Towards a New Paradigm
Gennady V. Mishinsky

Joint Institute for Nuclear Research, http://www.jinr.ru/
Dubna 141980, Moscow Region, Russian Federation
E-mail: mysh@jinr.ru

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Abstract: The discoveries of new low-energy nuclear reactions and a new resonant interference exchange interaction explaining the course of these reactions give grounds to assert that a necessary and inevitable process of changing the paradigm is currently taking place.

Keywords: low-energy nuclear reactions, resonant interference exchange interaction, transatoms and transmolecules, history of science, resonant technology, noosphere, evolution, ecology

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INTRODUCTION
In 1896, A. Becquerel discovered the natural radioactivity of uranium salts. Two years later, E. Rutherford and P. Villard showed that radioactive rays are composed of alpha, beta and gamma radiation. And in 1903, E. Rutherford and F. Soddy put forward a hypothesis about the transformation of chemical elements in the process of their radioactive decay. The nuclear nature of radioactivity was understood by Rutherford after he proposed a nuclear model of the atom in 1911 and came to the conclusion that radioactive radiation arises from nuclear processes that occur inside the atomic nucleus. In 1934, this conclusion was confirmed by the discovery, by the spouses Irene and Frederic Joliot-Curie, of artificial radioactivity and the discovery, in 1938 by O. Hahn and F. Strassmann, of uranium fission under the action of neutrons. Since then, radioactivity and nuclear reactions with the transformation of some chemical elements into other elements have always gone “hand in hand”. And the scientific community came to a stable, firm opinion that nuclear reactions are always accompanied by radioactive radiation.

However, almost a century after the discovery of radioactivity, in 1989-1992, dramatic events took place in nuclear physics, marked by the unexpected discovery of “impossible”, radiationless and low-energy nuclear reactions.

Due to the development, at the end of the last century, of analytical instrumentation and computer technology, certified analytical laboratories for general use began to be created everywhere to perform the investigation of substances and materials. One of the goals of those studies was to determine the presence of chemical elements and their amount in selected materials and samples. Analytical laboratories typically include mass spectrometers with various types of ion sources, atom-emission- and X-ray-spectrometers, including electron microscopes,
which allow X-ray microprobe analysis of substances and materials. Researchers have now the opportunity, to obtain, with extreme sensitivity levels [1], independent, reliable information about the mass, elemental composition of both geological samples and materials obtained in various experiments.

It turned out that “extraneous” chemical elements were found in the medium, in many physical experiments related to electron impact on a condensed matter, after their completion, which were absent in that medium before the start of the impact. It is extremely important to note that the isotopes of the “extraneous” elements were stable, i.e. non-radioactive. The amount of “extraneous” elements obtained could not be explained by the impurities of chemical elements present in the reaction volumes. In some experiments, “extraneous” elements accounted for tens of percent of the total mass of the condensed matter. Later on, the production of “extraneous” elements in processes different from ordinary nuclear reactions was called low-energy transmutation of atomic nuclei of chemical elements. The transmutation is a transformation of some chemical elements into other chemical elements in weakly excited condensed matter. Still later, low-energy nuclear transmutation and Cold nuclear Fusion (CF) were combined under the general name Low Energy Nuclear Reactions (LENR) or Condensed Matter Nuclear Science (CMNS).

Low-energy nuclear reactions are not a special case of conventional nuclear reactions. They occur everywhere in the Universe and are the basis for the formation of a new paradigm. Just as the new paradigm does not include the old paradigm, so low-energy nuclear reactions do not include conventional, collisional nuclear reactions.

Let’s identify this new paradigm.

2. LOW-ENERGY NUCLEAR REACTIONS

2.1. COLD FUSION

The cold fusion reaction (CF) was implemented by S. Pons and M. Fleischman in 1989 at the palladium (Pd) cathode electrolysis of a solution of deuterated lithium hydroxil in heavy water (0.1M LiOD in a solution 99.5% D₂O + 0.5% H₂O) [2]. They reported that a significant amount of excess heat is released during electrolysis, which cannot be explained by chemical reactions. In addition, a weak neutron flux (n) and tritium (t) generation was detected in those experiments. Those results allowed the authors to draw a conclusion about the nuclear origin of excess heat and to assume that the following nuclear reactions with deuterons (d) take place in palladium electrode:

\[ d + d \rightarrow ^3\text{He} + n + 3.26 \text{MeV}, \]  
\[ d + d \rightarrow t + p + 4.03 \text{MeV}. \]

Similar thermonuclear reactions (1) and (2) begin to proceed at a temperature of ~ 100 million degrees (12.9 keV).

Some time later, other researchers [3] found that reactions with tritium yield were up to 10⁹ times more intense than reactions with neutron yield. Thermonuclear reactions (1) and (2) proceed with equal yield.

Further investigations have shown that the electrolysis gas resulting from electrolysis in CF reactions contains the helium isotope ⁴He, and its amount correlates with the energy released in the fusion reaction [4]. Thus, an energy of ~32 MeV is released per ⁴He atom. Since ⁴He is synthesized, then, the following reaction proceeds:

\[ d + d + \text{Pd} \rightarrow ^4\text{He} + 23.8 \text{MeV} + \text{Pd}. \]

But the energy yielded in this reaction would be not enough for the existing correlation in the production of ⁴He atoms with the energy released. Therefore, other, additional CF reactions should proceed in parallel. For example, during the formation of a nuclear molecule (d-Pd⁹), consisting of a deuteron and a palladium nucleus Pd⁹, a reaction can occur with the capture of a neutron by palladium [5], which is a part of the deuteron nucleus, d ≡ (p − n):

\[ d + \text{Pd}^N \rightarrow \text{Pd}^{N+1} + p + (8−2.224−2q) \text{MeV}, \]

where N is the number of neutrons. In this reaction, an energy is released equal to the difference between the binding energy of a neutron in a palladium nucleus (on average ~8 MeV) and the binding energies of a 2.224 MeV...
deuteron and a doubled nuclear molecular bond q (d-PdN).

Thermonuclear d+d-reaction with the production of the helium isotope \(^{4}\text{He}\) is well known, but it always proceeds with the emission of gamma quantum \(\gamma\) with a probability of \(10^{-7}\) relative to reactions (1) and (2):
\[
d + d \rightarrow ^{4}\text{He} + \gamma + 23.8 \text{MeV}.
\]
No gamma quanta were found in CF reactions.

As a result, we can conclude: Cold fusion reactions differ from thermonuclear reactions in their properties, and they occur at "room" temperatures.

2.2. Low-Energy Transmutation Of Atomic Nuclei Of Chemical Elements

S. Pons and M. Fleischmann used palladium as the cathode in their experiments with electrolysis. That was due to the fact that palladium dissolves hydrogen well. So, one volume of Pd dissolves, under normal conditions, 850 volumes of \(\text{H}_2\), or there are 7 hydrogen atoms per 10 palladium atoms. Therefore, in CF experiments carried out by different authors, other metals that dissolve hydrogen well were often used, for example: Ti, Fe, Co, Ni, Pt. Or other methods were used to saturate palladium with hydrogen. One of these methods is the method of cathode saturation by means of gas glow discharge.

The installation created by the authors of [6,7] for carrying out experiments with a gas glow discharge consisted of a chamber with a cathode and an anode filled with a working gas to a pressure of 300–1000 Pa. Hydrogen, deuterium, argon, xenon and their combinations were used as the working gas. The glow discharge was carried out at a current density of 10-50 mA/cm\(^2\) and a discharge voltage of 500-1400 V. The experiments continued for up to 120 hours. The material for the cathodes was 100 μm thick foils made of palladium and other metals (Ti, Ag, Nb, etc.).

Samples of cathodes were analyzed for the detection of impurities of chemical elements in them before and after the experiments. They applied the following methods for the analysis of the samples: spark, secondary ion and secondary neutral mass spectrometry, as well as the method of X-ray microprobe analysis. The content of elements in the cathodes was recorded in a near-surface layer 100 nm thick. The difference in the content of impurities of chemical elements before and after the experiments was interpreted as the production of “extraneous” nuclides. “Extraneous” elements were mainly contained in the outgrowths formed on the surface of palladium cathodes. The size of these formations reached 15 microns. The highest yield of “extraneous” nuclides was registered in a glow discharge in deuterium in a palladium cathode. The main nuclides (with a content of more than 1%) are \(^7\text{Li}, \, ^{12}\text{C}, \, ^{15}\text{N}, \, ^{20}\text{Ne}, \, ^{28}\text{Si}, \, ^{44,48}\text{Ca}, \, ^{56,57}\text{Fe}, \, ^{59}\text{Co}, \, ^{64,66}\text{Zn}, \, ^{75}\text{As}, \, ^{107,109}\text{Ag}, \, ^{110-112,114}\text{Cd}, \, ^{115}\text{In}\). Fig. 1 shows the “extraneous” nuclides produced in the Pd cathode after its irradiation in a deuterium glow discharge for 22 hours at a discharge current of 50 mA. The absolute number of atoms of these nuclides amounts to \(10^{17}\). For such elements as Li, B, C, Ca, Ti, Fe, Ni, Ga, Ge, etc., a change in the natural isotope ratio was recorded, for some elements by several tens of times. For example: depending on the location on the cathode, the \(^{57}\text{Fe}/^{56}\text{Fe}\) ratio varies from 25 to 50 times, while the natural ratio is \(^{57}\text{Fe}/^{56}\text{Fe} = 0.024). At the same time, some basic isotopes are absent, for example: \(^{58}\text{Ni}, \, ^{70,72,74}\text{Ge}, \, ^{113,116}\text{Cd}\). In addition, a change in the natural ratio of palladium isotopes is observed in Pd cathodes.

![Fig. 1. “Extraneous” nuclides produced in a Pd cathode in a deuterium glow discharge. Palladium isotopes are highlighted with blue lines, without their relative abundance.](image-url)
During the glow discharge and after it was turned off, gamma radiation was recorded, by means of a Ge(Li) detector, in the energy range 0.1–3.0 MeV. The analysis of gamma spectra showed that the emitters are neutron-rich nuclei with masses from A = 16 to A = 136, that yield β-radioactive decay chains. However, according to the authors' estimates, the number of stable isotopes formed as a result of transmutation is $10^9$-$10^{13}$ times greater than that of radioactive isotopes. In addition, the tracks of 3 MeV protons and 14 MeV α-particles with an intensity of 10-15 s$^{-1}$·cm$^{-2}$ were recorded, with the help of CR-39 plastic detectors, in all experiments. The value of the energy of the registered protons allows, on the basis of the reaction equation (3), to estimate the energy of the nuclear molecular bond of the deuteron with the palladium nucleus (d-Pd$^N$): $3q \approx 8–2.224–2q$ (MeV). Therefore, $q \approx 1.4$ MeV.

The authors of [8,9] draw attention to the registration of unknown particles, which leave “strange” traces - tracks in X-ray and nuclear photographic emulsions. The size of the tracks varies from one to tens of millimeters. The form of these tracks is unusual and various; these are broken lines, rectilinear, curved and spiral lines that consist of separate spots. The spots, in turn, can be in the form of circles, ellipses, horseshoes. The authors underline the amazing ability of “strange” particles to penetrate into the metal and move around in it. Particles can escape from the metal, after they have changed its structure and composition and have left behind traces similar to those that remain on photographic emulsions.

Separately, the author [10, 11] investigated the emission of X-rays radiation from a palladium cathode in a high-current ~150 mA glow discharge of deuterium and hydrogen, as well as the production of excess thermal power.

In those experiments, X-ray radiation with an energy of 1.5-2 keV with an intensity of up to 100 roentgen/sec was registered and three various modes of X-ray emission were revealed when the parameters of the glow discharge were changed: diffuse X-ray radiation, radiation in the form of narrowly directed X-ray microbeams, and super-powerful generation of X-ray radiation. The microbeam diameter at a distance of 200 mm from the cathode was estimated to be 10–20 μm, and the angular divergence was $\sim10^4$. The author notes the anomalously high penetrating power of X-ray microbeams in continuous metallic media. The stationary power of the super-powerful generation of X-ray radiation is estimated to be up to 10 W at a stationary electric discharge power of 50 W.

The excess power was measured with a water flow calorimeter. The measurement system made it possible to control the input electrical power and the thermal power removed by the cooling water with an accuracy of ±0.5 W with an absolute value of electrical power up to 120 W. In some experiments, the excess thermal power was several tens of W and amounted up to 50%.

The properties of reactions of low-energy transmutation of elements (hereinafter referred to as LTE or transmutation), revealed in experiments with a glow discharge, are characteristic of other experiments that have nothing to do with cold nuclear fusion. For example: in industrial, electronic, zone melting of zirconium ingots in a vacuum furnace [12]; in explosions of metal targets irradiated by a powerful pulse of electrons [13,14]; during explosions in liquid dielectric media of metal foils, through which a powerful pulse of electric current was passed [15,16]; when exposed to a pulsed current on a melt of lead with copper [17]; when applying electric current in water-mineral media [18]; with ultrasonic treatment of aqueous saline solutions [19]; when irradiated with braking quanta of condensed gases [20-22]; in growing biological structures [23-25] and in many others [18,26,27].

All above experiments were carried out by the authors dozens and hundreds of times. The results of experiments on the transmutation of chemical elements are guaranteed to be reproduced and therefore there are no doubts about them.

The main properties of low-energy transmutation reactions include:

- In all these experiments, new chemical elements appear that were absent in the starting material
before the beginning of the transmutation processes. This indicates that the atomic nuclei of some chemical elements are converted into atomic nuclei of other elements.

- In the products of transmutation, a ratio of isotopes of chemical elements is registered that differs from the natural ratio.
- As a rule, in most experiments, the products of transmutation are stable isotopes of elements. In special experiments, the conversion of radioactive isotopes into stable elements was carried out.
- Transmutation reactions are not accompanied by gamma and beta radioactive radiation.
- The yield of transmutation products in some experiments reaches tens of percent (10-25%) of the total mass of the condensed matter. This yield is incomparable with the yield of such products in conventional nuclear reactions.
- In the reactions of LTE, excess thermal, in some cases, electrical energy is released, the values of which cannot be explained by chemical reactions.
- The experimental and calculated values of the excess energy released in a separate transmutation reaction are small and range from tens of keV to several MeV.
- In some experiments, the authors note that the process of transmutation is accompanied by unknown radiation, which leaves its “strange” traces in photographic emulsions, on thin sections of metals, and which, when interacting with a substance, change its structure and chemical composition.
- The methods of the experiments on transmutation are extremely diverse and fundamentally different from the methods of nuclear physics.

As a result, two conclusions can be drawn:

1. Nuclear reactions take place in transmutation reactions, just as in cold fusion reactions.
2. The properties of cold fusion reactions and transmutation reactions contradict to the properties of conventional nuclear reactions.

3. NEW PARADIGM

The existing contradiction between conventional and low-energy nuclear reactions cannot be resolved otherwise than by way of a worldview jump, like those made by the community of scientists: in the transition from the concept of a flat earth to a spherical earth, from a geocentric system to a heliocentric system; when Newton discovered gravitational interaction and created classical mechanics; and in the transition from classical mechanics to quantum mechanics, special and general theory of relativity; at the discovery of electromagnetic, strong and weak interactions and at the discovery of the atom and atomic nucleus.

According to T. Kuhn [28]: “a scientific revolution occurs when scientists discover anomalies that cannot be explained using the current paradigm, within which scientific progress has taken place up to this point. Therefore, the new paradigm should be considered not just as a current theory, but as a change of a whole worldview, in which this paradigm exists along with all the conclusions made thanks to it”.

To make a real worldview transition, it is necessary to realize that in nature

- In a condensed medium, in a strong magnetic field, nuclear reactions occur at low energies!
  (In the reaction volume, excitation energy is < 1 eV/atom).

In a vacuum, nuclear reactions occur at high energies (> 10 keV/nucleus – thermonuclear fusion). Here, vacuum is understood as the residual gas pressure (less than 10^{-2} Pa) required to accelerate elementary particles or heavy ions to energies sufficient for their subsequent implementation of ordinary collisional nuclear reactions. Such a vacuum exists in interstellar space and in the vacuum chambers of accelerators. All the rest: stars and planets are condensed matter, moreover, excited condensed matter.

Modern nuclear physics studies nuclear reactions that take place in a vacuum. At the same time, the scientific community projects a part of the laws of nuclear physics operating in a vacuum onto condensed matter. In some cases, this is incorrect. Investigations of low-energy nuclear
reactions occurring in weakly excited condensed matter are necessary and inevitable.

4. NEW STATE OF MATTER
Low-energy transmutation reactions of interacting atomic nuclei cannot be explained within the framework of the old paradigm, within the framework of traditional physical concepts. There are three theoretical prohibitions for the phenomenon of transmutation [16,29]:
1. The impossibility for atomic nuclei to overcome, at their collision, the Coulomb barrier between them.
2. Extremely small probabilities of weak processes, which are responsible for the necessary conversion of neutrons into protons or vice versa in order to obtain stable isotopes in the output channel of transmutation reactions.
3. Low probabilities of multiatomic and, therefore, multinuclear reactions even in the absence of a Coulomb barrier. Multinuclear transmutation reactions must be introduced to explain the production of heavy chemical elements in many experiments in a medium consisting of light elements. Such heavy elements cannot be obtained in paired reactions that occur between light elements of the medium.

The above properties of transmutation reactions and prohibitions on their occurrence in the system analysis revealed the requirements that must be fulfilled for the implementation of low-energy transmutation reactions [30]:
1. The electronic structure of atoms and the nucleon structure of nuclei must change. Atoms must turn into transatoms, and nuclei must turn into transnuclei.
2. The electrons of the transatom must be close to the transnucleus. The electron wave functions should overlap significantly with nuclear wave functions.
3. Some of the electronic states of the transatom, and especially those, which are closest to the transnucleus, should not be occupied by electrons.
4. Transatoms must be attracted to each other.
5. During transmutation, the interaction of many transatoms and, accordingly, many transnuclei should occur simultaneously.
6. Transnuclei should be able to approach each other within the range of nuclear forces.
7. After transmutation in a condensed matter, transatoms and transnuclei should be transformed into conventional atoms and nuclei.

The requirements listed above for the course of transmutation reactions are, in fact, at the same time the properties of a new state of matter called a spin nuclide electron condensate [30,31]. A spin nuclide electron condensate is a transatom, in which electrons are paired into orthobosons $S = 1h$. The paired electrons form a Bose-Einstein condensate. In the center of the transatom there is a transnucleus formed by the ultrastrong magnetic field of the electron Bose-Einstein condensate. The properties of the transnucleus differ from those of the conventional nucleus.

5. NEW FUNDAMENTAL INTERACTION
The most plausible scientific concept that satisfies all the requirements listed above is the theory of condensation of atomic electrons in the immediate vicinity of the nucleus due to their pairing into orthobosons with a spin equal to one $S=1h$ [32], and the mechanism of automatic concentration of transnuclei and the implementation of transmutation reactions by them when transatoms combine their orthobosons.

The interaction responsible for low-energy nuclear reactions is the interaction, which is associated with both indistinguishability of identical objects: elementary particles, protons, neutrons, atomic nuclei, molecules, etc; and with the interaction of objects that are connected by resonant R-states. This interaction is called resonant interference exchange (RIEX) interaction.

RIEX interaction includes both the well-known exchange interaction between identical objects [33] and recently discovered exchange interaction between any objects A and B, which have resonant R-states, which belong to a composite system, which consists of objects A+B [5,34]. A composite system of A+B objects is not the result
of merging these objects. The resonant R-state of the composite system A+B is, in a certain sense, a certain “image” of objects A and B. This “image” is similar and “identical” to both object A and object B. The nature of the exchange interaction is associated with the overlap and interference of wave functions of identical objects or objects that have resonant R-states.

The principle of identity states that it is impossible, experimentally, to distinguish between identical objects or identical particles. So, if the places or states $a$ and $b$ of two identical particles 1 and 2 are interchanged:

$$\psi_a(1)\psi_b(2) \rightarrow \psi_a(2)\psi_b(1),$$

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 the 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 particles is represented by a superposition of wave functions of two states - an eigenstate $\psi_a(1)\psi_b(2)$ and an identical state $\psi_a(2)\psi_b(1)$:

$$\psi^{(1,2)} = \frac{1}{2}\{\psi_a(1)\psi_b(2) \pm \psi_a(2)\psi_b(1)\}. \tag{4}$$

The plus sign in expression (4) describes bosons - particles with zero or integer spin, $s = 0$, $1h$, $2h$... The bosons obey Bose-Einstein 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 half-integer spin, $s = \frac{1}{2}h$, $\frac{3}{2}h$... Fermions obey the Fermi-Dirac statistics, in which the sign of the wave function $\psi^{(1,2)}$ changes to the opposite when the particles are rearranged. Our Universe consists mainly of fermions: electrons, protons, neutrons, neutrinos.

By definition, the square of the wave function of particles is equal to the probability density of their being at a given point in space and at a given moment in time. If expression (4) is squared, then

$$|\psi^{(1,2)}|^2 = \frac{1}{4}\{(|\psi_a(1)\psi_b(2)|^2 + |\psi_a(2)\psi_b(1)|^2) \pm \pm[\psi_a(1)\psi_a(2)\psi_b(2)\psi_b(1) + \psi_a(1)\psi_b(2)\psi_a(2)\psi_b(1)]\}.$$
The coefficient $K_B$: $\psi_B^*(B) = K_B \psi_B(B)$. Coefficients $K_A$ and $K_B$ characterize the similarity of objects A and B to the resonant R-state. The coefficients $K_A$ and $K_B$ are individual for each R-state. Usually $K_A$ and $K_B < 1$. And vice versa, the coefficients $K_A$ and $K_B$ characterize the similarity of the resonant R-state to objects A and B. Therefore, the wave function $\psi_a(A)$ of object A will be present in the $b$-state: $\psi_b(B) = K_A \psi_a(A) = K_B K_A \psi_a(A)$ (Fig. 3). With the same coefficient $K_A K_B$, the wave function $\psi_b(B)$ of object B will be present in the $a$-state: $\psi_a(B) = K_B \psi_b(B) = K_A K_B \psi_b(B)$.

Thus, we can say that objects A and B are “identical” to each other with a generalized similarity coefficient $K^2 \equiv K_A K_B$. The spatial area of the RIEX interaction for all fundamental potentials: F, EM, W, and IG, is determined by the reduced lengths of the wave functions of “identical” objects A and B with the coefficient $K^2$: $K^2 \lambda_{AB}$ (Fig. 3).

When the reduced lengths of the wave functions of objects A and B overlap, then they are simultaneously in two states: eigenstate $\psi_a(A) \psi_b(B)$ and identical $\psi_a(A) \psi_a(B)$. And their total wave function is equal to $\psi^*(A, B) = \psi_a(A) \psi_b(B) \pm \psi_a(B) \psi_b(A)$.

The eigenpart $\psi_a(A)$ interacts, in its place $a$, with the identical part $\psi_a(B)$, and the eigenpart $\psi_b(B)$ interacts, in its place $b$, with $\psi_b(A)$. Thus, due to the resonant interference exchange interaction, the short-range strong F and local weak W interactions become “long-range”.

As already mentioned, "identical" objects A and B, which have resonant R-states, participate in additional, fundamental RIEX interactions:

6. PROPERTIES OF RIEX INTERACTION

The main properties of fundamental resonant interference exchange interactions include:

1. Fundamental RIEX interactions between “identical” objects occur the more intensively, the more their wave functions overlap.
2. At the reduced lengths of the wave functions of “identical” objects, the short-range strong F and local weak W interactions become, due to the RIEX interaction, “long-range” interactions.
3. The energy of the RIEX interaction $E_{c}$ is an additional contribution to the total energy of the E system of interacting objects.
4. The energy of the RIEX interaction $E_{c}$ can be positive or negative, depending on the type of fundamental interaction.
5. The sign of the contribution of the exchange energy to the total energy of the system can be different: plus or minus $\pm E_{c}$, depending on whether the coordinate part of the total wave function of objects is symmetric or antisymmetric. Therefore, the exchange energy $E_{c}$ can reduce, and in some cases, completely compensate for the main part of the energy of the system $E \equiv C - E_{c}$.

One of the consequences of the exchange Coulomb interaction is that it allows, in an atom in a strong magnetic field $B > 30 \text{ T}$, electrons with parallel spins to pair into orthobosons with $S = \hbar$.

As indicated above, most transmutation experiments are induced through the electronic action on a condensed matter by powerful pulse
of electrons or powerful currents. The directed motion of electrons creates a magnetic field both due to the transfer of the electric charges of electrons $e^-$ and due to the transfer of their magnetic moments $\mu_e$. The magnetic moments of the electron flow, due to the property of helicity, are directed in one direction, towards their momenta. The spins of electrons and neutrinos ($e^-$ and $\nu$) are directed against the momentum - they have left helicity, and the spins of positrons and antineutrinos ($e^+$ and $\bar{\nu}$) are directed along the momentum - they have the right helicity of particles. The electron’s magnetic moment is directed against the spin. The $B_S$ magnetic field created by the magnetic moments is described by the Landau equation [35]:

$$B_S = \mu_0 \sum_i \frac{3n_i(\mu_i \cdot \mathbf{n}) - \mu_i}{r_i^3},$$

(5)

where $\mu_0 = 1.26 \times 10^{-6}$ H/m is magnetic constant; $\mu_e = 0.29 \times 10^{-24} J/T = 5.79 \times 10^{-5}$ eV/T, $r$ is the distance from the electron to the point at which the $B_S$ field is calculated; $\mathbf{n}$ is a unit vector in the $r$ direction, $i$ is the number of electrons with parallel spins. According to formula (5), the magnetic moment of an electron $\mathbf{p}_e$ creates a magnetic field equal to 30 T at a distance of 0.092 nanometers along its axis (the diameter of a hydrogen atom is 0.106 nm). The same magnetic field of 30 T is created in the center of an electron lattice cell with unidirectional magnetic moments of electrons and with a side of $1.6 \times 10^{10}$ m, which is comparable with the size of atoms. So an orthohelium atom, whose electron spins are parallel, has magnetic fields in the nuclear region of $\sim 410$ T and $\sim 70$ T at its diameter of $\sim 1.75 \times 10^{-10}$ m. The strong magnetic field $> 30$ T that arises in a condensed matter gives rise to pairing of atomic electrons into orthobosons with spins $S = 1\hbar$, thus forming a “magnetic nesting doll” with the creation of a spin nuclide electron condensate [31].

The paper [36] shows that, in a strong magnetic field, pairing of atomic electrons with parallel spins occurs due to:

- the exchange interaction of electrons, which has the character of attraction and, secondly, the appearance of oscillations of electrons around their orbitals (Fig. 4a,b).

The $l + s \equiv j + j$ bonds of all atomic electrons are broken, and their orbital moments $l$ are “frozen” into the field in a strong magnetic field $B$. The interaction between electrons makes them oscillate around the orbitals. These oscillations are quantized by introducing a new, oscillatory quantum number $n_s$. The exchange interaction between two electrons and their oscillations with quantum numbers $\pm n_s$ allow electrons to create an orthoboson with $S = \hbar$. The quantum numbers of oscillations of paired electrons are equal to each other in absolute value, but opposite in sign $n_b^1 = -n_b^2$, $n_b = 1, 2, 3...$. Therefore, the Pauli principle is fulfilled for them. Due to the exchange interaction, correlated oscillations appear in two electrons (Fig. 4a,b). The sum of the momenta of two electrons in a pair is equal to zero, i.e. electrons in a pair have momenta $P_{1e} = -P_{2e}$, which are equal in magnitude and opposite in direction.

Electrons in a pair oscillate both along and across the magnetic field $B$ (Fig. 4b). Since electrons in a pair oscillate in antiphase $P_{1e} = -P_{2e}$ ($n_b^1 = -n_b^2$), this motion allows two electrons in the same energy states to be in non-intersecting spatial regions (Fig. 4b). The trajectories of electron motion can be represented as closed spirals nested into each other, located on the surface of the toroid (Fig. 4c). The two electron spirals are similar to the double helix of a DNA molecule.

The trajectories of several orthobosons in a multielectron transatom create a toroidal spin electron magnetic twist - a torsem-twist of spirals nested into each other, which resembles the DNA code of the main character of the film “The Fifth Element” - Leeloo [37]. The torsem-twist is located on the surface of the toroid. The
multielectron atom forms a Transatom, which has an electron Bose-Einstein condensate (Fig. 6). The atomic electrons inevitably pair, in a strong magnetic field, into orthobosons, ordinary atoms inevitably transform into transatoms.

Since the coordinate part of the total wave function of electrons in the orthoboson is antisymmetric \( n'_b = -n'_s \), the total Coulomb energy of electrons is \( E = 6E_a + C - Ec \) (Fig. 4a), where \( 6E_a \) is the interaction energy of two paired electrons with a nucleus, \( E_a \) is the binding energy of a single electron with a nucleus, \( C \) is the basic, ordinary Coulomb energy of repulsion of two electrons, and \( Ec \) is their exchange Coulomb energy. The energies \( C \) and \( Ec \) are positive. And since both electrons are in equal energy states, then \( C = Ec \) and \( E^C = C + Ec = 0 \). The exchange Coulomb attraction of two electrons completely compensates their Coulomb repulsion. A quantum paradox arises: “The Waves extinguish the Wind”.

Two hydrogen atoms, which interact in a strong magnetic field, combine, due to the occurrence of electron oscillations \( \omega_p \), to form a hydrogen transmolecule \( \text{“H}_2 \)”, which electrons are paired into an orthoboson [36] (Fig. 5a). This orthoboson creates an electromagnetic potential well in the hydrogen transmolecule \( \text{“H}_2 \)”, with a magnetic induction vector at the center of \( \sim 10^4 \) T. The protons \( (S_p = h/2) \) in such a ultrastrong and inhomogeneous magnetic field will have parallel spins \( \uparrow \uparrow \). The protons in a hydrogen transmolecule form, like electrons, a bound state \( - \) a nuclear orthoboson \( S = 1h \) due to their own exchange interaction and their own correlated oscillations. Just like electrons, the exchange Coulomb interaction of protons completely compensates for their Coulomb repulsion. This will lead to the approaching of protons to each other to nuclear distances and the formation of a “helium-pp” (“He-pp”) transmolecule [36] (Fig. 5b). The protons in the "He-pp" transmolecule can be replaced with deuterons \( d \) or tritons \( t \). Then transmolecules "He-dd" and "He-"tt" are formed.

One of the perturbing potentials between electrons and between protons in orthobosons is the above Coulomb interaction: \( V_c = k \cdot e^2 / r_{12} \), where \( r_{12} \) is the distance between electrons or protons, \( k = 1/4\pi \varepsilon_0 = 8.99 \cdot 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \) (\( \varepsilon_0 = 8.85 \cdot 10^{-12} \text{ F/m} \) is the electrical constant), \( e = 1.6022 \cdot 10^{-19} \text{ C} \) is the electron and proton charges. Another disturbing potential between electrons and between protons in orthobosons is the gravitational interaction: \( V_g = G \cdot m^2 / r_{12} \), where \( G = 6.67 \cdot 10^{-11} \text{ m}^3/\text{kg}^2 \cdot \text{s}^{-2} \) is the gravitational constant, \( m \) is the electron mass \( 9.11 \cdot 10^{-31} \text{ kg} \) or proton \( 1.67 \cdot 10^{-27} \text{ kg} \). The gravitational energy of electrons or protons, or other identical nuclei bound into orthobosons, is equal to \( E^G = \mathcal{E} - E_{12} \), where \( \mathcal{E} \) is the usual gravitational energy of attraction of two electrons or two protons, or two other identical nuclei to each other, and \( E_{12} \) is their exchange gravitational energy. Gravitational energies \( \mathcal{E} \) and \( E_{12} \) of electrons, protons and other objects have negative values. And, as in the case of Coulomb interaction, the exchange gravitational repulsion of electrons, protons, neutrons and other identical nuclei, which form an orthoboson, fully compensates for their gravitational attraction \( E^G = 0 \).

Consequently, long-range Coulomb and gravitational interactions are absent in transmolecules for pairs of electronic and nuclear orthobosons. But in these transmolecules, strong and weak interactions act at the lengths of the wave functions of nuclear orthobosons. And weak interaction takes place in electronic orthobosons and between them and nuclear orthobosons.

The lengths of the wave functions \( \lambda \) of the orthobosons in the ground state with \( n = 1 \) are equal to the radii of the orthobosons \( R = \lambda = h/P \), where \( n \) is the principal quantum number, \( P \) is the momentum of the particles that make up
the orthoboson. Therefore, the wave functions of electrons in a torsem-twist overlap significantly with nuclear wave functions.

Thus, the resonant interference exchange interaction is a new, Fifth fundamental interaction. It is a Universal Interaction as it always includes all other four fundamental interactions. Moreover, RIXE interaction changes the action of components of its four interactions and controls them, like “The Fifth Element” from the film of the same name, which controls the four elements [37].

7. TRANSMUTATION REACTIONS

Since the protons in the "He-pp" transmolecule are at a nuclear distance, this will lead to a nuclear transmutation reaction with the participation of electronic orthoboson. This will synthesize a deuteron:
\[ p + p + 2e^- \rightarrow d + \nu_e + e^- + 1.44 \text{ MeV} \]

With the production of deuterium and tritium, transmolecules "He-dd" and "He-tt" will be formed, which are also nuclear orthobosons. They enter into nuclear transmutation reactions without a Coulomb barrier, including reactions with the participation of electronic orthoboson, \( 2e^- \), with the formation of protons, neutrons, tritons, \( ^3\text{He}, ^4\text{He}, ^6\text{He} \rightarrow ^6\text{Li} \) (Fig. 5c) [32]:
\[ d + d \rightarrow t + p + 4.03 \text{ MeV}, \]
\[ d + d \rightarrow ^3\text{He} + n + 3.26 \text{ MeV}, \]
\[ t + t \rightarrow ^4\text{He} + 2n + 11.3 \text{ MeV}, \]
\[ d + d + 2e^- \rightarrow ^4\text{He} + 2e^- + 23.85 \text{ MeV}, \]
\[ t + t + 2e^- \rightarrow 2e^- + 12.3 \text{ MeV} + ^4\text{He} (\beta^-, T_{1/2} = 0.8c) \rightarrow ^6\text{Li} + e^- + \bar{\nu}_e + 3.5 \text{ MeV}. \]

At the same time, orthohelium atoms will form multinuclear transmolecules \( k \cdot ^4\text{He} \) with helium Bose-Einstein condensate. The creation of such transmolecules leads to multinuclear reactions, with the emission of protons, neutrons, alpha particles and heavy chemical elements: A, B, C ..., with a nuclear charge \( Z \geq 6 \) [38]:
\[ k \cdot ^4\text{He} \rightarrow ^{4n-1}A + p + Q, \]
\[ k \cdot ^4\text{He} \rightarrow ^{4n-1}B + n + Q, \]
\[ k \cdot ^4\text{He} \rightarrow ^{4(n-1)}C + ^4\text{He} + Q, \]
\[ k \cdot ^4\text{He} \rightarrow A + B + C + \ldots + Q, \]

where \( Q \) is the energy released as a result of the reaction.

Since the spins \( s \) and the magnetic moments of the electrons \( \mu_e \) in the Bose-condensate are directed in the same direction, and they generate, in and around transatoms, an ultrastrong directed inhomogeneous and anisotropic magnetic field up to \( B_s \sim 10^5 - 10^6 \text{ T} \) [5]. In this case, the inhomogeneity and anisotropy of the magnetic field \( \Delta B_s \) exist at the dimensions of the interacting transnuclei. This leads to the uncertainty of the energies of nucleons with magnetic moments \( \mu_N \) in transnuclei - \( \Delta B_s \mu_N \), which is equivalent to the inhomogeneity of time. Thus, we can say that the RIXE interaction changes the space-time structure and properties. Consequently, during the interaction of transnuclei moving in a transmolecule, the integrals of motion are not preserved: the law of conservation of momentum, the law of conservation of angular momentum (spin) and the law of conservation of energy are violated. Thus, the conclusion supposes that the study of the physical vacuum is impossible otherwise than through the study of the condensed state of matter in extreme conditions.

The internal ultrastrong magnetic field \( B_s^0 \), when it interacts with the magnetic spin and magnetic orbital moments of nucleons in the nucleus, changes the structure of the nucleus, and turns it into a Transnucleus.

External ultrastrong magnetic fields \( B_s^B \) of transatoms attract them to each other (\( B_s^B \ast \mu_e > 10^5 \ast 5.8 \cdot 10^{-5} \text{ eV}^2 \)). Electronic Bose-condensates of two transatoms are combined into a common condensate. A double nuclear transmolecule is formed from the transnuclei. Other transnuclei can join it. A multinuclear transmolecule is formed, in which multinuclear reactions take place, including those that involve electronic orthobosons. Thus, nuclear-electron or strong-weak reactions occur, the products of which are non-radioactive.

These reactions are carried out due to the resonant interference exchange interaction. Fig. 6 shows the formation of a sodium transmolecule \( ^{23}\text{Na}^{2+} \) from the transatoms of boron \( ^{11}_2\text{B}^+ \) and
carbon \(^{12}_6\)C\(^T\). The transnuclei \(^{11}_5\)B\(^T\) and \(^{12}_6\)C\(^T\) in the transmolecule \(^{23}_1\)Na\(^M\) cannot merge because of the Coulomb barrier between them. But strong and electroweak forces act due to the existence of resonant R-states in the transmolecule between the transnuclei and between the transnuclei and their orthobosons.

The sodium transmolecule \(^{23}_1\)Na\(^M\) can be composed of other transatoms, for example: transhelium \(^{4}_2\)He\(^T\) and transfluorine \(^{19}_9\)F\(^T\). From the same number of nucleons, regardless of whether they are protons or neutrons, other transmolecules can be composed, for example: magnesium \(^{23}_1\)Mg\(^M\) from transhelium \(^{2}_2\)He\(^T\) and transneon \(^{20}_10\)Ne\(^T\). All these transmolecules have their own resonant R-states, but they have different nuclear and nuclear molecular binding energies. The energetically closer to each other are the binding energies of these transmolecules, the more their resonant R-states overlap and the more likely the transmutation reaction occurs. For this reason, the energy released in transmutation reactions is insignificant, if compared to conventional nuclear reactions: from tens of keV to several MeV. The Fig. 7 shows all possible computer-calculated transmutation reactions. It is not excluded that the transformation of the sodium transmolecule into the conventional sodium atomic nucleus may occur \(^{23}_1\)Na\(^M\): \(^{23}_1\)Na\(^M\) \(\rightarrow\) \(^{23}_1\)Na + 13.36 MeV. The energy released in the 13.36 MeV reaction is transferred to the electron orthobosons that surround the nucleus. Thus, transmutation reactions can be represented as reactions of nucleon and multinucleon transfers between transnuclei with a possible conversion of protons into neutrons and vice versa, as well as reactions of radiationless fusion and fission of transnuclei.

The atomic nuclei scatter after the implementation of low-energy nuclear reactions. And, if they are not in a strong magnetic field, then the reaction products form conventional nuclei and conventional atoms.

It is remarkable that the fission of the uranium-235 nucleus by a thermal neutron is associated with the RIEX interaction [5,34]. The process of a thermal neutron capture by a uranium-235 nucleus has a pronounced resonance character when the neutron energy is close to one of the values corresponding to the R-level of the composite system: a neutron plus a uranium-235 nucleus. After RIEX capture by the uranium-235 nucleus of a neutron to the R-level, it carries out an electromagnetic transition to the highly excited level of their common nucleus, uranium-236. The energy of this excited state \(\sim\)7-8 MeV is greater than the energy of the 6 MeV Coulomb fission barrier. Therefore, the uranium-236 nucleus with a greater degree of probability, determined by nuclear interaction, will split into two fragments than it founds itself in the ground state, the transition to which is determined by electromagnetic interaction. Thus, nuclear power engineering, unlike all other types of power engineering, is a resonant technology.

8. EVOLUTION AND ECOLOGY
In the last century, the evolutionary development of living nature, the biosphere passed into a new state, in the noosphere. In 1944, V.I.Vernadsky wrote [39]: “In the twentieth century, for the first time in the history of the Earth, the man recognized and embraced the entire biosphere. The Humankind, taken as a whole, has become
a powerful geological force, ever growing force. And the Humankind, its thinking and work face the question of restructuring the biosphere in the interests of free-thinking humanity as an integral whole. This new state of the biosphere is the noosphere”.

In the 21st century, ecology, which studies, among other things, the influence of human activity on the environment and wildlife, came to the conclusion that at this stage of evolution, the noosphere is characterized by a contradiction between its irresistible development and the necessary preservation. The main problem in the preservation of the noosphere is environmental pollution caused by the ever increasing production activity of mankind. The pollution of the environment and wildlife has reached geological proportions. The scale of pollution is so huge that the Earth's biosphere is no longer able to dispose and neutralize them. For this reason, the humankind faces the fundamental question of the existence of the Living ecosystem, in general, and the existence of humanity itself, in particular.

The main sources of pollution are the combustion of hydrocarbons for the needs of the energy sector and the processing of mineral materials. The combustion of hydrocarbons is accompanied by an increase in the level of carbon monoxide in the atmosphere, which leads to a greenhouse effect that catastrophically changes the Earth's climate. The processing of minerals entails the appearance of waste in the form of new chemical compounds, foreign and toxic materials, harmful to living organisms and not capable of being disposed in the biosphere.

Despite all the efforts of the humankind, including the creation of alternative energy sources, it is becoming more and more obvious that the modern technology is not able to eliminate the existing contradiction between the development and preservation of the noosphere.

With the discovery of low-energy nuclear reactions and resonant interference exchange interactions, this contradiction can be overcome. This conclusion is based on the idea of creating resonant technologies as a way to obtain maximum results at minimum costs.

First of all, this concerns the development of new energy sources based on low-energy nuclear reactions: cold nuclear fusion reactions and nuclear transmutation reactions. Due to the lack of carbon dioxide production, harmful emissions and effluents, due to the absence of radiation and radioactive waste, such resonant energy sources (RES) are environment friendly energy sources. In future, they will replace energy sources using fossil fuels. As a result, the need for the extraction, transportation and processing of fossil fuels for energy purposes will disappear. Powerful and compact, RES can be deployed in centralized or dispersed configurations. RES are cheap and practically inexhaustible sources of energy. For these reasons, they can be widely used in the elimination of waste products harmful to the biosphere. Waste disposal facilities can use resonant technologies in the same way as industrial production itself should use such technologies.

The composition of many modern materials that are used in the manufacture of industrial products include rare chemical elements and elements scattered in nature. The concentration of such elements in mineral deposits can be tenths of a gram per ton. Obviously, the production of such elements in industrial quantities requires the processing of hundreds of millions of tons of ore. Since some chemical elements are converted into others in transmutation reactions, these resonance reactions can be used in the production of rare elements and their isotopes from cheap and widespread chemical elements. This will save huge energy, material and human resources.

Based on the properties of low-energy nuclear reactions and the properties of transatoms, it is possible to create other, both obvious and non-trivial, disruptive innovation [29]. Such resonant technologies will radically change the technological structure of the noosphere. And, as a consequence, they will inevitably affect the evolution of the noosphere and save it at the same time.
9. CONCLUSION
Low-energy nuclear reactions in condensed matter occur due to resonant interference exchange interaction. The new paradigm is based on new nuclear reactions, on a new state of matter: a spin nuclide electron condensate, and, first of all, on a new resonant interference exchange interaction. The RIEX interaction is a universal interaction not only because it includes and controls all the other four fundamental interactions, but also because its actions extend to the Whole of Nature, from elementary particles to complex biological and social systems.

The new paradigm gave a start to the formation of new technological ways and a new civilizational paradigm.

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