelerate, sometimes in a revolutionary way, during these periods.

4. External energy sources are the Sun, jet streams of energy and matter from the Galaxy. Perhaps there are other, external energy sources available. Galactic energy sources can influence the Earth directly or indirectly, through the Sun.

The present concept is based on the concept of open systems both in relation to the Earth and the solar system, and in relation to the Galaxy. Therefore, this concept is not centrist. All energy sources operate in it simultaneously, with varying degrees of intensity.

According to a new study published in the journal Geoscience Frontiers [53], geological activity on Earth has a well-traced cycle of approximately 27.5 million years. Previously, it was believed that geological events are random. But the analysis of geological events over the past 260 million years has shown that, in fact, there is a strict cyclicity in geological activity. **Fig. 21** presents the results of the analysis of 89 geological events using a 10 million-year sliding window centered every 0.5 million years. The number of events that fell into the sliding window was calculated with an interval of 1 million years. Ten peaks, or clusters of events, are surely visible. That analysis was carried out due to significant improvements in radioisotope dating methods and in methods of measuring time according to geological scale.

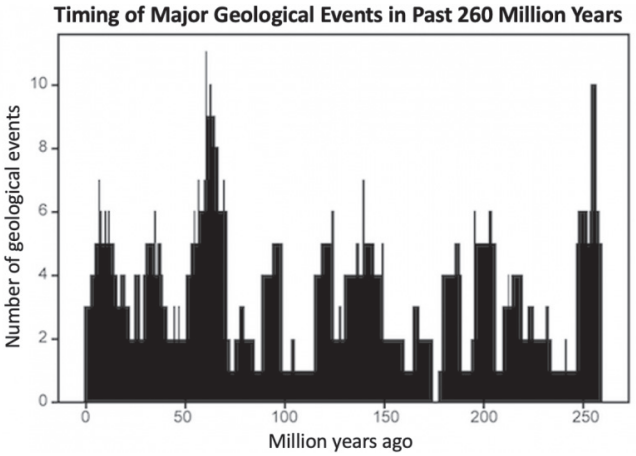



**Fig. 21.** *The cyclicity of the geological activity of the Earth* [53].

The last cluster of geological events occurred approximately 7 million years ago. This suggests and hopes that the next major, catastrophic geological activity will begin in more than 20 million years.

The availability of cyclical fluctuations ingeological activity of the Earth is a serious deviation from generally accepted views. However, the observed cyclicity fits perfectly into the above-mentioned new doctrine of the geological development of the Earth. The duration of the galactic year is, according to various estimates, from 180 to 250 million years. The Sun and its planets periodically, four times in a galactic year, approximately every 60 million years, are believed to intersect visible jet streams of matter and energy ejected from the center of the Galactic disk [12,54]. If the cycle of geological activity on Earth equal to 27.5 million is connected with galactic energy flows, then four additional, invisible energy flows located between the visible flows are assumed to exist. Based on these considerations and on a cycle of 27.5 million years, the Galactic Year will be equal to 220 million years.

Scientists have called the cycle of 27.5 million years as "pulse" of the Earth. It is obvious that the "pulse" of the Earth is set by the rhythm of the energetic "heartbeat" of our Galaxy. An interesting task for planetary science and astronomy is the registration the invisible energy flows of the Galaxy and detection of their effects on stars and other planets.

## 8. CONCLUSION

The paper demonstrated that in a quasi-neutral plasma, the directed, collective motion of electrons creates a magnetic field. At electron density $>10^{21}$ cm$^{-3}$, the magnetic field generates a Coulomb exchange field, which causes the pairing of free electrons into orthobosons $S$ = 1h. Such orthobosons create strong magnetic fields >30 $T$, in which atoms turn into transatoms. Transatoms have ultrastrong magnetic fields in the range of $10^5$-$10^{10}$ $T$. Due to this mechanism, the existence of strong and ultrastrong magnetic fields in cosmic plasma is explained.

The ultrastrong magnetic fields of transatoms combine them into nuclear transmolecules, in which, due to resonant interference exchange interaction, multinuclear reactions occur. Multinuclear transmutation reactions can be considered as a multinucleon exchange between arbitrary transnuclei. Transmutation reactions that continuously occur in a condensed matter lead to quasi-equilibrium mass-number distributions of isotopes – the reaction products. These quasi-equilibrium distributions reflect the abundance of chemical elements and their isotopes in different objects and regions of the Universe.

In transmutation reactions, nuclear physics has moved from describing resonant transitions in individual nuclei (in individual atoms, molecules) and from describing the interaction between two nuclei to collective nuclide interactions. Moreover, these collective transnuclide interactions through resonant interference exchange interactions simultaneously include all currently known interactions: strong-weak, electromagnetic and inertial-gravitational interactions.

The RIEX-interaction is a universal interaction, because it not only unites all fundamental interactions, but also because its influence extends to the whole of Nature, from elementary particles to complex biological and social systems.

Proceeding from the idea of planetary nucleosynthesis based on the mechanism of multinuclear quantum transitions of some atomic nuclei into others, we formulated a new doctrine of geological development of Earth that caused a creation of a new scientific discipline – Quantum Planetology (Geology) [48-50]. Within the framework of quantum geology, the strict temporal cyclicity observed in the geological activity of the Earth has found its explanation. This cyclicity made it possible to more accurately determine the value of the Galactic year equal to 220 million years.

The synthesis of chemical elements in transmutation reactions and resonant interference exchange interaction already in the era of Recombination triggered first organic chemical reactions, and after the formation of "boson bodies" − biochemical reactions. Already at this stage, the Universe has generated biological and intelligent life on the formed organic and biological planets.

It clearly follows from the above that low-energy transmutation reactions are a natural mechanism for obtaining energy in stars and on planets, in the production of all chemical elements heavier than helium and in the origin of life at different stages of the development of the Universe, stars and planets.

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