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QUANTIZATION OF DIFFERENCES BETWEEN ATOMIC AND NUCLEAR REST MASSES AND SELF-ORGANIZATION OF ATOMS AND NUCLEI

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Abstract

We come to the conclusion that all atomic models based on either the Newton equation and the Kepler laws, or the Maxwell equations, or the Schrodinger and Dirac equations are in reasonable agreement with experimental data. We can only suspect that these equations are grounded on the same fundamental principle(s) which is (are) not known or these equations can be transformed into each other. We proposed a new mechanism of LENR: cooperative processes in the whole system - nuclei+atoms+condensed matter - nuclear reactions in plasma - can occur at smaller threshold energies than the corresponding ones on free constituents. We were able to quantize phenomenologically the first time the differences between atomic and nuclear rest masses by the formula (in MeV/c^2) $\Delta M = \frac{n_1}{n_2} * 0.0076294,\ n_1 = 1, 2, 3, ...\ n_2 = 1, 2, 4, 8$ Note that

this quantization rule is justified for atoms and nuclei with different A, N and Z and the nuclei and atoms represent a coherent synchronized systems - a complex of coupled oscillators (resonators). The cooperative resonance synchronization mechanisms are responsible for explanation of how the electron volt world can influence the nuclear mega electron volt world. It means that we created new possibilities for inducing and controlling nuclear reactions by atomic processes.

1 Introduction

The review of possible stimulation mechanisms of LENR (low energy nuclear reaction) is presented in [2]. We have concluded that transmutation of nuclei at low energies and excess heat are possible in the framework of the known fundamental physical laws the universal cooperative resonance synchronization principle [1], and different enhancement mechanisms of reaction processes [2]. The superlow energy of external fields, the excitation and ionization of atoms may play the role of a trigger for LENR. Superlow energy of external fields may stimulate LENR [3]. We bring strong arguments that the cooperative resonance synchronization mechanisms are responsible for explanation of how the electron volt world can influence the nuclear mega electron volt world [3].

Nuclear physicists are absolutely sure that this cannot happen. Almost all nuclear experiments were carried out in conditions when colliding particles interacted with the nuclear targets which represented a gas or a solid body. The nuclei of the target are in the neutral atoms surrounded by orbital electrons. All existing experimental data under such conditions teach us that nuclear low energy transmutations are not observed due to the Coulomb barrier.

LENR with transmutation of nuclei occurs in different conditions and different processes (see publications in http://www.lenr-canr.org/ which contain more than 500 papers) but these processes have common properties: interacting nuclei are in the ionized atoms or completely without electrons (bare nuclei). Therefore, LENR with bare nuclei and nuclei in ionized atoms demonstrated a drastically different properties in comparison with nuclei in neutral atoms [1]. This is nuclear physics in condensed matter or in plasma state of matter. For example, the measured half-life [4] for bare $^{187}Re^{75+}$ of $T_{1/2} = (32.9 \pm 2.0)$ yr is billion times shorter than that for neutral ^{187}Re.

Natural geo-transmutations of nuclei in the atmosphere and earth are established very well [7, 8, 9]. They occur at the points of a strong change in geo- and electromagnetic fields. Moreover, there are a lot of experimental data [10] that the nuclear fusion and transmutation in biological systems are the real phenomena.

Nucleons in nuclei and electrons in atoms represent the whole system in which all motions are synchronized and self-sustained (see

our publications [1, 2, 3, 5] and Shadrin V.N. talk [6]). Nucleons in nuclei and electrons in atoms are nondecomposable into independent motions of nucleons and electrons.

Investigation of this phenomenon requires the knowledge of different branches of science: nuclear and atomic physics, chemistry and electrochemistry, condensed matter and solid state physics, astrophysics, biology, medicine, ...

• The differentiation of science which was rather useful at the beginning brings civilization to a catastrophe. Therefore the integration of different branches of science is a question of vital importance.

The puzzle of poor reproducibility of experimental data is the fact that LENR occurs in open systems and it is extremely sensitive to parameters of external fields and systems. The classical reproducibility principle should be reconsidered for LENR experiments. Poor reproducibility and unexplained results do not mean the experiment is wrong. Our main conclusion is: LENR may be understood in terms of the known fundamental laws without any violation of basic physics. The fundamental laws of physics should be the same in micro- and macrosystems.

• LENRs take places in open systems in which all frequencies and phases are coordinated according to the universal cooperative resonance synchronization principle. Poor reproducibility of experimental results and extreme difficulties of their interpretation in the framework of modern standard theoretical physics (there are about 150 theoretical models [11] which are not accepted by physical society) are the main reasons for the persistent nonrecognition of cold fusion and transmutation phenomenon.

Recent progress in both directions is remarkable (see http://www.lenr-canr.org/, http://www.iccf12.org/, http://www.iscmns.org/);in spite of being rejected by physical society, this phenomenon is a key point for further success in the corresponding fundamental and applied research. The results of this research field can provide new ecologically pure sources of energy, substances, and technologies.

The possibilities of inducing and controlling nuclear reactions at low temperatures and pressures by using different low-energy fields and various physical and chemical processes were discussed in [2, 3, 5]. The aim of this paper is to present the results of phenomenological quantization of nuclear and atomic mass differences which can bring

new possibilities for inducing and controlling nuclear reactions by atomic processes and new interpretation of self-organizations of the hierarchial systems in the Universe including the living cells. How do the atoms and nuclei have their perpetual motions? How is the Universe constructed? How it links the smallest structures in the Universe to the largest? The three questions are interconnected.

Let us start with the description of the hydrogen atom structure in different models using the standard basic physics that is well established, both theoretically and experimentally in micro- and macrosystems.

2 The Bohr Model

At the end of the 19th century it was established that the radiation from hydrogen was emitted at specific quantized frequencies. Niels Bohr developed the model to explain this radiation using four postulates:

1. An electron in an atom moves in a circular orbit about the nucleus under the influence of the Coulomb attraction between the electron and the nucleus, obeying the laws of classical mechanics.

2. Instead of the infinity of orbits which would be possible in classical mechanics, it is only possible for an electron to move in an orbit for which its orbital angular momentum L is integral multiple of $\hbar$:

$$L = n\hbar, \quad n = 1, 2, 3, \tag{1}$$

3. Despite the fact that it is constantly accelerating, an electron moving in such an allowed orbit does not radiate electromagnetic energy. Thus, its total energy E remains constant.

4. Electromagnetic radiation is emitted if an electron, initially moving in an orbit of total energy E_i, discontinuously changes its motion so that it moves in an orbit of total energy E_f. The frequency ν of the emitted radiation is equal to the quantity

$$\nu_{if} = \frac{E_i - E_f}{h}, \tag{2}$$

where h is Planck's constant. The electron is held on a stable circular orbit around the proton. The hydrogen atom consists of one heavy proton in the center of atom with one lighter electron orbiting

around proton. The Coulomb force is equal to the centripetal force, according to Newton's second law

$$\frac{e^2}{r^2} = \frac{mv^2}{r}, \tag{3}$$

where r is is the radius of the electron orbit, and v is the electron speed. The force is central; hence from the quantization condition (1) we have

$$L = \mid \vec{r} * \vec{p} \mid = mvr = n\hbar. \tag{4}$$

After solving equations (3) and (4) we have

$$v = \frac{e^2}{n\hbar},\ r = \frac{n^2\hbar^2}{me^2} = n^2 a_0. \tag{5}$$

Following equation (3) the kinetic energy is equal to

$$E_k = \frac{1}{2}mv^2 = \frac{e^2}{2r}, \tag{6}$$

and hence the total energy is

$$E = E_k + V = \frac{e^2}{2r} - \frac{e^2}{r} = -\frac{e^2}{2r}. \tag{7}$$

Having r from equation (5) one can write the expression for the energy levels for hydrogen atoms

$$E = -\frac{me^4}{2\hbar^2 n^2}; \tag{8}$$

the same results were further obtained by quantum mechanics.

Using the angular momentum quantization condition $L = pr = nh/2\pi$ and Louis de Broglie's relationship $p = h/\lambda$ between momentum and wavelength one can get

$$2\pi r = n\lambda. \tag{9}$$

$\otimes$ *It means that the circular Bohr orbit is an integral number of the de Broglie wavelengths.*

2.1 The Bohr 3th postulate

Let us remember the Bohr 3th postulate:
• *Despite the fact that it is constantly accelerating, an electron moving in such an allowed orbit does not radiate electromagnetic energy. Thus, its total energy E remains constant.*

The classical electrodynamics law: an accelerating electron radiates electromagnetic energies in full agreement with experimental data.

Therefore, Bohr's postulate asserts that the classical electrodynamics does not work on an atomic scale. Surprisingly, the physical society accepts this postulate which declares that the physical laws in macro- and microworld are different. An electron in the Bohr model rotates around the motionless proton so the proton is a nonactive partner. The motion of proton in hydrogen atom was ignored completely – fatal error of the Bohr model.

We are convinced that the physical laws are unique and are the same in different scale systems. The proton and an electron represent two components of the same system – a hydrogen atom. We consider the hydrogen atom as the whole nondecomposable system in which the motions of proton and electron are synchronized. Therefore, if proton stops to move, it should not be allowed for an electron to keep its own motion.

• *The hydrogen atom in the ground state does not radiate electromagnetic energy – experimental fact.*

It was possible to describe the nonradiation hydrogen atom in the ground state even in 1913 on the basis of classical electrodynamics as the result of standing wave formation in which the motions of proton and electron are synchronized in such a way that the electromagnetic energy flows are equal to zero.

Bohr's 3rd postulate can be reformulated in the following way:
• *The hydrogen atom is an open system in which all frequencies and phases of proton and electron are coordinated according to the universal cooperative resonance synchronization principle.*

The proton and electron in a hydrogen atom form standing electromagnetic waves so that the sum of radiated and absorbed electromagnetic energy flows by electron and proton is equal to zero at distances larger than the orbit of electron [13] the secret of success of the Bohr model (nonradiation of the electron on the stable orbit).

The formation standing electromagnetic waves with zero energy flows is the main reason of the hydrogen atom stability.

2.2 Bohr's 4th Postulate

Let us remember the Bohr 4th postulate:
• **Electromagnetic radiation is emitted if an electron, initially moving in an orbit of total energy E_i, discontinuously changes its motion so that it moves in an orbit of total energy E_f. The frequency ν of the emitted radiation is equal to the quantity**

$$\nu_{if} = \frac{E_i - E_f}{h}, \tag{2}$$

where h is Planck's constant.

The following old Rutherford question is: what is a source of information that an electron knows in advance the value of emitted (absorbed) energy. Rutherford put it in a letter to Bohr:

• *How does an electron decide what frequency it is going to vibrate at when it passes from one stationary state to another. It seems to me that you would have to assume that electron knows beforehand where it is going to stop.*

The answer is very simple but it was waiting in during 87 years [1].

We consider an electron motion in the one-dimensional infinite potential well whose coordinates are equal to $z = -L/2$ and $z = L/2$. Assume that an electron state is a superposition of the ground state and first excited one

$$\psi(z,t) = \psi_1(z,t) + \psi_2(z,t),$$

$$\psi_1(z,t) = A_1 e^{-i\omega_1 t} cosk_1 z,\ k_1 L = \pi,$$
$$\psi_2(z,t) = A_2 e^{-i\omega_2 t} cosk_2 z,\ k_2 L = 2\pi.$$

It is easy to calculate [14] the average value of a $\overline{z}$ – coordinate electron in one dimension potential:

$$\overline{z} = \frac{32L}{9\pi^2} \frac{A_1 A_2}{A_1^2 + A_2^2} cos(\omega_2 - \omega_1)t.$$

Therefore, the average position of a charge oscillates with the frequency of beating $\omega_{beating} = \omega_2 - \omega_1$.

• It means that the radiation frequency of the electromagnetic waves is equal to the beating frequency between the first excited state and the ground state

$$\omega_{radiation} = \omega_{beating} = \omega_2 - \omega_1,$$

according to the classical electrodynamics. An electron in the mixed states knows the value of emitted (absorbed) energy in advance which is equal to the beating frequency multiplied by Planck's constant. This is the resonance process in which the de Broglie wavelength λ changes an integer number. Therefore, the de Broglie wavelength plays the role of the standard one. For example, the musical instruments emit the sounds with frequencies that are equal to instruments eigenfrequencies. The physical laws should be the same in micro- and macro-world.

The Bohr postulates were completely arbitrary and even violated the well established laws of the classical electrodynamics.

The standard point of view is that the Bohr model is actually accurate only for a one-electron system, see below.

2.3 The Sukhorukov Model – Generalization of the Bohr-Sommerfield Model

The Sukhorukov model [15] is the generalization of the Bohr-Sommerfield model for multi-electron atoms. Atoms have a planetary structure. Rydberg's constant $R_{\rm inf}$ is the same for all atoms. The ionization potentials have been calculated [16] for 36 chemical elements with accuracy better than 1 eV.

2.4 The Parson Model

A.L. Parson [17] developed a model of atoms in which each electron forms a small magnet (in 1915). The rings of the charge represent the shape of a toroid surrounding the nucleus. This model was not accepted by physical society and was forgotten despite that H.Stanley Allen [18] proved many outstanding properties in comparison with other models of atom.

2.5 The Lucas Model of Atoms and Nuclei

We quote D.L. Bergman's conclusion [19]: *In 1996, while still a student in secondary school, Joseph Lucas introduced his model of atom [20]. In this model, electrons, protons and neutrons are all based on Bergman's Spinning Charge Ring Model of Elementary Particles [21, 22] (a refinement of Parson's Magneton). In terms of its predictive ability and conformance with all known experiments, the Lucas Model of the Atom is by far the most successful of all models of the atom ever proposed. It is a physical model that shows where particles are located throughout the volume of the atoms. This model predicts the "magic numbers" 2,8,18, and 32 of electrons in the filled shells and also able to predict why the Periodic Table of the Elements has exactly seven rows. The Lucas model also predicts the structure of the nucleus and correctly predicts thousands of nuclide spins. Boudreaux and Baxter recently have shown that the Lucas model of the nucleus produces more accurate predictions of radioactivity and decay rates than prior models [23].*

2.6 The Bergman-Lucas Model for Elementary Particles, Atoms and Nuclei

The abstract of paper [24]:*A theory of physical matter based on fundamental laws of electricity and magnetism is presented. A new physical model for elementary particles, the atom and the nucleus implements scientific principles of objective reality, causality and unity. The model provides the experimentally observed size, mass, spin, and magnetic moment of all the stable charged elementary particles. The model is based on a classical electrodynamics rotating charge ring. From combinatorial geometry, the complete structure of the Periodic Table of Elements is predicted, and the nuclear spins and structure of nuclear shells predicted. Unlike modern mathematical models based on point-like objects, a physical model has characteristics of size and structure – providing a causal mechanism for forces on objects and the interchange of energy between objects. From the fundamental laws of electrodynamics and Galilean invariance, the so-called relativistic fields of a charged particle moving at high velocity have been derived. The results are mathematically identical to those predicted*

by the Special Theory of Relativity, but the origin of the effect is entirely physical. The model even accounts for the interaction of light and matter, and the physical process for absorption and emission of radiation by an electron is explained from classical electrodynamics. Using a ring particle absorption mechanism, classical explanations are given for black body radiation and photoelectric effect.

2.7 The Hydrogen Atom in Classical Mechanics

Is it possible to understand some properties of a hydrogen atom from classical mechanics ? The Hamiltonian for a hydrogen atom is

$$H = \frac{m_p \dot{\vec{r}}_p^{\,2}}{2} + \frac{m_e \dot{\vec{r}}_e^{\,2}}{2} - \frac{e^2}{\mid \vec{r}_p - \vec{r}_e \mid}. \tag{10}$$

All notation is standard. The definition of the center of mass is

$$m_p \vec{r}_p + m_e \vec{r}_e = 0, \tag{11}$$

and the relative distance between electron and proton is

$$\vec{r} = \vec{r}_p - \vec{r}_e. \tag{12}$$

Equations (10)-(12) lead to the results:

$$\vec{r}_p = \frac{m_e}{m_p + m_e}\vec{r},\ \vec{r}_e = -\frac{m_p}{m_p + m_e}\vec{r}, \tag{13}$$

$$H = \frac{\mu \dot{\vec{r}}^{\,2}}{2} - \frac{e^2}{r}, \tag{14}$$

where

$$\mu = \frac{m_p m_e}{m_p + m_e}. \tag{15}$$

The Hamiltonian (14) coincides with the Hamiltonian for the fictitious material point with reduced mass μ moving in the external field $-e^2/r$. If we known the trajectory of this fictitious particle $\vec{r} = \vec{r}(t)$ then we can reconstruct the trajectories of electron and proton using equations (13)

$$\vec{r}_p(t) = \frac{m_e}{m_p + m_e}\vec{r}(t), \quad \vec{r}_e(t) = -\frac{m_p}{m_p + m_e}\vec{r}(t). \tag{16}$$

It is evident from (16) that the proton and electron move in the opposite directions synchronously. So the motions of proton, electron and their relative motion occur with equal frequency

$$\omega_p = \omega_e = \omega_\mu, \tag{17}$$

over the closed trajectories scaling by the ratio

$$\frac{v_e}{v_p} = \frac{m_p}{m_e},\ \frac{v_e}{v_\mu} = \frac{m_\mu}{m_e},\ \frac{v_\mu}{v_p} = \frac{m_p}{m_\mu}. \tag{18}$$

I.A. Schelaev [25] proved that the frequency spectrum of any motion on ellipse contains only one harmonic.

We can get from (16) that

$$\vec{P}_p = \vec{P},\ \vec{P}_e = -\vec{P}, \tag{18a}$$

where – $\vec{P}_i = m_i \dot{\vec{r}}_i$. All three impulses are equal to each other in absolute value, which means the equality of

$$\lambda_D(p) = \lambda_D(e) = \lambda_D(\mu) = h/P. \tag{19}$$

Conclusion:

$\otimes$ *Therefore, the motions of proton and electron and their relative motion occur with the same FREQUENCY, IMPULSE (linear momentum) and the de Broglie WAVELENGTH. All motions are synchronized and self-sustained. Therefore, the whole system -hydrogen atom nondecomposable into independent motions of proton and electron despite the fact that the kinetic energy ratio of electron to proton is small:*

$$\frac{E_k(e)}{E_k(p)} = 4.46 * 10^{-4}.$$

It means that the nuclear and the corresponding atomic processes must be considered as a unified entirely determined whole process as the motions in the Solar system (remember the Moon faces the Earth without changing its visible side, the same case is in hydrogen atoms for protons and electrons)

For example, V.F. Weisskopf [47] came to the conclusion that the maximum height H of mountains in terms of the Bohr radius a is equal to

$$\frac{H}{a} = 2.6 * 10^{14},$$

and water wave lengths λ on the surface of a lake in terms of the Bohr radius is equal to

$$\frac{\lambda}{a} \approx 2\pi * 10^{7}.$$

• The greatness of mountains, the finger sized drop, the shiver of a lake, and the smallness of an atom are all related by simple laws of nature Victor F. Weisskopf [47].

2.8 The Gareev Model

Let us introduce the quantity $f = rv$ which is the invariant of motion, according to the second Kepler law, then

$$\mu v = \frac{\mu v r}{r} = \frac{\mu f}{r}, \tag{20}$$

and we can rewrite equation (14) in the following way:

$$H = \frac{\mu f^2}{2r^2} - \frac{e^2}{r}. \tag{21}$$

We can obtain the minimal value of (21) by taking its first derivative over r and setting it equal to zero. The minimal value occurs at

$$r_0 = \frac{\mu f^2}{e^2}, \tag{22}$$

and the result is

$$H_{min} = E_{min} = -\frac{e^4}{2\mu f^2}. \tag{23}$$

The values of invariant of motion μf (in MeV*s) can be calculated from (23) if we require the equality of E_{min} to the energy of the ground state of a hydrogen atom

$$\mu f = \mu v r = 6.582118 * 10^{-22} = \hbar, \tag{24}$$

Conclusion:

⊗ *The Bohr quantization conditions were introduced as a hypothesis. We obtain these conditions from a classical Hamiltonian requiring its minimality. It is necessary to strongly stress that no assumption was formulated about trajectories of proton and electron. We reproduced exactly the Bohr result and modern quantum theory. The Plank constant $\hbar$ is the Erenfest adiabatic invariant for a hydrogen atom: $\mu vr = \hbar$.*

Let us briefly review our steps:

• We used a well established interaction between proton and electron.

• We used a fundamental fact that the total energy=kinetic energy+potential energy.

• We used the second Kepler law.

• We used usual calculus to determine the minimum values of H.

• We required the equality of E_{min} to the energy of the ground state of hydrogen atom.

Classical Hamiltonian + classical interaction between proton and electron + classical second Kepler law + standard variational calculus – these well established steps in macrophysics reproduce exactly results of the Bohr model and modern quantum theory (Schrodinger equation) – results of microphysics. We have not done anything spectacular or appealed to any revolutionary and breakthrough physics.

2.9 The Gryzinski model

In this subsection we shortly highlighted a very important results (which were entirely ignored and forgotten despite that these papers were published in famous peer-reviewed journals) obtained by M. Gryzinski [26] on the basis of the Newton equation with well established Coulomb interactions. M. Grysinski pointed out that there was a lot of arguments that classical dynamics at the atomic level work, and that the concept of a localized electron was abandoned too early. It is a very interesting to bring some of his quotations (http://www.iea.cyf.gov.pl/gryzinski/misiek.html):

• *Since the time Bohr formulated his famous correspondence principle questioning applicability of classical dynamics to description of atomic system, and Heisenberg spread an electron in space by*

his famous inequality, dynamical considerations initiated by works of Thomson [27] and Rutherford [28] have disappeared from atomic physics almost completely. It was a result of a highly restrictive form of both the principles.

The author ignoring these principles turned back in 1957 to the old idea of a localized electron and showed that the classical collision theory developed on the basis of a classical two body problem worked [29].

On the basis of the Newton equation of motion and Coulomb low there were accurately described:

1. Collisional ionization and excitation of atoms and molecules [30],

2. Ramsauer effect and Vander Waals forces [31, 32],

3. Atomic diamagnetism [33] and atomic energy level shifts [34],

4. Electronic structure of He_2^+ [35] as well as dynamical nature of a covalent bond [36].

M. Gryzinski [26] proved that atoms have the quasi-crystal structure with definite angles: 90°, 109° and 120° which are the well-known angles in crystallography.

2.10 The Gudim-Andreeeva Model

Authors of [37, 38, 39] propose a classical procedure to calculate the potential energy of electrons in the ground state of atoms using the interaction between an electron and a proton in the form

$$V = -\frac{e^2}{r} + \frac{\hbar^2}{2mr^2}.$$

They were able to calculate the ground state energies for six lightest atoms in the reasonable agreement with experimental data.

It is well-known that the electron trajectories in the Kepler problem with the Coulomb potential for the finite motion are represent the closed orbits for any energy. Note that the closed orbits for the binomial potential (g1) exist only for discrete values of energy [37]. The Bohr model use the Coulomb force plus centrifugal one which means that an electron rotate around the nucleus. This assumption leads to the difficulties in the interpretations of the experimental data for the hydrogen atom.

2.11 The Huang Model

We should like to highlight of results obtained by X. Q. Huang [40] using the classical electromagnetic field theory.

• X.Q. Huang wrote [40]:
We study the energy conversion laws of the macroscopic harmonic LC oscillator, the electromagnetic wave (photon) and the hydrogen atom. As our analysis indicates that the energies of these apparently different systems obey exactly the same energy conversion law. Based on our results and the wave-particle duality of electron, we find that the atom in fact is a natural microscopic LC oscillator. In the framework of classical electromagnetic field theory we analytically obtain, for the hydrogen atom, the quantized electron atom orbit radius $r_n = a_0 n^2$, *and quantized energy* $E_n = -R_H hc/n^2, (n = 1, 2, 3, ..)$, *where* a_0 *is the Bohr radius and* R_H *is the Rydberg constant. Without any adaptation of the quantum theory, we present a reasonable explanation of the polarization of photon, the Zeeman effect, Selection rules and Pauli exclusion principle. Our results show that the concept of electron spin is not the physical reality and should be replaced by the intrinsic characteristic of the helical moving electron (Left-hand and Right-hand). In addition, a possible physical mechanism of superconductivity and a deeper physical understanding of the electron mass are also provided.*

X.Q. Huang considered in first time the hydrogen atom as a natural microscopic *LC* oscillator and he obtained the results in excellent agreement with the Bohr model and quantum mechanical theory.

2.12 The Mills Model

The conventional point of view is that the validity of the Maxwell equations is restricted only to the macroscale and that they do not apply to the atomic scale. R.L. Mills [41] developed the model of atoms on the Maxwell equation which he called "The Grand Unified Theory of Classical Quantum Mechanics" (CQM). Under special conditions, an extended distribution of charge may accelerate without radiation energy. The mathematical formulation for zero radiation based on Maxwell's equations follows from a derivation by Haus[42].

This leads to a physical model of subatomic particles, atoms, and molecules.

Equations are closed-form solutions containing fundamental constants only and agree with experimental observations. The calculated energies from exact solutions of one through twenty-electron atoms are available from the internet [43].

• R.L. Mills came to the conclusion: *for 400 atoms and ions the agreement between the predicted and experimental results is remarkable. Other problems exactly solved as further tests of CQM are the anomalous magnetic moment of the electron, the Lamb Shift, the fine structure and superfine structure of the hydrogen atom, the superfine structure intervals of positronium and muonium. The agreement between observations and predictions based on closed-form equations with fundamental constants only matches the limit permitted by the error in the measured fundamental constants.*

The solution of the nature of the electron and photon for the first time also allow for exact solutions of excited states. For ever 100 excited states of the helium atom, the r-squared value is 0.999994, and the typical average relative difference is about 5 significant figures which is within the error of the experimental data.. Using only the Coulomb energy at the calculated radii, the agreement is remarkable. These results demonstrate the predictive power of CQM that further provides the nature of and conditions to form lower-energy states of hydrogen which are also based on electron-photon interactions.

• Conclusion: Splendidly, all atomic models based on either the Newton equation and the Kepler laws or the Maxwell equations, or the Schrodinger and Dirac equations achieved agreement with experimental data.

We can only suspect that these equations are grounded on the same fundamental principle(s) which is (are) not known or these equations can be transformed into each other. R.D. Feynman [44] proved the Maxwell equations assuming only Newton's law of motion and the commutation relation between the position and velocity for a single nonrelativistic particle. The Dirac equation can be rewritten in the Maxwell equations form [45] and the Schrodinger equation can be obtained from Newtonian mechanics [46].

Bohr and Schrodinger assumed that the laws of physics that are valid in the macrosystem do not hold in the microworld of the atom.

We think that the laws in macro- and microworld are the same.

2.13 The Gareev Model. Nuclei, Atoms, Molecules, Bio - molecules, Chrystalls,... as Open Coupled Resonators

Detailed description of this model the reader can found in [1, 3, 5].

1) LENR may be understood in terms of the known fundamental laws without any violation of the basic physics. The fundamental laws of physics should be the same in micro- and macrosystems.

2)Weak and electromagnetic interactions may show a strong influence of the surrounding conditions on the nuclear processes.

3)The conservation laws are valid for closed systems. Therefore, the failure of parity in weak interactions means that the corresponding systems are open systems. Periodic variations (24 hours, 27, and 365 days in beta-decay rates indicate that the failure of parity in weak interactions has a cosmophysical origin. Modern quantum theory is the theory for closed systems. Therefore, it should be reformulated for open systems. The closed systems are idealization of nature, they do not exist in reality.

4)The universal cooperative resonance synchronization principle is a key issue to make a bridge between various scales of interactions and it is responsible for self-organization of hierarchical systems independent of substance, fields, and interactions. We give some arguments in favor of the mechanism ORDER BASED on ORDER, declared by Schrodinger in [12], a fundamental problem of contemporary science.

5)The universal resonance synchronization principle became a fruitful interdisciplinary science of general laws of self-organized processes in different branches of physics because it is the consequence of the energy conservation law and resonance character of any interaction between wave systems. We have proved the homology of atom, molecule and crystal structures including living cells. Distances of these systems are commensurable with the de Broglie wave length of an electron in the ground state of a hydrogen atom, it plays the role of the standard distance, for comparison.

6)First of all, the structure of a hydrogen atom should be established. Proton and electron in a hydrogen atom move with the same frequency that creates attractive forces between them, their motions are synchronized. A hydrogen atom represents the radiating and accepting antennas (dipole) interchanging energies with the surrounding substance. The sum of radiated and absorbed energy flows by electron and proton in a stable orbit is equal to zero [13] the secret of success of the Bohr model (nonradiation of the electron on a stable orbit). "The greatness of mountains, the finger sized drop, the shiver of a lake, and the smallness of an atom are all related by simple laws of nature" Victor F. Weisskopf [47].

7)These flows created standing waves due to the cooperative resonance synchronization principle. A constant energy exchange with substances (with universes) create stable auto-oscillation systems in which the frequencies of external fields and all subsystems are commensurable. The relict radiation (the relict isotropic standing waves at T=2.725 K the Cosmic Microwave Background Radiation (CMBR)) and many isotropic standing waves in cosmic medium [53] should be results of self-organization of the stable atoms, according to the universal cooperative resonance synchronization principle that is a consequence of the fundamental energy conservation law. One of the fundamental predictions of the Hot Big Bang theory for the creation of the Universe is CMBR.

8)The cosmic isotropic standing waves (many of them are not discovered yet) should play the role of a conductor responsible for stability of elementary particles, nuclei, atoms,, galaxies ranging in size more than 55 orders of magnitude.

9)The phase velocity of standing microwaves can be extremely high; therefore, all objects of the Universe should get information from each other almost immediately using phase velocity.

The aim of this paper is to discuss the possibility of inducing and controlling nuclear reactions at low temperatures and pressures by using different low energy external fields and various physical and chemical processes. The main question is the following: is it possible to enhance LENR rates by using low and extremely low energy

external fields? The review of possible stimulation mechanisms is presented in [2, 13]. We will discuss new possibilities to enhance LENR rates in condensed matter.

2.14 The Magarshak model

The Magarshak model was published recently [48]. The abstract and postulates this model are taken from this publication:

As shown recently, the set of electronic configurations of all chemical elements in the subshell partitioning has a four-dimensional structure. Hence, all elements can be subdivided into cycles and supercycles rather than into periods of the conventional Periodic Table. Moreover, in the plane of the principal and orbital quantum numbers there is an obvious symmetry between the hydrogen-atom spectrum (one-electron problem) and electronic configurations of all atoms (multi-electron problem). (It seems that this remarkable finding was done by Yu. Magarshak [49] first time - our remark.) In order to explain these phenomena, it is hypothesized that between shell electrons and nuclei protons there exists a reversible quantum-field interaction (electron+proton $leftrightarrow$ *neutron+neutrino resonance. Even if this interaction were a rare event, it can explain the existence of 4D symmetries mentioned above.Howewer, the model considered here is based on frequent epn interactions, taking place more often than* 10^{15} *per second. in this case, epn resonance and resonance between such resonances are supposed to underline the structure of all atoms and molecules. In particular, the functioning of all biological molecules, including electron transfer and enzymatic activity, is determined by resonance, resonance between resonances, hierarchy of resonance, and networks of resonances.*

Note this conclusion is a consequence of the universal cooperative resonance synchronization principle which we formulated in publications [1, 3, 5, 50]. Schrodinger wrote [51] that an interaction between microscopic physical objects is controlled by specific resonance laws. As the resonance conditions arise from fundamental energy conservation law, rhythms and synchronization of the majority of phenomena to be observed are the reflection of the universal property of self-organization of the Universe. We have demonstrated the universality of the cooperative resonance synchronization principle independent

of substance, fields and interactions for microsystem. Thereby, we bring some arguments in favor of the mechanism – ORDER from ORDER, declared by Schrodinger [12], a fundamental problem of contemporary science.

It is interesting the quotation from the popular in India Shanti mantra [52]:

(That) Resonance: The same resonance, through resonance, expands resonance. By resonance, supplementing resonance remains ever resonant.

The Magarshak model is formulated a such way that unify electrons and nucleons to whole systems –atoms [48]:

RESONANCE MODEL OF THE ATOM

Postulate 1: In atoms, there are no stationary electronic states.

Postulate 2: All electrons constituting the shell of the atom are involved in the process with the following basic steps (collectively called resonance path):

i) $\psi\beta$ capture of a shell electron by the atom nucleus;

ii) electron-proton $\leftrightarrow$ neutron resonance interaction (epn-resonance) of the shell electron with the proton of the nucleus;

iii) by release of the electron from the nuclei and its return to a nonlocalized ψ-state in the shell.

Postulate 3: The physical nature of the $\psi\beta$ shell electron capture by the nucleus, and the $\beta\psi$ by electron release from the nucleus is not the same. The $\psi\beta$ capture takes place owing to the overlap of the electronic ψ-function with the volume occupied by the nucleus. The $\beta\psi$ release of the electron from the nucleus is possible only at energies determined by the Schrodinger equation for the space around the nucleus in which the electronic shell is disposed.

THE RESONANCE NATURE OF THE VALENCE BOND

Postulate 1: In the valence interaction between atoms in a molecule, an electron on the shell of one of the atoms is involved in the epn-resonance interaction with a proton in the nucleus of another atom.

Postulate 2: A valence bond is formed owing to jumps of the shell electron between the nuclei connected by the valence bond, and each jump to a certain nucleus is of the epn-resonance nature.

Postulate 3: In molecules consisting of more than two atoms, resonance between resonances can occur. The number of the hierarchical levels of resonances in Nature is unlimited.

The modern chemical bond models have some well-known difficulties which can be solve these problems by the Magarshak model which provide the basis for the formation of not only molecules, but also solids. However, discussion of this problem is beyond the scope of our paper.

3 LENR in Condensed Matter

Modern understanding of the decay of the neutron is

$$n \rightarrow p + e^{-} + \overline{\nu}_e. \tag{25}$$

The energetics of the decay can be analyzed using the concept of binding energy and the masses of particles by their rest mass energies. The energy balance from neutron decay can be calculated from the particle masses. The rest mass difference ($0.7823 MeV/c^2$) between neutron and (proton+electron) is converted to the kinetic energy of proton, electron, and neutrino. The neutron is about 0.2% more massive than a proton, a mass difference is 1.29 MeV. A free neutron will decay with a half-life of about 10.3 minutes. Neutron in a nucleus will decay if a more stable nucleus results; otherwise neutron in a nucleus will be stable. A half-life of a neutron in nuclei changes dramatically and depends on the isotopes.

The capture of electrons by protons

$$p + e^{-} \rightarrow n + \nu_e, \tag{26}$$

but for free protons and electrons this reaction has never been observed which is the case in nuclear+ atomic physics. The capture of electrons by protons in a nucleus will occurs if a more stable nucleus results.

3.1 Cooperative Processes

The processes (25) and (26) in LENR are going with individual nucleons and electrons. In these cases the rest mass difference is equal to $0.7823 MeV/c^2$. In the case of neutron decay the corresponding energy (Q = 0.7823 MeV) converted to kinetic energies of proton,

electron, and antineutrino. In the case of the capture of electrons by protons the quantity $Q = 0.7823$ MeV is a threshold electron kinetic energy under which the process (26) is forbidden for free proton and electron.

We have formulated the following postulate:
$\otimes$ *The processes (25) and (26) in LENR are going in the whole system: cooperative processes including all nucleons in nuclei and electrons in atoms, in condensed matter. In these cases a threshold energy Q can be drastically decreased by internal energy of the whole system or even more – the electron capture by proton can be accompanied by emission of internal binding energy - main source of excess heat phenomenon in LENR.*

The processes (25) and (26) are weak processes. A weak interaction which is responsible for electron capture and other forms of beta decay is of a very short range. So the rate of electron capture and emission (internal conversion) is proportional to the density of electrons in nuclei. It means that we can manage the electron-capture (emission) rate by the change of the total electron density in the nuclei using different low energy external fields. These fields can play a role of triggers for extracting internal energy of the whole system or subsystems, changing quantum numbers of the initial states in such a way that forbidden transitions become allowed ones. The distances between proton and electron in atoms are of the order $10^{-6} - -10^{-5}$ cm and any external field decreasing these distances even for a small value can increase the process (26) in nuclei in an exponential way. Therefore, the influence of an external electron flux (discharge in condensed matter: breakdown, spark and ark) on the velocity processes (25) and (26) can be of great importance.

The role of external electrons is the same as the catalytic role of neutrons in the case of the chain fission reactions in nuclei – neutrons bring to nuclei binding energies (about 8 MeV) which enhance the fission rates by about 30 orders.

4 Predicted Effects and Experimentum Crucis

Postulated enhancement mechanism of LENR by external fields can be verified by the Experimentum Crucis. We [13] predicted that natural geo-transmutation in the atmosphere and earth occurs in the

regions of a strong change in geo-, bio-, acoustic-,... and electromagnetic fields.

Various electrodynamic processes at thunderstorms are responsible for different phenomena: electromagnetic pulses, γ-rays, electron fluxes, neutron fluxes, and radioactive nuclei fluxes.

4.1 Neutron Production by Thunderstorms

The authors of [59] concluded that a neutron burst is associated with lighting. The total number of neutrons produced by one typical lightning discharge was estimated as $2.5 * 10^{10}$.

4.2 Production of Radiocarbon and Failing of Radiocarbon Dating

The radiocarbon dating is based on the decay rate of radioactive isotope ^{14}C which is believed to be constant irrespective of the physical and chemical conditions. The half-life of radiocarbon ^{14}C is 5730 years. A method for historical chronometry was developed assuming that the decay ratio of ^{14}C and its formation are constant in time. It was postulated that ^{14}C is formed only by the cosmic ray neutrons

$$^{14}N(n,p)^{14}C. \tag{27}$$

Radiocarbon dating is widely used in archeology, geology, antiquities,... There are over 130 radiocarbon dating laboratories. The radiocarbon method of dating was developed by Willard F. Libby who was awarded the Nobel prize in Chemistry for 1960.

The radiocarbon method does not take into account the following facts which have been established recently:

$\otimes$ The neutron production by thunderstorms [59]

$\otimes$ The Production of radiocarbon by lighting bolts [57].

Let us consider the reaction

$$^{14}_{7}N + e^{-} \rightarrow^{14}_{6} C + \nu_e, \tag{27a}$$

$T_k(e)$=156.41 keV is the threshold energy which should by compared with 782.3 keV for process (26). Production of radiocarbon by lighting bolts was established in [57].

4.3 Production Radiophosphorus by Thunderstorms

The life-times of ${}^{32}_{15}P$ and ${}^{33}15P$ are equal to 14.36 and 25.34 days, respectively. They were found in rain-water after thunderstorms [56]. Production of the radiophosphorus by thunderstorms can be understood in the following way:

$$ {}^{32}_{16}S + e^- \rightarrow {}^{32}_{15}\, P + \nu_e, \tag{28} $$

$$ {}^{33}_{16}S + e^- \rightarrow {}^{33}_{15}\, P + \nu_e, \tag{29} $$

thresholds of these processes are equal to 1.710 and 0.240 MeV, respectively. The precipitation of MeV electrons from the inner radiation belt [58] and enhancement of the processes by lightning are possible.

4.4 LENR Stimulated by Condensed Matter Discharge

Let us consider the condensed matter discharge (breakdown, spark and arc) using the different electrode. There are the following processes:

1. The electrode is Ni. Orbital or external electron capture

$$ {}^{58}_{28}Ni(68.27\%) + e^- \rightarrow {}^{58}_{27}\, Co(70.78\ days) + \nu_e, \tag{30} $$

The threshold $Q_1 = 0.37766\ keV$ of this reaction on Ni should be compared with the threshold $Q_2 = 0.7823$ energy for electron capture by free protons: $Q_2/Q_1 \approx 2$. The velocity of orbital electron capture can be enhanced by the discharge.

2.Orbital or external electron capture

$$ {}^{58}_{27}Co(70.78\ days) + e^- \rightarrow {}^{58}_{26}\, Fe(0.28\%) + \nu_e, \tag{31} $$

with emission of energy $Q_2 = 2.30408$ MeV.

3. Double orbital or external electron capture

$$ {}^{58}_{28}Ni(68.27\%) + 2e^- \rightarrow {}^{58}_{26}\, Fe(0.28\%) + 2\nu_e, \tag{32} $$

with emission of energy $Q_3 = 1.92642$ mostly by neutrinos.

The proposed cooperative mechanism of LENR in this case can be proved in an extremely simple way: presence of radioactive ${}^{58}_{27}Co$ and enriched isotope of ${}^{58}_{26}Fe$.

$\otimes$ *This mechanism can give possibilities to get a way of controlling the necessary isotopes and excess heat.*

4.5 Neutrinoless Double Beta Decay

As we known [2], the physical roles of electron and neutrino for LENR in condensed matter has not been investigated in detail up to now despite the fact that weak processes in nuclei are well understood. The double beta decay is the rarest spontaneous nuclear transition,in which the nuclear charge changes by two units while the mass number remains the same. Such a case can occur for the isobaric triplet $A(Z,N)$, $A(Z\pm1,N\mp1)$, $A(Z\pm2,N\mp2)$, in which the middle isobar has a greater rest mass than the extreme ones, and the extremes are the nuclei with the even Z and N. The usual beta-decay transferring a given nucleus into another via an intermediate nucleus is energetically forbidden.

The double beta decay in nuclei can proceed in different modes [60]:

$\otimes$The two neutrinos decay mode $2\nu\beta\beta$ is

$$A(Z,N)\rightarrow A(Z+2,N-2)+2e^{-}+2\overline{\nu}_{e}, \tag{33}$$

which is allowed by the Standard Model of particle physics. The total kinetic energy of two emitted electrons present continuous spectra up to E_{max}.

$\otimes$The neutrinoless mode $0\nu\beta\beta$

$$A(Z,N)\rightarrow A(Z+2,N-2)+2e^{-}, \tag{34}$$

which requires violation of a lepton number. The total kinetic energy of two emitted electrons is equal to E_{max}.

Two neutrinos in the mode $2\nu\beta\beta$ carry out almost all emitted energies. A fundamental question is: Does the neutrinoless double beta decay exist or not (for the review of the history see [60, 61])?. The emerged energies in the neutrinoless $0\nu\beta\beta$ mode are easily detected for practical use but these are the rarest spontaneous nuclear transitions ($T\approx10^{18}-10^{30}$ years). Is it possible to enhance the decay rate?

Above and in [1, 2, 3] we have discussed the cooperative and resonance synchronization enhancement mechanisms of LENR. Some of the low energy external fields can be used as triggers for starting and enhancing exothermic LENR. It is natural to expect that in the case

of beta-decay (capture) the external electron flux with high density, or the laser of high intensity, or any suitable external fields should play this role. Any external field shortening distances between protons in nuclei and electrons in atoms should enhance beta-decay (capture) or double-beta decay (capture).

There is a great number of experiments in Japan, Italy, Russia, US, India, China, Israel, and Canada in which cold transmutations and excess energy were measured (see http://www.lenr-canr.org). Indeed the existence of LENR is now well established but the proposed about 150 theoretical models for interpretation of experimental data are not accepted (A. Takahashi, ICCF12).

It is very popular to use Ni, Pd, Pt and W as electrodes in the condensed matter discharge (breakdown, spark, arc, and explosion) experiments. Let us consider the case of Pd electrodes. The difference of the rest masses are equal

$$m(^{110}_{46}Pd) - m(^{110}_{48}Cd) = 1.9989\ MeV/c^2;$$

therefore, the external field can open the channel $^{110}_{46}Pd \rightarrow ^{110}_{48}Cd$ with $Q = 1.9989$ MeV. In the cases Ni, Pt, and W we have

$$m(^{58}_{28}Ni) - m(^{58}_{26}Fe) = 1.92642\ MeV/c^2,$$
$$m(^{186}_{74}W) - m(^{186}_{76}Os) = 0.47302\ MeV/c^2,$$
$$m(^{198}_{78}Pt) - m(^{198}_{80}Hg) = 1.05285\ MeV/c^2.$$

The proposed cooperative mechanism of LENR in these cases can be proved in an extremely simple way: presence of enriched isotopes of $^{58}_{26}Fe$, $^{110}_{48}Cd$, $^{186}_{76}Os$, and $^{198}_{80}Hg$ for the indicated above electrodes.

The experimental data [62, 63, 64, 65, 66] seem to confirm such expectations.

Therefore, expensive and time consuming double beta decay experiments can be performed in extremely cheap and short-time experiments by using suitable external fields. This new direction of research can give answers for fundamental problems of modern physics (the lepton number conservation, type of neutrino, neutrino mass spectrum,...), it can open production of new elements (utilization of radioactive waste) and excess heat without an ecological problem.

A careful analysis of the double beta decay shows that the $2e^-$ cluster can be responsible for the double beta decay. The difference

between the rest mass $^{130}_{56}Ba$ and $^{130}_{52}Te$, which is equal to 92.55 keV, indicates the possibilities to capture the $4e^-$ cluster by $^{130}_{56}Ba$. It is a full analogy with the Iwamura reactions [67].

5 Quantization of Nuclear and Atomic Rest Masses

Almost all quantomechanical models describe excited states of nuclei, atoms, molecules, condensed matter,... neglecting structure of the ground state of the investigated systems. Therefore, we have very restricted information about the properties of nuclei, atoms,... in their ground states. Note that the mutual influence of the nucleon and electron spin (the superfine splitting), the Mossbauer effect,... are well-known. The processes going in the surrounding matter of nuclei change the nuclear moments and interactions of nucleons in nuclei.

We proved that the motions of proton and electron in the hydrogen atom in the ground state occur with the same frequency; therefore, their motions are synchronized. The cooperation in motion of nucleons in nuclei and electrons in atoms in their ground states is still an open problem for nuclei and atoms having many nucleons and electrons, respectively.

• *We formulate a very simple and audacious working hypothesis: the nuclear and the corresponding atomic processes must be considered as a unified entirely determined whole process. The nucleons in nuclei and the electrons in atoms form open nondecomposable whole systems in which all frequencies and phases of nucleons and electrons are coordinated according to the universal cooperative resonance synchronization principle.*

This hypothesis can be proved at least partly by investigation of the difference between nuclear and atomic rest masses. We performed this analysis for the first time, experimental data from [68].

Table 1.
The differences between nuclear and atomic rest masses
$\Delta M(Z,A) = M_{atom}(Z,A) - M_{nuclei}(Z,A)$,
$\Delta = \Delta M(Z,A) - \Delta M(Z,A-1)$, in MeV/c^2

	ΔM	Δ		ΔM	Δ
${}^{1}_{1}H$	0.51099				
${}^{2}_{1}H$	0.51105	0.00006	${}^{3}_{2}He$	1.02187	
${}^{3}_{1}H$	0.51117	0.00012	${}^{4}_{2}He$	1.02210	0.00023
${}^{4}_{1}H$	0.51093	0.00024	${}^{5}_{2}He$	1.02186	0.00024
${}^{4}_{3}Li$	1.53327		${}^{6}_{2}He$	1.02186	0.00000
${}^{5}_{3}Li$	1.53351	0.00024	${}^{7}_{2}He$	1.02186	0.00000
${}^{6}_{3}Li$	1.53255	0.00096	${}^{8}_{2}He$	1.02186	0.00000
${}^{7}_{3}Li$	1.53350	0.00095	${}^{9}_{2}He$	1.02139	0.00047
${}^{8}_{3}Li$	1.53351	0.00001	${}^{10}_{2}He$	1.02138	0.00001
${}^{9}_{3}Li$	1.53256	0.00095			
${}^{6}_{4}Be$	2.04420		${}^{7}_{5}B$	2.55537	
${}^{8}_{4}Be$	2.04468	0.00048	${}^{8}_{5}B$	2.55537	0.00000
${}^{9}_{4}Be$	2.04468	0.00000	${}^{9}_{5}B$	2.55584	0.00047
${}^{10}_{4}Be$	2.04468	0.00000	${}^{10}_{5}B$	2.55489	0.00095
${}^{11}_{4}Be$	2.04467	0.00001	${}^{11}_{5}B$	2.55584	0.00047
${}^{12}_{4}Be$	2.04373	0.00094	${}^{12}_{5}B$	2.55584	0.00000
${}^{13}_{4}Be$	2.04372	0.00001	${}^{13}_{5}B$	2.55585	0.00001
${}^{14}_{4}Be$	2.04467	0.00095	${}^{14}_{5}B$	2.55489	0.00096
			${}^{15}_{7}B$	2.55585	0.00096
${}^{8}_{6}C$	3.06702		${}^{11}_{7}N$	3.57914	
${}^{9}_{6}C$	3.06702	0.00000	${}^{12}_{7}N$	3.57819	0.00095
${}^{10}_{6}C$	3.06701	0.00001	${}^{13}_{7}N$	3.57819	0.00000
${}^{11}_{6}C$	3.06702	0.00001	${}^{14}_{7}N$	3.57818	0.00001
${}^{12}_{6}C$	3.06702	0.00000	${}^{15}_{7}N$	3.57818	0.00000
${}^{13}_{6}C$	3.06702	0.00000	${}^{16}_{7}N$	3.58819	0.00001
${}^{14}_{6}C$	3.06702	0.00000	${}^{17}_{7}N$	3.57818	0.00001
${}^{15}_{6}C$	3.06701	0.00001	${}^{18}_{7}N$	3.57818	0.00000
${}^{16}_{6}C$	3.06702	0.00001	${}^{19}_{7}N$	3.57818	0.00000
${}^{17}_{6}C$	3.06702	0.00000	${}^{20}_{7}N$	3.57628	0.00190
${}^{18}_{6}C$	3.06893	0.00191	${}^{21}_{7}N$	3.57818	0.00190
			${}^{22}_{7}N$	3.57819	0.00001

Table 1 (continued)

	ΔM	Δ		ΔM	Δ
$^{12}_{8}O$	4.09031		$^{15}_{9}F$	4.60148	
$^{13}_{8}O$	4.09031	0.00000	$^{16}_{9}F$	4.60243	0.00095
$^{14}_{8}O$	4.08936	0.00095	$^{17}_{9}F$	4.60147	0.00096
$^{15}_{8}O$	4.09031	0.00095	$^{18}_{9}F$	4.60244	0.00097
$^{16}_{8}O$	4.09031	0.00000	$^{19}_{9}F$	4.60243	0.00001
$^{17}_{8}O$	4.09031	0.00000	$^{20}_{9}F$	4.60243	0.00000
$^{18}_{8}O$	4.08936	0.00095	$^{21}_{9}F$	4.60434	0.00191
$^{19}_{8}O$	4.08936	0.00000	$^{22}_{9}F$	4.60052	0.00382
$^{20}_{8}O$	4.09031	0.00095	$^{23}_{9}F$	4.60053	0.00001
$^{21}_{8}O$	4.09126	0.00095	$^{24}_{9}F$	4.60053	0.00000
$^{22}_{8}O$	4.08936	0.00190	$^{25}_{9}F$	4.60052	0.00001
$^{16}_{10}Ne$	5.11360		$^{19}_{11}Na$	5.62477	
$^{17}_{10}Ne$	5.11360	0.00000	$^{20}_{11}Na$	5.62668	0.00191
$^{18}_{10}Ne$	5.11361	0.00001	$^{21}_{11}Na$	5.62477	0.00191
$^{19}_{10}Ne$	5.11361	0.00000	$^{22}_{11}Na$	5.62477	0.00000
$^{20}_{10}Ne$	5.11360	0.00001	$^{23}_{11}Na$	5.62477	0.00000
$^{21}_{10}Ne$	5.11550	0.00190	$^{24}_{11}Na$	5.62478	0.00001
$^{22}_{10}Ne$	5.11360	0.00190	$^{25}_{11}Na$	5.62477	0.00001
$^{23}_{10}Ne$	5.11360	0.00000	$^{26}_{11}Na$	5.62667	0.00190
$^{24}_{10}Ne$	5.11169	0.00191	$^{27}_{11}Na$	5.62478	0.00189
$^{25}_{10}Ne$	5.11169	0.00000	$^{28}_{11}Na$	5.62667	0.00189
$^{26}_{10}Ne$	5.11170	0.00001	$^{29}_{11}Na$	5.62667	0.00001
$^{20}_{12}Mg$	6.13594		$^{24}_{14}Si$	7.16018	
$^{21}_{12}Mg$	6.13594	0.00000	$^{25}_{14}Si$	7.16018	0.00000
$^{22}_{12}Mg$	6.13785	0.00191	$^{26}_{14}Si$	7.16209	0.00191
$^{23}_{12}Mg$	6.13785	0.00000	$^{27}_{14}Si$	7.16210	0.00001
$^{24}_{12}Mg$	6.13785	0.00000	$^{28}_{14}Si$	7.16209	0.00001
$^{25}_{12}Mg$	6.13785	0.00000	$^{29}_{14}Si$	7.16209	0.00000
$^{26}_{12}Mg$	6.13785	0.00000	$^{30}_{14}Si$	7.16210	0.00001
$^{27}_{12}Mg$	6.13594	0.00191	$^{31}_{14}Si$	7.16209	0.00001
$^{28}_{12}Mg$	6.13784	0.00190	$^{32}_{14}Si$	7.16210	0.00001
$^{29}_{12}Mg$	6.13594	0.00190	$^{33}_{14}Si$	7.16019	0.00191
$^{26}_{12}Mg$	6.13594	0.00000			

Table 1 (continued)

	ΔM	Δ		ΔM	Δ
$^{28}_{15}P$	7.67517		$^{28}_{16}S$	8.18824	
$^{29}_{15}P$	7.67517	0.00000	$^{29}_{16}S$	8.18634	0.00190
$^{30}_{15}P$	7.67517	0.00000	$^{30}_{16}S$	8.18634	0.00000
$^{31}_{15}P$	7.67326	0.00191	$^{31}_{16}S$	8.18634	0.00000
$^{32}_{15}P$	7.67327	0.00001	$^{32}_{16}S$	8.18634	0.00000
$^{33}_{15}P$	7.67327	0.00000	$^{33}_{16}S$	8.18634	0.00000
$^{34}_{15}P$	7.67326	0.00001	$^{34}_{16}S$	8.18634	0.00000
$^{35}_{15}P$	7.67135	0.00191	$^{35}_{16}S$	8.18634	0.00000
$^{36}_{15}P$	7.67517	0.00382	$^{36}_{16}S$	8.18634	0.00000
$^{37}_{15}P$	7.67135	0.00382	$^{37}_{16}S$	8.19016	0.00382
$^{38}_{15}P$	7.67135	0.00000	$^{38}_{16}S$	8.18252	0.00764
$^{39}_{15}P$	7.67517	0.00382	$^{39}_{16}S$	8.19015	0.00763
$^{40}_{15}P$	7.67136	0.00381	$^{40}_{16}S$	8.18634	0.00381
$^{41}_{15}P$	7.67899	0.00763	$^{41}_{16}S$	8.18634	0.00000
$^{85}_{40}Zr$	20.54596		$^{85}_{41}Nb$	21.05713	
$^{86}_{40}Zr$	20.53070	0.01526	$^{86}_{41}Nb$	21.04950	0.00763
$^{87}_{40}Zr$	20.54596	0.01526	$^{87}_{41}Nb$	21.04950	0.00000
$^{88}_{40}Zr$	20.53833	0.00763	$^{88}_{41}Nb$	21.04950	0.00000
$^{89}_{40}Zr$	20.53070	0.00763	$^{89}_{41}Nb$	21.05713	0.00763
$^{90}_{40}Zr$	20.53833	0.00763	$^{90}_{41}Nb$	21.05713	0.00000
$^{91}_{40}Zr$	20.53071	0.00762	$^{91}_{41}Nb$	21.04950	0.00763
$^{92}_{40}Zr$	20.53833	0.00762	$^{92}_{41}Nb$	21.05713	0.00763
$^{93}_{40}Zr$	20.53833	0.00000	$^{93}_{41}Nb$	21.05713	0.00000
$^{94}_{40}Zr$	20.53833	0.00000	$^{94}_{41}Nb$	21.05713	0.00000
$^{95}_{40}Zr$	20.53833	0.00000	$^{95}_{41}Nb$	21.04950	0.00763
$^{96}_{40}Zr$	20.53070	0.00763	$^{96}_{41}Nb$	21.04950	0.00000
$^{97}_{40}Zr$	20.53833	0.00763	$^{97}_{41}Nb$	21.05713	0.00763
$^{98}_{40}Zr$	20.53833	0.00000	$^{98}_{41}Nb$	21.05713	0.00000

Table 1 (continued)

	ΔM	Δ		ΔM	Δ
$^{199}_{82}Pb$	42.43470		$^{199}_{83}Bi$	42.96875	
$^{200}_{82}Pb$	42.43469	0.00001	$^{200}_{83}Bi$	42.96875	0.00000
$^{201}_{82}Pb$	42.43469	0.00000	$^{201}_{83}Bi$	42.95349	0.01526
$^{202}_{82}Pb$	42.44995	0.01526	$^{202}_{83}Bi$	42.98401	0.03052
$^{203}_{82}Pb$	42.43470	0.01525	$^{203}_{83}Bi$	42.96875	0.01526
$^{204}_{82}Pb$	42.43469	0.00001	$^{204}_{83}Bi$	42.96875	0.00000
$^{205}_{82}Pb$	42.44996	0.01526	$^{205}_{83}Bi$	42.96875	0.00000
$^{206}_{82}Pb$	42.43469	0.01527	$^{206}_{83}Bi$	42.96875	0.00000
$^{207}_{82}Pb$	42.43469	0.00000	$^{207}_{83}Bi$	42.96875	0.00000
$^{208}_{82}Pb$	42.43469	0.00000	$^{208}_{83}Bi$	42.96875	0.00000
$^{209}_{82}Pb$	42.43469	0.00000	$^{209}_{83}Bi$	42.96875	0.00000
$^{210}_{82}Pb$	42.44995	0.01526	$^{210}_{83}Bi$	42.96875	0.00000
$^{211}_{82}Pb$	42.43469	0.01526	$^{211}_{83}Bi$	42.96875	0.00000
$^{212}_{82}Pb$	42.44995	0.01526	$^{212}_{83}Bi$	42.96875	0.00000
$^{229}_{92}U$	47.72949		$^{229}_{93}Np$	48.26354	
$^{230}_{92}U$	47.71423	0.01526	$^{230}_{93}Np$	48.24830	0.01524
$^{231}_{92}U$	47.71423	0.00000	$^{231}_{93}Np$	48.24829	0.00001
$^{232}_{92}U$	47.71424	0.00001	$^{233}_{93}Np$	48.24829	0.00000
$^{233}_{92}U$	47.72951	0.01527	$^{234}_{93}Np$	48.24829	0.00000
$^{234}_{92}U$	47.71424	0.01527	$^{235}_{93}Np$	48.26355	0.01526
$^{235}_{92}U$	47.71423	0.00001	$^{236}_{93}Np$	48.23304	0.03051
$^{236}_{92}U$	47.72949	0.01526	$^{237}_{93}Np$	48.24829	0.01525
$^{237}_{92}U$	47.72949	0.00000	$^{238}_{93}Np$	48.24829	0.00000
$^{238}_{92}U$	47.71424	0.01525	$^{239}_{93}Np$	48.24829	0.00000
$^{239}_{92}U$	47.71423	0.00001	$^{240}_{93}Np$	48.24829	0.00000
$^{240}_{92}U$	47.71424	0.00001	$^{241}_{93}Np$	48.24829	0.00000

We demonstrated only a small part of our results in Tables 1. The differences between nuclear and atomic rest masses are quantized: $\Delta\Delta M = 0.06,\ 0.11 - 0.12,\ 0.24,\ 0.47 - 0.48,\ 0.94 - 0.96,\ 1.89 - 1.91,\ 2.86,\ 3.81 - 3.82,\ 7.62 - 7.64,\ 15.25 - 15.27,\ 30.50 - 30.53\ keV/c^2$. The minimal value of the quanta is equal to $\Delta\Delta M \approx 0.06\ keV/c^2$.

• The differences of nuclear and atomic rest masses are quantized

$$\Delta\Delta M = M_0 * 2^n,\ \ n = 1, 2, 3, ... \tag{35}$$

where $M_0 \approx 0.06\ keV/c^2$. It is essential to note that this new phenomenological quantization rule of mass differences introduced a simple doubling process of the mass quanta M_0. What is a mechanism of such quantization?

5.1 Electron Capture and β-decay

The main quantity which characterizes electron capture and β-decay processes in nuclei is the rest mass differences $\Delta M(A, Z, Z' = Z \pm 1, Z \pm 2)$ of the initial and final atoms with the same atomic number.

We observed accidentally long time ago (seventies) that some quantities ΔM are the same or their ratios are equal to an integer number for the atoms independent of A and Z:

$$\Delta M = n * 0.167847,\ n = 1, 2, 3, ...12$$

One can see from Table 2 that the quantities $\delta =\mid \Delta M(exp) - n * 0.167847 \mid$ are equal to zero or 0.00001 MeV/c^2 within the experimental errors.

Table 2.
The differences between atomic rest masses
$\Delta M(exp) = M(A, Z) - M(A, Z'), Z - Z' = \pm 1, \pm 2,$
$M(theory) = n * 0.167847 \mid$.

Atoms	$\Delta M(exp)$	n*0.167847
$m(^{35}_{16}S) - m(^{35}_{17}Cl)$	0.16785	1*0.167847=0.16785
$m(^{96}_{40}Zr) - m(^{96}_{41}Nb)$	0.16785	1*0.167847=0.16785
$m(^{100}_{43}Tc) - m(^{100}_{42}Mo)$	0.16785	1*0.167847=0.16785
$m(^{111}_{47}Ag) - m(^{111}_{49}In)$	0.16784	1*0.167847=0.16785
$m(^{145}_{61}Pm) - m(^{145}_{60}Nd)$	0.16785	1*0.167847=0.16785
$m(^{198}_{79}Au) - m(^{198}_{78}Pt)$	0.33569	2*0.167847=0.33569
$m(^{153}_{64}Gd) - m(^{153}_{63}Eu)$	0.50354	3*0.167847=0.50354
$m(^{177}_{71}Lu) - m(^{177}_{72}Hf)$	0.50354	3*0.167847=0.50354
$m(^{183}_{73}Ta) - m(^{183}_{75}Re)$	0.50354	3*0.167847=0.50354
$m(^{127}_{54}Xe) - m(^{127}_{55}I)$	0.67139	4*0.167847=0.67139
$m(^{175}_{72}Hf) - m(^{175}_{71}Lu)$	0.67138	4*0.167847=0.67139
$m(^{177}_{73}Ta) - m(^{177}_{71}Lu)$	0.67138	4*0.167847=0.67139

Table 2 (continued)

Atoms	ΔM	n*0.167847
$m(^{70}_{30}Zn) - m(^{70}_{32}Ge)$	1.00708	6*0.167847=1.00708
$m(^{129}_{55}Cs) - m(^{129}_{53}I)$	1.00708	6*0.167847=1.00708
$m(^{185}_{76}Os) - m(^{185}_{75}Re)$	1.00708	6*0.167847=1.00708
$m(^{189}_{75}Re) - m(^{189}_{76}Os)$	1.00708	6*0.167847=1.00708
$m(^{75}_{32}Ge) - m(^{75}_{33}As)$	1.17493	7*0.167847=1.17493
$m(^{102}_{46}Pd) - m(^{102}_{44}Ru)$	1.17492	7*0.167847=1.17493
$m(^{166}_{69}Tm) - m(^{166}_{67}Ho)$	1.17493	7*0.167847=1.17493
$m(^{177}_{73}Ta) - m(^{177}_{72}Hf)$	1.17492	7*0.167847=1.17493
$m(^{232}_{92}U) - m(^{232}_{91}Pa)$	1.34277	8*0.167847=1.34277
$m(^{244}_{94}Pu) - m(^{244}_{96}Cm)$	1.34277	8*0.167847=1.34277
$m(^{147}_{63}Eu) - m(^{147}_{61}Pm)$	1.51062	9*0.167847=1.51062
$m(^{187}_{77}Ir) - m(^{187}_{76}Os)$	1.51062	9*0.167847=1.51062
$m(^{187}_{77}Ir) - m(^{187}_{75}Re)$	1.51062	9*0.167847=1.51062
$m(^{98}_{43}Tc) - m(^{98}_{42}Mo)$	1.67847	10*0.167847=1.67847
$m(^{168}_{69}Tm) - m(^{168}_{68}Er)$	1.67846	10*0.167847=1.67847
$m(^{162}_{68}Er) - m(^{162}_{66}Dy)$	1.84631	11*0.167847=1.84632
$m(^{92}_{41}Nb) - m(^{92}_{40}Zr)$	2.01416	12*0.167847=2.01416
$m(^{156}_{66}Dy) - m(^{156}_{64}Gd)$	2.01416	12*0.167847=2.01416

We decided to investigate in a systematic way the differences between atomic rest masses with the same atomic numbers in which the number of electrons differs to one or two. The unique restriction was the requirement that the final atoms (nuclei) should be stable. We are not able to present all results only a very small amount shown below in Tables 3. The calculations were performed by formula $\Delta M = n * 0.0076294,\ MeV/c^2,\ n$-integer number.

Table 3.
The differences between atomic rest masses ΔM, *in* MeV/c^2

Atoms	$\Delta M(exp)$	n*0.0076294	δ
$m(^{127}_{52}Tl) - m(^{127}_{54}Xe)$	0.03051	4*a=0.03052	0.00001
$m(^{164}_{68}Er) - m(^{164}_{66}Dy)$	0.03052	4*a=0.03052	0.00000
$m(^{184}_{76}Os) - m(^{184}_{75}Re)$	0.04578	6*a=0.04578	0.00000
$m(^{193}_{78}Pt) - m(^{193}_{77}Ir)$	0.06103	8*a=0.06103	0.00000
$m(^{151}_{62}Sm) - m(^{151}_{63}Eu)$	0.06103	8*a=0.06103	0.00000
$m(^{136}_{54}Xe) - m(^{136}_{55}Cs)$	0.06866	9*a=0.06866	0.00000
$m(^{136}_{54}Xe) - m(^{136}_{58}Ce)$	0.06866	9*a=0.06866	0.00000
$m(^{157}_{65}Tb) - m(^{157}_{64}Gd)$	0.07630	10*a=0.07629	0.00001
$m(^{150}_{61}Pm) - m(^{150}_{60}Nd)$	0.09155	12*a=0.09155	0.00000
$m(^{244}_{95}Am) - m(^{244}_{94}Pu)$	0.09155	12*a=0.09155	0.00000
$m(^{130}_{56}Ba) - m(^{130}_{52}Te)$	0.09155	12*a=0.09155	0.00000
$m(^{171}_{69}Tm) - m(^{171}_{70}Yb)$	0.10681	14*a=0.10681	0.00000
$m(^{176}_{71}Lu) - m(^{176}_{70}Yb)$	0.10681	14*a=0.10681	0.00000
$m(^{179}_{73}Ta) - m(^{179}_{72}Hf)$	0.10681	14*a=0.10681	0.00000
$m(^{98}_{42}Mo) - m(^{98}_{44}Ru)$	0.11444	15*a=0.11444	0.00000
$m(^{193}_{76}Os) - m(^{193}_{77}Ir)$	0.11444	15*a=0.11444	0.00000
$m(^{235}_{93}Np) - m(^{235}_{92}U)$	0.12207	16*a=0.12207	0.00000
$m(^{180}_{74}W) - m(^{180}_{72}Hf)$	0.13733	18*a=0.13733	0.00000
$m(^{197}_{78}Pt) - m(^{197}_{80}Hg)$	0.13733	18*a=0.13733	0.00000
$m(^{238}_{93}Np) - m(^{238}_{92}U)$	0.15258	20*a=0.15259	0.00001
$m(^{35}_{16}S) - m(^{35}_{17}Cl)$	0.16785	22*a=0.16785	0.00000
$m(^{96}_{40}Zr) - m(^{96}_{41}Nb)$	0.16785	22*a=0.16785	0.00000
$m(^{100}_{43}Tc) - m(^{100}_{42}Mo)$	0.16785	22*a=0.16785	0.00000
$m(^{111}_{47}Ag) - m(^{111}_{49}In)$	0.16784	22*a=0.16785	0.00001
$m(^{145}_{61}Pm) - m(^{145}_{60}Nd)$	0.16785	22*a=0.16785	0.00000
$m(^{178}_{71}Lu) - m(^{178}_{73}Ta)$	0.18310	24*a=0.18311	0.00001
$m(^{181}_{74}W) - m(^{181}_{73}Ta)$	0.18310	24*a=0.18311	0.00001
$m(^{106}_{46}Ag) - m(^{106}_{48}Gd)$	0.19836	26*a=0.19836	0.00000
$m(^{190}_{77}Ir) - m(^{190}_{76}Os)$	0.19834	26*a=0.19836	0.00002
$m(^{200}_{81}Tl) - m(^{200}_{79}Au)$	0.21363	28*a=0.21362	0.00001
$m(^{195}_{79}Au) - m(^{195}_{78}Pt)$	0.21363	28*a=0.21362	0.00001
$m(^{175}_{72}Hf) - m(^{175}_{70}Yb)$	0.21362	28*a=0.21362	0.00000
$m(^{103}_{44}Ru) - m(^{103}_{46}Pd)$	0.22126	29*a=0.22125	0.00001
$m(^{147}_{61}Pm) - m(^{147}_{62}Sm)$	0.22888	30*a=0.22888	0.00000
$m(^{155}_{63}Eu) - m(^{155}_{64}Gd)$	0.22888	30*a=0.22888	0.00000

Table 3 (continued).

$m(^{55}_{26}Fe) - m(^{55}_{25}Mn)$	0.22888	30*a=0.22888	0.00000
$m(^{71}_{32}Ge) - m(^{71}_{31}Ga)$	0.23651	31*a=0.23651	0.00000
$m(^{194}_{79}Au) - m(^{194}_{77}Ir)$	0.24414	32*a=0.24414	0.00000
$m(^{96}_{43}Tc) - m(^{96}_{44}Ru)$	0.25177	33*a=0.25177	0.00000
$m(^{168}_{69}Tm) - m(^{168}_{70}Yb)$	0.25940	34*a=0.25940	0.00000
$m(^{167}_{67}Ho) - m(^{167}_{69}Tm)$	0.25940	34*a=0.25940	0.00000
$m(^{161}_{67}Ho) - m(^{161}_{65}Tb)$	0.25940	34*a=0.25940	0.00000
$m(^{108}_{48}Cd) - m(^{108}_{46}Pd)$	0.26703	35*a=0.26703	0.00000
$m(^{135}_{55}Cs) - m(^{135}_{56}Ba)$	0.26703	35*a=0.26703	0.00000
$m(^{158}_{66}Dy) - m(^{158}_{64}Gd)$	0.27465	36*a=0.27466	0.00001
$m(^{139}_{58}Ce) - m(^{139}_{57}La)$	0.27466	36*a=0.27466	0.00000
$m(^{81}_{36}Kr) - m(^{81}_{35}Br)$	0.28229	37*a=0.28229	0.00000
$m(^{174}_{71}Lu) - m(^{174}_{72}Hf)$	0.28992	38*a=0.28992	0.00000
$m(^{124}_{53}I) - m(^{124}_{54}Xe)$	0.28992	38*a=0.28992	0.00000
$m(^{91}_{39}Y) - m(^{91}_{41}Nb)$	0.28992	38*a=0.28992	0.00000
$m(^{99}_{43}Tc) - m(^{99}_{44}Ru)$	0.29755	39*a=0.29755	0.00000
$m(^{117}_{51}Sb) - m(^{117}_{49}In)$	0.29754	39*a=0.29755	0.00001
$m(^{153}_{62}Sm) - m(^{153}_{64}Gd)$	0.30517	40*a=0.30518	0.00001
$m(^{162}_{67}Ho) - m(^{162}_{68}Er)$	0.30518	40*a=0.30518	0.00000
$m(^{191}_{76}Os) - m(^{191}_{77}Ir)$	0.30518	40*a=0.30518	0.00000
$m(^{93}_{42}Mo) - m(^{93}_{40}Zr)$	0.31280	41*a=0.31281	0.00001
$m(^{75}_{32}Ge) - m(^{75}_{34}Se)$	0.31281	41*a=0.31281	0.00000
$m(^{170}_{69}Tm) - m(^{170}_{68}Er)$	0.32043	42*a=0.32043	0.00000
$m(^{113}_{48}Cd) - m(^{113}_{49}In)$	0.32043	42*a=0.32043	0.00000
$m(^{97}_{43}Tc) - m(^{97}_{42}Mo)$	0.32043	42*a=0.32043	0.00000
$m(^{198}_{79}Au) - m(^{198}_{78}Pt)$	0.33569	44*a=0.33569	0.00000
$m(^{73}_{33}As) - m(^{73}_{32}Ge)$	0.34332	45*a=0.34332	0.00000
$m(^{131}_{55}Cs) - m(^{131}_{54}Xe)$	0.35095	46*a=0.35095	0.00000
$m(^{169}_{68}Er) - m(^{169}_{69}Tm)$	0.35095	46*a=0.35095	0.00000
$m(^{204}_{81}Tl) - m(^{204}_{80}Hg)$	0.35095	46*a=0.35095	0.00000
$m(^{54}_{24}Cr) - m(^{54}_{26}Fe)$	0.35095	46*a=0.35095	0.00000
$m(^{72}_{33}As) - m(^{72}_{31}Ga)$	0.35095	46*a=0.35095	0.00000
$m(^{159}_{66}Dy) - m(^{159}_{65}Tb)$	0.36621	48*a=0.36621	0.00000
$m(^{140}_{57}La) - m(^{140}_{59}Pr)$	0.36621	48*a=0.36621	0.00000
$m(^{130}_{55}Cs) - m(^{130}_{56}Ba)$	0.36621	48*a=0.36621	0.00000

Table 3 (continued).

$m(^{122}_{50}Sn) - m(^{122}_{52}Te)$	0.36621	48*a=0.36621	0.00000
$m(^{92}_{41}Nb) - m(^{92}_{42}Mo)$	0.36621	48*a=0.36621	0.00000
$m(^{85}_{38}Sr) - m(^{85}_{36}Kr)$	0.37384	49*a=0.37384	0.00000
$m(^{165}_{68}Er) - m(^{165}_{67}Ho)$	0.38147	50*a=0.38147	0.00000
$m(^{121}_{50}Sn) - m(^{111}_{51}Sb)$	0.38910	51*a=0.38910	0.00000
$m(^{149}_{61}Pm) - m(^{149}_{63}Eu)$	0.39673	52*a=0.39673	0.00000
$m(^{151}_{64}Gd) - m(^{151}_{62}Sm)$	0.39673	52*a=0.39673	0.00000
$m(^{43}_{21}Sc) - m(^{43}_{19}K)$	0.40436	53*a=0.40436	0.00000
$m(^{93}_{42}Mo) - m(^{93}_{41}Nb)$	0.40436	53*a=0.40436	0.00000
$m(^{192}_{76}Os) - m(^{192}_{78}Pt)$	0.41199	54*a=0.41199	0.00000
$m(^{41}_{20}Ca) - m(^{41}_{19}K)$	0.41962	55*a=0.41962	0.00000
$m(^{67}_{31}Ga) - m(^{67}_{29}Cu)$	0.42725	56*a=0.42725	0.00000
$m(^{130}_{53}I) - m(^{130}_{52}Te)$	0.42725	56*a=0.42725	0.00000
$m(^{133}_{54}Xe) - m(^{133}_{55}Cs)$	0.42725	56*a=0.42725	0.00000
$m(^{156}_{65}Tb) - m(^{156}_{66}Dy)$	0.42725	56*a=0.42725	0.00000
$m(^{185}_{74}W) - m(^{185}_{75}Re)$	0.42724	56*a=0.42725	0.00001
$m(^{204}_{80}Hg) - m(^{204}_{82}Pb)$	0.42724	56*a=0.42725	0.00001
$m(^{25}_{13}Al) - m(^{25}_{11}Na)$	0.44250	58*a=0.30518	0.00000
$m(^{123}_{52}Te) - m(^{123}_{51}Sb)$	0.45777	60*a=0.45776	0.00001
$m(^{151}_{64}Gd) - m(^{151}_{63}Eu)$	0.45776	60*a=0.45776	0.00000
$m(^{175}_{70}Yb) - m(^{175}_{71}Lu)$	0.45776	60*a=0.45776	0.00000
$m(^{199}_{79}Au) - m(^{199}_{80}Hg)$	0.45776	60*a=0.45776	0.00000
$m(^{136}_{57}La) - m(^{136}_{58}Ce)$	0.46539	61*a=0.46539	0.00000
$m(^{186}_{74}W) - m(^{186}_{76}Os)$	0.47302	62*a=0.47302	0.00000
$m(^{203}_{80}Hg) - m(^{203}_{81}Tl)$	0.47302	62*a=0.47302	0.00000
$m(^{232}_{91}Pa) - m(^{132}_{90}Th)$	0.48828	64*a=0.48828	0.00000
$m(^{203}_{82}Pb) - m(^{203}_{80}Hg)$	0.48829	64*a=0.48828	0.00001
$m(^{201}_{81}Tl) - m(^{201}_{80}Hg)$	0.48828	64*a=0.48828	0.00000
$m(^{189}_{77}Ir) - m(^{189}_{75}Re)$	0.48828	64*a=0.48828	0.00000
$m(^{115}_{49}In) - m(^{115}_{50}Sn)$	0.49591	65*a=0.49591	0.00000
$m(^{153}_{64}Gd) - m(^{153}_{63}Eu)$	0.50354	66*a=0.50354	0.00000
$m(^{177}_{71}Lu) - m(^{177}_{72}Hf)$	0.50354	66*a=0.50354	0.00000
$m(^{183}_{73}Ta) - m(^{183}_{75}Re)$	0.50354	66*a=0.50354	0.00000

Table 3 (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{86}_{37}Rb) - m(^{86}_{36}Te)$	0.51117	67*a=0.51117	0.00000
$m(^{189}_{77}Ir) - m(^{189}_{76}Os)$	0.51880	68*a=0.51880	0.00000
$m(^{133}_{56}Ba) - m(^{133}_{55}Cs)$	0.52643	69*a=0.52643	0.00000
$m(^{114}_{48}Cd) - m(^{114}_{50}Sn)$	0.54168	71*a=0.54169	0.00001
$m(^{144}_{61}Pm) - m(^{144}_{62}Sm)$	0.54931	72*a=0.54932	0.00001
$m(^{148}_{60}Nd) - m(^{148}_{61}Pm)$	0.54932	72*a=0.54932	0.00000
$m(^{101}_{45}Rh) - m(^{101}_{44}Ru)$	0.54932	72*a=0.54932	0.00000
$m(^{103}_{46}Pd) - m(^{103}_{45}Rh)$	0.54932	72*a=0.54932	0.00000
$m(^{10}_{5}B) - m(^{10}_{4}Be)$	0.55695	73*a=0.55695	0.00000
$m(^{39}_{18}Ar) - m(^{39}_{19}K)$	0.56458	74*a=0.56458	0.00000
$m(^{105}_{45}Rh) - m(^{105}_{46}Pd)$	0.56458	74*a=0.56458	0.00000
$m(^{169}_{70}Yb) - m(^{169}_{68}Er)$	0.56458	74*a=0.56458	0.00000
$m(^{64}_{29}Cu) - m(^{64}_{30}Zn)$	0.57983	76*a=0.57983	0.00000
$m(^{125}_{51}Sb) - m(^{125}_{53}I)$	0.57983	76*a=0.57983	0.00000
$m(^{137}_{55}Cs) - m(^{137}_{57}La)$	0.57984	76*a=0.57983	0.00001
$m(^{141}_{58}Ce) - m(^{141}_{59}Pr)$	0.57983	76*a=0.57983	0.00000
$m(^{185}_{76}Os) - m(^{185}_{74}W)$	0.57984	76*a=0.57983	0.00001
$m(^{124}_{54}Xe) - m(^{124}_{50}Sn)$	0.58747	77*a=0.58747	0.00000
$m(^{197}_{80}Hg) - m(^{197}_{79}Au)$	0.59510	78*a=0.59509	0.00001
$m(^{186}_{75}Re) - m(^{186}_{74}W)$	0.59509	78*a=0.59509	0.00000
$m(^{161}_{65}Tb) - m(^{161}_{66}Dy)$	0.59510	78*a=0.59509	0.00001
$m(^{155}_{65}Tb) - m(^{155}_{63}Eu)$	0.59509	78*a=0.59509	0.00000
$m(^{53}_{25}Mn) - m(^{53}_{24}Cr)$	0.59510	78*a=0.59509	0.00001
$m(^{47}_{21}Sc) - m(^{47}_{22}Ti)$	0.60272	79*a=0.60272	0.00000
$m(^{49}_{23}V) - m(^{49}_{22}Ti)$	0.60273	79*a=0.60272	0.00001
$m(^{137}_{57}La) - m(^{137}_{56}Ba)$	0.60272	79*a=0.60272	0.00000
$m(^{159}_{64}Gd) - m(^{159}_{66}Dy)$	0.61035	80*a=0.61035	0.00000
$m(^{190}_{77}Ir) - m(^{190}_{78}Pt)$	0.61035	80*a=0.61035	0.00000
$m(^{124}_{51}Sb) - m(^{124}_{50}Sn)$	0.61798	81*a=0.61798	0.00000
$m(^{131}_{53}I) - m(^{131}_{55}Cs)$	0.62561	82*a=0.62561	0.00000
$m(^{173}_{69}Tm) - m(^{173}_{71}Lu)$	0.62561	82*a=0.62561	0.00000
$m(^{96}_{40}Zr) - m(^{96}_{44}Ru)$	0.63324	83*a=0.63324	0.00000
$m(^{172}_{71}Lu) - m(^{172}_{69}Tm)$	0.64087	84*a=0.64087	0.00000

Table 3 (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{121}_{52}Te) - m(^{121}_{50}Sn)$	0.64850	85*a=0.64850	0.00000
$m(^{70}_{31}Ga) - m(^{70}_{30}Zn)$	0.64850	85*a=0.64850	0.00000
$m(^{170}_{68}Er) - m(^{170}_{70}Yb)$	0.65613	86*a=0.65613	0.00000
$m(^{209}_{82}Pb) - m(^{209}_{83}Bi)$	0.65613	86*a=0.65613	0.00000
$m(^{112}_{49}In) - m(^{112}_{50}Sn)$	0.66376	87*a=0.66376	0.00000
$m(^{127}_{54}Xe) - m(^{127}_{53}I)$	0.67139	88*a=0.67139	0.00000
$m(^{175}_{72}Hf) - m(^{175}_{71}Lu)$	0.67138	88*a=0.67139	0.00001
$m(^{177}_{73}Ta) - m(^{177}_{71}Rh)$	0.67138	88*a=0.67139	0.00001
$m(^{196}_{79}Au) - m(^{196}_{80}Hg)$	0.67139	88*a=0.67139	0.00000
$m(^{54}_{26}Fe) - m(^{54}_{24}Cr)$	0.67902	89*a=0.67902	0.00000
$m(^{77}_{35}Br) - m(^{77}_{33}As)$	0.67902	89*a=0.67902	0.00000
$m(^{138}_{58}Ce) - m(^{138}_{56}Ba)$	0.68664	90*a=0.68665	0.00001
$m(^{149}_{63}Eu) - m(^{149}_{62}Sm)$	0.68665	90*a=0.68665	0.00000
$m(^{173}_{71}Lu) - m(^{173}_{70}Yb)$	0.68665	90*a=0.68665	0.00000
$m(^{188}_{77}Ir) - m(^{188}_{75}Re)$	0.68665	90*a=0.68665	0.00000
$m(^{85}_{36}Kr) - m(^{85}_{37}Rb)$	0.69428	91*a=0.69428	0.00000
$m(^{127}_{52}Te) - m(^{127}_{53}I)$	0.70190	92*a=0.70190	0.00000
$m(^{154}_{63}Eu) - m(^{154}_{62}Sm)$	0.70191	92*a=0.70190	0.00001
$m(^{54}_{25}Mn) - m(^{54}_{26}Fe)$	0.70190	92*a=0.70190	0.00000
$m(^{78}_{35}Br) - m(^{78}_{36}Kr)$	0.70190	92*a=0.70190	0.00000
$m(^{180}_{73}Ta) - m(^{180}_{74}W)$	0.71716	94*a=0.71716	0.00000
$m(^{191}_{78}Pt) - m(^{191}_{76}Os)$	0.71717	94*a=0.71716	0.00001
$m(^{113}_{50}Sn) - m(^{113}_{48}Cd)$	0.71716	94*a=0.71716	0.00000
$m(^{167}_{67}Ho) - m(^{167}_{68}Er)$	0.73242	96*a=0.73242	0.00000
$m(^{197}_{78}Pt) - m(^{197}_{79}Au)$	0.73242	96*a=0.73242	0.00000
$m(^{52}_{25}Mn) - m(^{52}_{23}V)$	0.74005	97*a=0.74005	0.00000
$m(^{142}_{59}Pr) - m(^{142}_{58}Ce)$	0.74768	98*a=0.74768	0.00000
$m(^{125}_{51}Sb) - m(^{125}_{52}Te)$	0.76294	100*a=0.76294	0.00000
$m(^{95}_{43}Tc) - m(^{95}_{41}Nb)$	0.76294	100*a=0.76294	0.00000
$m(^{201}_{79}Au) - m(^{201}_{81}Tl)$	0.76294	100*a=0.76294	0.00000
$m(^{103}_{44}Ru) - m(^{103}_{45}Rh)$	0.77057	101*a=0.77057	0.00000
$m(^{105}_{47}Ag) - m(^{105}_{45}Rh)$	0.77819	102*a=0.77820	0.00001
$m(^{204}_{81}Tl) - m(^{204}_{80}Hg)$	0.77820	102*a=0.77820	0.00000

Table 3 (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{106}_{62}Sm) - m(^{106}_{63}Eu)$	0.80871	106*a=0.80871	0.00000
$m(^{37}_{18}Ar) - m(^{37}_{17}Cl)$	0.81635	107*a=0.81635	0.00000
$m(^{134}_{54}Xe) - m(^{134}_{56}Ba)$	0.82397	108*a=0.89397	0.00000
$m(^{155}_{65}Tb) - m(^{155}_{64}Gd)$	0.82397	108*a=0.89397	0.00000
$m(^{196}_{80}Hg) - m(^{196}_{78}Pt)$	0.82397	108*a=0.89397	0.00000
$m(^{132}_{56}Ba) - m(^{132}_{54}Xe)$	0.83161	109*a=0.83160	0.00001
$m(^{181}_{72}Hf) - m(^{181}_{74}W)$	0.83924	110*a=0.83923	0.00001
$m(^{232}_{90}Th) - m(^{232}_{92}U)$	0.85449	112*a=0.85449	0.00000
$m(^{161}_{67}Ho) - m(^{161}_{66}Dy)$	0.85450	112*a=0.85449	0.00001
$m(^{180}_{73}Ta) - m(^{180}_{72}Hf)$	0.85449	112*a=0.85449	0.00000
$m(^{54}_{25}Mn) - m(^{54}_{24}Cr)$	0.86212	113*a=0.86212	0.00000
$m(^{75}_{34}Se) - m(^{75}_{33}As)$	0.86212	113*a=0.86212	0.00000
$m(^{56}_{27}Co) - m(^{56}_{25}Mn)$	0.86975	114*a=0.86975	0.00000
$m(^{111}_{49}In) - m(^{111}_{48}Ag)$	0.86976	114*a=0.86975	0.00001
$m(^{128}_{52}Te) - m(^{128}_{54}Xe)$	0.86976	114*a=0.86975	0.00001
$m(^{58}_{27}Co) - m(^{58}_{28}Ni)$	0.89264	117*a=0.89264	0.00000
$m(^{84}_{37}Rb) - m(^{84}_{38}Sr)$	0.89264	117*a=0.89264	0.00000
$m(^{110}_{47}Ag) - m(^{110}_{46}Pd)$	0.89264	117*a=0.89264	0.00000
$m(^{126}_{54}Xe) - m(^{126}_{52}Te)$	0.89264	117*a=0.89264	0.00000
$m(^{94}_{41}Nb) - m(^{94}_{40}Zr)$	0.90027	118*a=0.90027	0.00000
$m(^{109}_{46}Pd) - m(^{109}_{48}Cd)$	0.90027	118*a=0.90027	0.00000
$m(^{195}_{77}Ir) - m(^{195}_{77}Au)$	0.90027	118*a=0.90027	0.00000
$m(^{69}_{30}Zn) - m(^{69}_{31}Ga)$	0.90790	119*a=0.90790	0.00000
$m(^{76}_{33}As) - m(^{76}_{32}Ge)$	0.92316	121*a=0.92316	0.00000
$m(^{95}_{41}Nb) - m(^{95}_{42}Mo)$	0.93078	122*a=0.93079	0.00001
$m(^{135}_{57}La) - m(^{135}_{55}Cs)$	0.93078	122*a=0.93079	0.00001
$m(^{143}_{59}Pr) - m(^{143}_{60}Nd)$	0.93079	112*a=0.93079	0.00000
$m(^{158}_{65}Tb) - m(^{158}_{66}Dy)$	0.94605	124*a=0.94605	0.00000
$m(^{164}_{67}Ho) - m(^{164}_{68}Er)$	0.96130	126*a=0.96130	0.00000
$m(^{203}_{82}Pb) - m(^{203}_{81}Tl)$	0.96131	126*a=0.96130	0.00001
$m(^{159}_{64}Gd) - m(^{159}_{65}Tb)$	0.97656	128*a=0.97656	0.00000
$m(^{131}_{53}I) - m(^{131}_{44}Xe)$	0.97656	128*a=0.97656	0.00000
$m(^{120}_{51}Sb) - m(^{120}_{52}Te)$	0.97656	128*a=0.97656	0.00000
$m(^{170}_{69}Tm) - m(^{170}_{70}Yb)$	0.97656	128*a=0.97656	0.00000

Table (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{46}_{20}Ca) - m(^{46}_{22}Ti)$	0.99182	130*a=0.99182	0.00000
$m(^{207}_{81}Tl) - m(^{207}_{83}Bi)$	0.99182	130*a=0.99182	0.00000
$m(^{199}_{81}Tl) - m(^{199}_{79}Au)$	0.99182	130*a=0.99182	0.00000
$m(^{182}_{75}Re) - m(^{182}_{73}Ta)$	0.99182	130*a=0.99182	0.00000
$m(^{167}_{67}Ho) - m(^{167}_{68}Er)$	0.99182	130*a=0.99182	0.00000
$m(^{164}_{67}Ho) - m(^{164}_{66}Dy)$	0.99182	130*a=0.99182	0.00000
$m(^{38}_{19}K) - m(^{38}_{17}Cl)$	0.99946	131*a=0.99946	0.00000
$m(^{70}_{30}Zn) - m(^{70}_{32}Ge)$	1.00708	132*a=1.00708	0.00000
$m(^{129}_{55}Cs) - m(^{129}_{53}I)$	1.00708	132*a=1.00708	0.00000
$m(^{185}_{76}Os) - m(^{185}_{75}Re)$	1.00708	132*a=1.00708	0.00000
$m(^{189}_{75}Re) - m(^{189}_{76}Os)$	1.00708	132*a=1.00708	0.00000
$m(^{181}_{72}Hf) - m(^{181}_{73}Ta)$	1.02234	134*a=1.02234	0.00000
$m(^{191}_{78}Pt) - m(^{191}_{76}Os)$	1.02234	134*a=1.02234	0.00000
$m(^{50}_{23}V) - m(^{50}_{24}Cr)$	1.03760	136*a=1.03760	0.00000
$m(^{111}_{47}Ag) - m(^{111}_{48}Cd)$	1.03760	136*a=1.03760	0.00000
$m(^{113}_{50}Sn) - m(^{113}_{49}In)$	1.03759	136*a=1.03760	0.00001
$m(^{121}_{52}Te) - m(^{121}_{51}Sb)$	1.03760	136*a=1.03760	0.00000
$m(^{138}_{57}La) - m(^{138}_{58}Ce)$	1.03760	136*a=1.03760	0.00000
$m(^{143}_{61}Pm) - m(^{143}_{60}Nd)$	1.05286	138*a=1.05286	0.00000
$m(^{192}_{77}Ir) - m(^{192}_{76}Os)$	1.05285	138*a=1.05286	0.00001
$m(^{198}_{78}Pt) - m(^{198}_{80}Hg)$	1.05285	138*a=1.05286	0.00001
$m(^{183}_{73}Ta) - m(^{183}_{74}W)$	1.06811	140*a=1.06812	0.00001
$m(^{186}_{75}Re) - m(^{186}_{76}Os)$	1.06811	140*a=1.06812	0.00001
$m(^{85}_{38}Sr) - m(^{85}_{37}Rb)$	1.06812	140*a=1.06812	0.00000
$m(^{101}_{43}Tc) - m(^{101}_{45}Rh)$	1.07574	141*a=1.07575	0.00001
$m(^{149}_{61}Pm) - m(^{149}_{62}Sm)$	1.08338	142*a=1.08337	0.00001
$m(^{176}_{70}Yb) - m(^{176}_{72}Hf)$	1.08337	142*a=1.08337	0.00000
$m(^{193}_{76}Os) - m(^{193}_{78}Pt)$	1.08338	142*a=1.08338	0.00001
$m(^{174}_{72}Hf) - m(^{174}_{70}Yb)$	1.09863	144*a=1.09863	0.00000
$m(^{195}_{77}Ir) - m(^{195}_{78}Pt)$	1.11389	146*a=1.11389	0.00000
$m(^{109}_{46}Pd) - m(^{109}_{47}Ag)$	1.11389	146*a=1.11389	0.00000
$m(^{238}_{92}U) - m(^{238}_{94}Pu)$	1.12916	148*a=1.12915	0.00001
$m(^{104}_{45}Rh) - m(^{104}_{44}Ru)$	1.13678	149*a=1.13678	0.00000
$m(^{193}_{76}Os) - m(^{193}_{77}Ir)$	1.14441	150*a=1.14441	0.00000

Table 3 (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{36}_{16}S) - m(^{36}_{17}Cl)$	1.14441	150*a=1.14441	0.00000
$m(^{94}_{40}Zr) - m(^{94}_{42}Mo)$	1.14441	150*a=1.14441	0.00000
$m(^{102}_{45}Rh) - m(^{102}_{46}Pd)$	1.15204	151*a=1.15204	0.00000
$m(^{210}_{83}Bi) - m(^{210}_{84}Po)$	1.15966	152*a=1.15967	0.00001
$m(^{75}_{32}Ge) - m(^{75}_{33}As)$	1.17493	154*a=1.17493	0.00000
$m(^{102}_{46}Pd) - m(^{102}_{44}Ru)$	1.17492	154*a=1.17493	0.00001
$m(^{166}_{69}Tm) - m(^{166}_{67}Ho)$	1.17493	154*a=1.17493	0.00000
$m(^{177}_{73}Ta) - m(^{177}_{72}Hf)$	1.17492	154*a=1.17493	0.00001
$m(^{137}_{55}Cs) - m(^{137}_{56}Ba)$	1.18256	155*a=1.18256	0.00000
$m(^{176}_{71}Lu) - m(^{176}_{72}Hf)$	1.19018	156*a=1.19019	0.00001
$m(^{129}_{55}Cs) - m(^{129}_{54}Xe)$	1.19018	156*a=1.19019	0.00000
$m(^{135}_{57}La) - m(^{135}_{56}Ba)$	1.19781	157*a=1.19782	0.00001
$m(^{74}_{34}Se) - m(^{74}_{32}Ge)$	1.20545	158*a=1.20545	0.00000
$m(^{54}_{25}Mn) - m(^{54}_{26}Fe)$	1.21307	159*a=1.21307	0.00000
$m(^{134}_{55}Cs) - m(^{134}_{56}Ba)$	1.22071	160*a=1.22070	0.00001
$m(^{158}_{65}Tb) - m(^{158}_{64}Gd)$	1.22070	160*a=1.22070	0.00000
$m(^{141}_{60}Nd) - m(^{141}_{58}Ce)$	1.25122	164*a=1.25122	0.00000
$m(^{154}_{62}Sm) - m(^{154}_{64}Gd)$	1.25122	164*a=1.25122	0.00000
$m(^{201}_{79}Au) - m(^{201}_{80}Hg)$	1.25122	164*a=1.25122	0.00000
$m(^{209}_{84}Po) - m(^{209}_{82}Pb)$	1.25122	164*a=1.25122	0.00000
$m(^{73}_{31}Ga) - m(^{73}_{33}As)$	1.25122	164*a=1.25122	0.00000
$m(^{91}_{41}Nb) - m(^{91}_{40}Zr)$	1.25122	164*a=1.25122	0.00000
$m(^{128}_{53}I) - m(^{128}_{52}Te)$	1.25122	164*a=1.25122	0.00000
$m(^{86}_{36}Kr) - m(^{86}_{38}Sr)$	1.25885	165*a=1.25885	0.00000
$m(^{126}_{53}I) - m(^{126}_{54}Xe)$	1.25885	165*a=1.25885	0.00000
$m(^{132}_{55}Cs) - m(^{132}_{56}Ba)$	1.28173	168*a=1.28174	0.00001
$m(^{238}_{93}Np) - m(^{238}_{94}Pu)$	1.28173	168*a=1.28174	0.00001
$m(^{157}_{63}Eu) - m(^{158}_{65}Tb)$	1.29699	170*a=1.29700	0.00001
$m(^{81}_{34}Se) - m(^{81}_{36}Kr)$	1.30462	171*a=1.30463	0.00001
$m(^{104}_{44}Ru) - m(^{104}_{46}Pd)$	1.30463	171*a=1.30463	0.00000
$m(^{173}_{69}Tm) - m(^{173}_{70}Yb)$	1.31226	172*a=1.31226	0.00000
$m(^{40}_{19}K) - m(^{40}_{20}Ca)$	1.31226	172*a=1.31226	0.00000
$m(^{69}_{32}Ge) - m(^{69}_{30}Zn)$	1.31988	173*a=1.31988	0.00000
$m(^{89}_{40}Zr) - m(^{89}_{38}Sr)$	1.33514	175*a=1.33514	0.00000

Table 3 (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{105}_{47}Ag) - m(^{105}_{46}Pd)$	1.34277	176*a=1.34277	0.00000
$m(^{232}_{91}Pa) - m(^{232}_{92}U)$	1.34277	176*a=1.34277	0.00000
$m(^{244}_{94}Pu) - m(^{244}_{96}Cm)$	1.34277	176*a=1.34277	0.00000
$m(^{65}_{30}Zn) - m(^{65}_{29}Cu)$	1.35040	177*a=1.35040	0.00000
$m(^{74}_{33}As) - m(^{74}_{34}Se)$	1.35040	177*a=1.35040	0.00000
$m(^{123}_{50}Sn) - m(^{123}_{52}Te)$	1.35040	177*a=1.35040	0.00000
$m(^{77}_{35}Br) - m(^{77}_{34}Se)$	1.36566	177*a=1.36566	0.00000
$m(^{157}_{63}Eu) - m(^{157}_{64}Cd)$	1.37329	180*a=1.37329	0.00000
$m(^{171}_{71}Lu) - m(^{171}_{69}Tm)$	1.37329	180*a=1.37329	0.00000
$m(^{190}_{78}Pt) - m(^{190}_{76}Os)$	1.37329	180*a=1.37329	0.00000
$m(^{202}_{81}Tl) - m(^{202}_{80}Hg)$	1.37329	180*a=1.37329	0.00000
$m(^{54}_{25}Mn) - m(^{54}_{24}Cr)$	1.38092	181*a=1.38092	0.00000
$m(^{107}_{48}Cd) - m(^{107}_{46}Pd)$	1.38855	182*a=1.38855	0.00000
$m(^{174}_{71}Lu) - m(^{174}_{70}Yb)$	1.38855	182*a=1.38855	0.00000
$m(^{198}_{79}Au) - m(^{198}_{80}Hg)$	1.38855	182*a=1.38855	0.00000
$m(^{179}_{71}Lu) - m(^{179}_{72}Hf)$	1.40381	184*a=1.40381	0.00000
$m(^{49}_{21}Sc) - m(^{49}_{23}V)$	1.40381	184*a=1.40381	0.00000
$m(^{123}_{50}Sn) - m(^{123}_{51}Sb)$	1.41144	185*a=1.41144	0.00000
$m(^{142}_{58}Ce) - m(^{142}_{60}Nd)$	1.41907	186*a=1.41907	0.00000
$m(^{168}_{70}Yb) - m(^{168}_{68}Er)$	1.41906	186*a=1.41907	0.00001
$m(^{207}_{81}Tl) - m(^{207}_{82}Pb)$	1.41907	186*a=1.41907	0.00000
$m(^{235}_{91}Pa) - m(^{235}_{92}U)$	1.41907	186*a=1.41907	0.00000
$m(^{244}_{95}Am) - m(^{244}_{96}Cm)$	1.43432	188*a=1.43432	0.00000
$m(^{114}_{49}In) - m(^{114}_{48}Cd)$	1.44959	190*a=1.44959	0.00000
$m(^{184}_{76}Os) - m(^{184}_{74}W)$	1.44958	190*a=1.44959	0.00001
$m(^{199}_{81}Tl) - m(^{199}_{80}Hg)$	1.44958	190*a=1.44959	0.00001
$m(^{117}_{49}In) - m(^{117}_{50}Sn)$	1.45722	191*a=1.45722	0.00000
$m(^{146}_{61}Pm) - m(^{146}_{60}Nd)$	1.46484	192*a=1.46484	0.00000
$m(^{192}_{77}Ir) - m(^{192}_{78}Pt)$	1.46484	192*a=1.46484	0.00000
$m(^{79}_{36}Kr) - m(^{79}_{34}Se)$	1.46485	192*a=1.46484	0.00001
$m(^{184}_{75}Re) - m(^{184}_{74}W)$	1.49536	196*a=1.49536	0.00000
$m(^{196}_{79}Au) - m(^{196}_{78}Pt)$	1.49536	196*a=1.49536	0.00000
$m(^{89}_{38}Sr) - m(^{89}_{39}Y)$	1.49536	196*a=1.49536	0.00000
$m(^{40}_{18}Ar) - m(^{40}_{19}K)$	1.50299	197*a=1.50299	0.00000

Table 3 (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{147}_{63}Eu) - m(^{147}_{61}Pm)$	1.51062	198*a=1.51062	0.00000
$m(^{187}_{77}Ir) - m(^{187}_{76}Os)$	1.51062	198*a=1.51062	0.00000
$m(^{187}_{77}Ir) - m(^{187}_{75}Re)$	1.51062	198*a=1.51062	0.00000
$m(^{206}_{81}Tl) - m(^{206}_{82}Pb)$	1.52588	200*a=1.52588	0.00000
$m(^{146}_{61}Pm) - m(^{146}_{62}Sm)$	1.52588	200*a=1.52588	0.00000
$m(^{205}_{80}Hg) - m(^{205}_{81}Tl)$	1.54114	202*a=1.54114	0.00000
$m(^{91}_{39}Y) - m(^{91}_{40}Zr)$	1.54113	202*a=1.54114	0.00001
$m(^{59}_{26}Fe) - m(^{59}_{27}Co)$	1.56403	205*a=1.56403	0.00000
$m(^{202}_{79}Au) - m(^{202}_{81}Tl)$	1.57165	206*a=1.57165	0.00000
$m(^{81}_{34}Se) - m(^{81}_{35}Br)$	1.58691	208*a=1.58691	0.00000
$m(^{87}_{39}Yb) - m(^{87}_{38}Rb)$	1.58691	208*a=1.58691	0.00000
$m(^{73}_{31}Ga) - m(^{73}_{32}Ge)$	1.59454	209*a=1.59454	0.00000
$m(^{97}_{41}Nb) - m(^{97}_{43}Tc)$	1.61743	212*a=1.61743	0.00000
$m(^{122}_{51}Sb) - m(^{122}_{52}Te)$	1.61743	212*a=1.61743	0.00000
$m(^{101}_{43}Tc) - m(^{101}_{44}Ru)$	1.62506	213*a=1.62506	0.00000
$m(^{79}_{36}Kr) - m(^{79}_{35}Br)$	1.62507	213*a=1.62506	0.00001
$m(^{145}_{59}Pr) - m(^{145}_{61}Pm)$	1.63269	214*a=1.63269	0.00000
$m(^{92}_{42}Mo) - m(^{92}_{40}Zr)$	1.64795	216*a=1.64795	0.00000
$m(^{108}_{47}Ag) - m(^{108}_{48}Cd)$	1.64795	216*a=1.64795	0.00000
$m(^{18}_{9}F) - m(^{18}_{8}O)$	1.65558	217*a=1.65558	0.00000
$m(^{70}_{31}Ga) - m(^{70}_{32}Ge)$	1.65558	217*a=1.65558	0.00000
$m(^{95}_{43}Tc) - m(^{95}_{42}Mo)$	1.69372	222*a=1.69373	0.00001
$m(^{88}_{37}Rb) - m(^{88}_{39}Y)$	1.69372	222*a=1.69373	0.00000
$m(^{120}_{52}Te) - m(^{120}_{50}Sn)$	1.70135	223*a=1.70136	0.00001
$m(^{138}_{57}La) - m(^{138}_{56}Ba)$	1.72424	226*a=1.72424	0.00000
$m(^{147}_{53}Eu) - m(^{147}_{62}Sm)$	1.73950	228*a=1.73950	0.00000
$m(^{99}_{45}Rh) - m(^{99}_{43}Tc)$	1.74713	229*a=1.74713	0.00000
$m(^{117}_{51}Sb) - m(^{117}_{50}Nd)$	1.75476	230*a=1.75476	0.00000
$m(^{86}_{37}Rb) - m(^{86}_{38}Sr)$	1.77002	232*a=1.77002	0.00000
$m(^{144}_{62}Sm) - m(^{144}_{60}Nd)$	1.78528	234*a=1.78528	0.00001
$m(^{84}_{38}Sr) - m(^{84}_{36}Kr)$	1.78528	234*a=1.78528	0.00000
$m(^{98}_{43}Tc) - m(^{98}_{44}Ru)$	1.79291	235*a=1.79291	0.00000
$m(^{145}_{59}Pr) - m(^{145}_{60}Nd)$	1.80054	236*a=1.80054	0.00000
$m(^{163}_{65}Tb) - m(^{163}_{66}Dy)$	1.80054	236*a=1.80054	0.00000
$m(^{163}_{65}Tb) - m(^{163}_{67}Ho)$	1.80054	236*a=1.80054	0.00000

Table 3 (continued).

Atoms	ΔM	n*0.0076294	δ
$m(^{45}_{22}Ti) - m(^{45}_{20}Ca)$	1.80816	237*a=1.80817	0.00001
$m(^{152}_{63}Eu) - m(^{152}_{64}Gd)$	1.81579	238*a=1.81580	0.00001
$m(^{182}_{73}Ta) - m(^{182}_{74}W)$	1.81580	238*a=1.81580	0.00000
$m(^{43}_{19}K) - m(^{43}_{20}Ca)$	1.81580	238*a=1.81580	0.00000
$m(^{141}_{60}Nd) - m(^{141}_{59}Pr)$	1.83105	240*a=1.83106	0.00001
$m(^{162}_{68}Er) - m(^{162}_{66}Dy)$	1.84631	242*a=1.84631	0.00000
$m(^{166}_{67}Ho) - m(^{166}_{68}Er)$	1.86157	244*a=1.86157	0.00000
$m(^{87}_{39}Yb) - m(^{87}_{38}Sr)$	1.86157	244*a=1.86157	0.00000
$m(^{80}_{35}Br) - m(^{80}_{34}Se)$	1.87684	246*a=1.87683	0.00001
$m(^{152}_{63}Eu) - m(^{152}_{62}Sm)$	1.87683	246*a=1.87683	0.00000
$m(^{172}_{69}Tm) - m(^{172}_{70}Yb)$	1.89209	248*a=1.89209	0.00000
$m(^{209}_{84}Po) - m(^{209}_{83}Bi)$	1.90735	250*a=1.90735	0.00000
$m(^{108}_{47}Ag) - m(^{108}_{46}Pd)$	1.91498	251*a=1.91498	0.00000
$m(^{112}_{50}Sn) - m(^{112}_{48}Cd)$	1.92260	252*a=1.92261	0.00001
$m(^{148}_{60}Nd) - m(^{148}_{62}Sm)$	1.92261	252*a=1.92261	0.00000
$m(^{178}_{73}Ta) - m(^{178}_{71}Lu)$	1.92261	252*a=1.92261	0.00000
$m(^{123}_{50}Sn) - m(^{123}_{51}Sb)$	1.93023	253*a=1.93024	0.00000
$m(^{97}_{41}Nb) - m(^{97}_{42}Mo)$	1.93787	254*a=1.93787	0.00000
$m(^{154}_{63}Eu) - m(^{154}_{64}Gd)$	1.95313	256*a=1.95313	0.00000
$m(^{190}_{77}Ir) - m(^{190}_{76}Os)$	1.98364	260*a=1.98364	0.00000
$m(^{122}_{51}Sb) - m(^{122}_{52}Te)$	1.98365	260*a=1.98364	0.00001
$m(^{114}_{49}In) - m(^{114}_{50}Sn)$	1.99127	261*a=1.99127	0.00000
$m(^{110}_{46}Pd) - m(^{110}_{48}Cd)$	1.99890	262*a=1.99890	0.00000
$m(^{49}_{21}Sc) - m(^{49}_{22}Ti)$	2.00654	263*a=2.00653	0.00001
$m(^{80}_{35}Br) - m(^{80}_{36}Kr)$	2.00653	263*a=2.00653	0.00000
$m(^{92}_{41}Nb) - m(^{92}_{40}Zr)$	2.01416	264*a=2.01416	0.00000
$m(^{156}_{66}Dy) - m(^{156}_{64}Gd)$	2.01416	264*a=2.01416	0.00000
$m(^{139}_{56}Ba) - m(^{139}_{58}Ce)$	2.02942	266*a=2.02942	0.00000
$m(^{94}_{41}Nb) - m(^{94}_{42}Mo)$	2.04468	268*a=2.04468	0.00000
$m(^{99}_{45}Rh) - m(^{99}_{44}Ru)$	2.04468	268*a=2.04468	0.00000
$m(^{134}_{55}Cs) - m(^{134}_{56}Ba)$	2.04468	268*a=2.04468	0.00000
$m(^{178}_{71}Lu) - m(^{178}_{72}Hf)$	2.10571	276*a=2.10571	0.00000
$m(^{132}_{55}Cs) - m(^{132}_{54}Xe)$	2.11334	277*a=2.11334	0.00000
$m(^{188}_{75}Re) - m(^{188}_{76}Os)$	2.12097	278*a=2.12097	0.00000
$m(^{128}_{53}I) - m(^{128}_{54}Xe)$	1.12098	278*a=2.12097	0.00001

The rest mass differences of atoms in the $\beta-decay$ (single and double) and electron capture (single and double) processes are quantized by the formula

$$M = \frac{n_1}{n_2} * 0.0076294,\ (MeV/c^2), \tag{35}$$

where n_1 are integer numbers and $n_2 = 1, 2, 4, 8$. The cases with $n_2 = 1$ and $n_1 = 4, ...278$ are presented in Tables 3.

5.2 α-decay

The differences between atomic rest masses in the case of α-decay were calculated by the formula

$$\Delta M = m(^{A}_{Z}X) - m(^{A-4}_{Z-2}Y) - m(\alpha)$$

and are presented in Tables 4.

Table 4.

Nuclei	ΔM	$\Delta\Delta M$	n*0.0076294	δ
$^{237}_{93}Np$	4.96791			
$^{233}_{92}U$	4.90689	0.06102	8*a=0.06103	0.00001
$^{229}_{90}Th$	5.16630	0.25941	34*a=0.25940	0.00001
$^{225}_{89}Ac$	5.92923	0.76293	100*a=0.76294	0.00001
$^{221}_{87}Fr$	6.44803	0.51880	68*a=0.51880	0.00000
$^{217}_{85}At$	7.22623	0.77820	102*a=0.77820	0.00000
$^{213}_{83}Bi$	5.97500	1.25123	164*a=1.25122	0.00001
$^{213}_{84}Po$	8.52323	2.54823	334*a=2.54822	0.00001
$^{228}_{90}Th$	5.51724	3.00599	394*a=3.00598	0.00001
$^{224}_{88}Ra$	5.79190	0.27466	36*a=0.27466	0.00000
$^{220}_{86}Rn$	6.40225	0.61035	80*a=0.61035	0.00000
$^{216}_{84}Po$	6.90580	0.50355	66*a=0.50354	0.00001
$^{212}_{83}Bi$	6.20389	0.70191	92*a=0.70190	0.00001
$^{212}_{84}Po$	8.93522	2.73133	358*a=2.73133	0.00000
$^{218}_{86}Rn$	7.25674	1.67848	220*a=1.67847	0.00001
$^{218}_{85}At$	6.87528	0.38146	50*a=0.38147	0.00001
$^{214}_{83}Bi$	5.62406	1.25122	164*a=1.25122	0.00000

Table 4(continued).

Nuclei	ΔM	$\Delta\Delta M$	n*0.0076294	δ
$^{235}_{92}U$	4.67800			
$^{231}_{91}Pa$	5.15103	0.47303	62*a=0.47302	0.00001
$^{227}_{89}Ac$	5.04422	0.10681	14*a=0.10681	0.00000
$^{223}_{87}Fr$	5.42569	0.38147	50*a=0.38147	0.00000
$^{219}_{85}At$	6.38700	0.96131	126*a=0.96130	0.00001
$^{227}_{90}Th$	6.14286	0.24414	32*a=0.24414	0.00000
$^{223}_{88}Ra$	5.97500	0.16786	22*a=0.16785	0.00001
$^{219}_{86}Rn$	6.93631	0.96131	126*a=0.96130	0.00001
$^{215}_{84}Po$	7.53140	0.59509	78*a=0.59509	0.00000
$^{215}_{85}At$	8.17227	0.64087	84*a=0.64087	0.00000
$^{211}_{33}Bi$	6.76847	1.40380	184*a=1.40381	0.00001
$^{238}_{92}U$	4.26603	2.50244	328*a=2.50244	0.00000
$^{234}_{92}U$	4.86112	0.59509	78*a=0.59509	0.00000
$^{230}_{90}Th$	4.75430	0.10681	14*a=0.10681	0.00000
$^{226}_{88}Ra$	4.89164	0.13734	18*a=0.13733	0.00001
$^{222}_{86}Ru$	5.57828	0.68664	90*a=0.68665	0.00001
$^{218}_{84}Po$	6.11233	0.53405	70*a=0.53406	0.00001
$^{210}_{83}Bi$	5.04422	1.06811	140*a=1.06812	0.00001
$^{210}_{84}Po$	5.41044	0.36622	48*a=0.36621	0.00000

6 Conclusion

We come to the conclusion that all atomic models based on either the Newton equation and the Kepler laws, or the Maxwell equations or the Schrodinger and Dirac equations are in reasonable agreement with experimental data. We can only suspect that these equations are grounded on the same fundamental principle(s) which is (are) not known or these equations can be transformed into each other.

Bohr and Schrodinger assumed that the laws of physics that are valid in the macrosystem do not hold in the microworld of the atom. We think that the laws in macro- and microworld are the same.

We proposed a new mechanism of LENR: cooperative processes in the whole system - nuclei+atoms+condensed matter - nuclear reactions in plasma - can occur at smaller threshold energies than the corresponding ones on free constituents. The cooperative processes can be induced and enhanced by low energy external fields, according

to the universal resonance synchronization principle. The excess heat is the emission of internal energy and transmutations at LENR are the result of redistribution inner energy of the whole system.

We were able to quantize phenomenologically (numerology) the first time the differences between atomic and nuclear rest masses by the formula (in MeV/c^2)

$$\Delta M = 0.0076294 * \frac{n_1}{n_2},\ n_1 = 1, 2, 3, ..., n_2 = 1, 2, 4, 8. \qquad (36)$$

Note that this quantization rule is justified for atoms and nuclei with different A, N and Z, and the nuclei and atoms represent a coherent synchronized systems - a complex of coupled oscillators (resonators). It means that nucleons in nuclei and electrons in atoms contain all necessary information about the structure of other nuclei and atoms. This information is used and reproduced by simple rational relations, according to the fundamental conservation law of energy-momentum. We originated the universal cooperative resonance synchronization principle and this principle is the consequence of the conservation law of energy-momentum. As a final result the nucleons in nuclei and electrons in atoms have commensurable frequencies and the differences between those frequencies are responsible for creation of beating modes. The phase velocity of standing beating waves can be extremely high; therefore, all objects of the Universe should get information from each other almost immediately (instantaneously) using phase velocity [1, 3]. Remember that the beating (modulated) modes are responsible for radio and TV-casting.

Therefore, we came to understand the Mach principle. There are the different interpretations of the Mach principle. The Mach principle can be viewed as an entire Universe being altered by changes in a single particle and vice versa.

$\otimes$ The universal cooperative resonance synchronization principle is responsible for the very unity of the Universe.

We have shown only a very small part of our calculations by formula (36) and the corresponding comparison with experimental data for atomic and nuclear rest mass differences. This formula produces a surprisingly high accuracy description of the existing experimental data. Our noncomplete tentative analysis has shown that the quanti-

zation of rest mass differences demonstrated a very interesting periodical properties in the whole Mendeleev Table of Chemical Elements. We hope that it is possible to create an analog of the Mendeleev Table describing atomic and nuclear properties of the atomic and nuclear systems simultaneously.

We have proved [1, 3] the homology of atom, molecule (in living molecules too including DNA) and crystal structures. So interatomic distances in molecules, crystals and solid-state matter can be written in the following way:

$$d = \frac{n_1}{n_2}\lambda_e, \tag{37}$$

where λ_e=0.3324918 nm is the de Broglie electron wavelength in a hydrogen atom in the ground state ($\lambda_e = \lambda_p$ in a hydrogen atom in the ground state) and $n_1(n_2) = 1, 2, 3, ...$

In 1953 Schwartz [69] proposed to consider the nuclear and the corresponding atomic transitions as a united process. This process contains the β-decay which represents the transition of nucleon from state to state with emission of electron and antineutrino, and simultaneously the transition of atomic shell from the initial state to the final one. A complete and strict solution of this problem is still needed.

We did the first step to consider the nuclear and atomic rest masses as a unified processes (coupled resonators) which led us to establish the corresponding phenomenological quantization formulas (35) and (36), and can bring new possibilities for inducing and controlling nuclear reactions by atomic processes and new interpretation of self-organizations of the hierarchial systems in the Universe including the living cells.

LENR can be stimulated and controlled by the superlow energy external fields. If frequencies of external field are commensurable with frequencies of nucleon and electron motions than we should have resonance enhancement of LENR. Anomalies LENR in condensed matter (in plasma) and many anomalies in different branches in science and technologies (for example, homoeopathy, influence of music in nature, nanostructures) should be results of cooperative resonance synchronization frequencies of subsystems with open system frequencies, with surrounding and external field frequencies. In these cases a threshold energy can be drastically decreased by internal energy of

the whole system - the systems are going to change their structures if a more stable systems result. Therefore we have now real possibilities to stimulate and control many anomalies phenomena including LENR.

7 Warning

For nuclear physicists, the LENR (cold fusion) contradicts a majority of what they have learned throughout most of their professional lives [70]. The highly specialized profession created a narrow departmental approach to prediction of global catastrophes. The ignorance of the whole physical society of LENR and the lack of financial support may lead to catastrophes:

⊗The mechanism of shortening the runaway of the reactor at the Chernobyl Nuclear Power Plant and catastrophes induced by the HAARP (High Frequency Active Auroral Research Program) program or by other human activities may be based on our postulated cooperative resonance synchronization mechanism.

⊗The same mechanism should be responsible for the ITER (The International Thermonuclear Experimental Reactor) explosion in future.

⊗A. Lipson and G. Miley (ICCC12) showed that the walls of the ITER TOKAMAK could be damaged by low energy d, t, He and intense soft X-ray quanta.

⊗The storage of the nuclear waste in stainless steel containers is a source of real explosion in future. Such explosion can be caused by radiations of HAARP, for example.

⊗The attack on the World Trade Center (WTC) by terrorists was a trigger for the low energy nuclear reactions. The whole destruction of the WTC is a result of the LENR which is very easy to prove by isotopic analysis of stainless steel in towers.

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