Bose Condensation of Atomic Electrons. Experimental Regularities Discussion

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The experimental data analysis overturns «modern scientific representation» of the atomic structure. In articles [1-3] is shown, that atomic electrons do not form stochastic orbitals «spread» in space, but «are condensed» in ring or spherical electron shells, and do not behave as independent particles, but demonstrate collective properties.

Besides in atom the nonlinear nature of a microcosm becomes evident: the main quantum number of electron states, alongside with integer numbers, gets also fractional values - due to interactions on harmonic components. The weighty confirmation of microcosm nonlinearity was obtained at the analysis of a quantum Hall effect [4].

These discoveries have key value not only for physics development, but also for all natural sciences using in varying degree knowledge about substance structure.

Therefore discussion of the experimental regularities showing an inconsistency of the atom theory, which almost century dominated in physics, is extremely important for acceleration of transition to new representations.

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1. Introduction

The founders of the quantum-mechanical atom theory, carried away by formalism, have initiated key errors in the atom structure understanding.

In particular, they proceeded from the assumption of three-dimensional «motion» of each electron in atom (and accordingly they have used *3D Ψ* - function).

Actually space around nucleus is an «ideal» place for Bose condensation of atomic electrons, as in comparison with this potential well depth making about unity and even hundreds of electron-volt, the energy of a thermal motion (~ *0,03 eV*) is very small.

Therefore in atomic electron shells the Bose condensates are formed, featured by one-dimensional and two-dimensional wave functions [2]:
- The resonant one-dimensional (ring) shells consisting of 1 - 3 electrons are characterized by *1D Ψ* - function;
- The resonant two-dimensional (spherical) electron shells are featured by *2D Ψ* - functions.

That fact, that the electrons in shells form Bose condensates, removes a lot of questions, which remained actually without answer.

How the set of random moving electrons, nevertheless, provides not diffused, but stable atom characteristics? Moreover any charged particles movement in atom would provide radiation, but in the ground state of atom it is not observed.

Even in case of simple hydrogen atom the theory actually gives rather strange deduction that an electron all the time flies through the nucleus.

In Bose condensates of atomic shells the electrons do not move being in resonant interaction among themselves, which only simulates electrons motion making them hovering above a nucleus. Including a case of the hydrogen atom where the single electron of atomic shell, having wave properties, sits in one of the antinodes of a ring «auto resonance» Bohr radius apart from a nucleus.

As well as in case of a ring superconductor, the wave function of an electron in atom has minimum one period at turning around the centre, so the impossibility of electron presence in area near a nucleus is determined.

In this article the ring (one-dimensional) electron shells of some atoms and ions described by $1D$ Ψ - function are discussed.

In particular, it concerns the electron shell of all atoms (except for hydrogen) proximate to nucleus, consisting of two electrons as Cooper pair, which is the base shell to build-up all subsequent shells.

Proceeding from this concept the nature of electron affinity of univalent atoms is analyzed, as well as issue is under examination, why the hydrogen atom in a series of chemicals shows properties of a divalent atom.

The Bose Condensation of atomic electrons in many-electron spherical shells and parameters of these shells are discussed.

2. Electron shell proximate to atom nucleus

The basis of the electron structure of any atom (except for hydrogen) is a shell proximate to a nucleus and consisting of two electrons. It makes reliable foundation for all the subsequent electron shells filling.

Now it became clear, why the shell proximate to a nucleus consists of two electrons. It is not because of spin influence, as it is presented by the existing atom theory, though the spins of electrons really tend to minimum of mutual energy.

Actually the first electron shell is one-dimensional ring shell, and its electrons sit in wave antinodes of a resonance $n=1$, forming a superconducting electron pair.
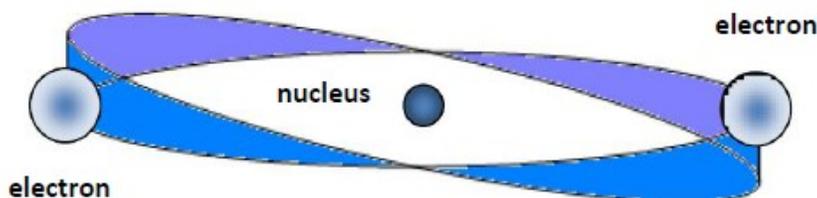
Fig. 1. Proximate to a nucleus electron shell of atom
(except for hydrogen) forms a Cooper pair.

Thus, the resonant nature of Bose condensation of electrons in atom shell proximate to a nucleus shows itself in electrons settle down in opposite parts from the nucleus; and the attachment of additional electrons to this shell is impossible, as both antinodes of a resonance with п=1 (minimum possible number of spatial periods) are already occupied (fig. 1). Most brightly these properties are shown in a noble-gas helium atom, which has only one electron shell in the form of a superconducting electron pair.

The quantitative assessments made according to the proposed model have given close fit to the experimental data.

Let's remind, that in general case of nucleus charge *ze*, the formulas for radius of the first electron shell of atom and for the sum of ionization potentials of this shell (of two electrons) when *п = 1* look like [2]:

$$R = \frac{4}{4z-1}R_{Б}, \qquad \varphi_1 + \varphi_2 = \frac{(4z-1)^2}{8} \cdot 13,6 \mathfrak{z}B. \tag{1}$$

The derivation of these formulas in general case is given in the next paragraph.

Formulae (1) evaluation and corresponding experimental data for atoms with different nucleus charges are given in the table 1.

From the table 1 follows (column: calculation/fact), that the ionization potentials sum of the first electron shell depending on nucleus charge fits the appropriate experimental data (disagreement decreases from 5,44 % up to 1,18 %).

Formula for ionization potentials sum of two electrons of the shell and known precise value of ionization potential of the last electron

$$\varphi_2 = z^2 \cdot 13,6 \mathfrak{z}B, \tag{2}$$

apparently, make it possible to estimate magnitude of the second summand. For example, using data of tab. 1 for the sum of ionization potentials and formula (2), we obtain the guess value of the first ionization potential of helium atom: 83,3 - 54,4 = 28,9 (eV).

The actual value of the first ionization potential of helium atom is 24,58 eV, that shows order-of-magnitude agreement with calculation, but thus the error of calculation is increased up to 17,6 % (calculation/fact = 28,9/24,58 = 1,176). It turns out that rather small calculation error of the ionization potentials sum (1) is completely transferred to one of the summands (and the smaller one in magnitude).

Table 1

Parameters of the electron shell (two electrons) nearest to a nucleus

Atom	Calc. $\varphi_1+\varphi_2$, eV	Exper. $\varphi_1+\varphi_2$, eV	Calc/Exper.	R / R_B
2 (He)	83,3	79	1,0544	0,571
3 (Li)	205,7	198	1,0389	0,364
4 (Be)	382,5	371,51	1,0296	0,267
5 (B)	613,7	599,43	1,0238	0,211
6 (C)	899,3	881,83	1,0198	0,174
7 (N)	1239,3	1218,76	1,0168	0,148
8 (O)	1633,7	1610,23	1,0146	0,129
9 (F)	2082,5	2057,6	1,0121	0,114
10 (Ne)	2585,7	2555,6	1,0118	0,102

Formulae (1) can also be applied for the description of hydrogen negative ion (item 3), which electron shell very much reminds a helium atom shell structure with two occupied antinodes of the electron shell resonance.

3. Electron affinity and divalent hydrogen atom.

The ionization energy of a negative ion (equal-in-magnitude to electron-atom binding energy), is defined as an electron affinity.

Assuming *z=1* in the formulae (1), we derive, that electron shell radius of a negative hydrogen ion is more than electron shell radius of hydrogen atom (is equal to *4/3* Bohr radius), and the ionization potentials sum of two electrons of a shell is equal to *15,3 eV*.

Ionization potential of a neutral hydrogen atom is known (*13,6 eV*), therefore, knowing the sum of ionization potentials of two electrons, it is possible to estimate an electron affinity of hydrogen atom: *15,3 - 13,6 = 1,7 eV*.

The calculated value shows order-of-magnitude agreement with experiments (electron affinity of hydrogen atom is *0,754 eV*) and proves model efficiency. However, as well as at calculation of ionization potential of helium atom, here we observe an apparent reduction of calculation precision because of aforesaid transition of rather small calculation error of ionization potentials sum (1) to the smaller summand (single order less!).

Really, ratio calculation/fact for the ionization potentials sum of a negative hydrogen ion: *15,3/(13,6 + 0,754) = 15,3/14,354 = 1,066*, shows rather small calculation error, such as it was at calculation of ionization potentials sum of helium atom etc. (tab. 1).

What causes a wide gap between two ionization potentials?

Initially two electrons sitting symmetrically on opposite sides relative to nucleus have identical energy and, apparently, should have close values of ionization potentials. The fact is that after each ionizing event not only atomic core charge becomes more and more positive, so that the subsequent electron removal is impeded. Besides, the removal of the first electron increases centripetal force acting on the electron remaining in a shell, and consequently the ionizing event is accompanied by simultaneous shift of a remaining electron closer to nucleus, so that the released energy reduces energy consumption for the first electron removal. Thus, the first ionizing event occurs much more easily, than second.

Negative ions of other atoms (as contrasted to hydrogen atom) can have main quantum numbers differing from integer values; therefore formulae derivation should be made more generally.

Similarly to formulae (1) derivation, made in article [2], we shall use the balance of forces acting on each of two electrons, located symmetrically on opposite sides relative to nucleus (atom core), as it is shown in fig. 1.

On the one hand, it is force of electrostatic attraction to a nucleus and rather smaller repulsive force of two electrons, and, on the other hand, centrifugal force caused by impulse (energy) circulation in resonant electron shell:

$$F_{цс} = \frac{ze^2}{4\pi\varepsilon R^2} - \frac{e^2}{4\pi\varepsilon(2R)^2}, \qquad F_{цб} = \frac{mv^2}{R} = \frac{p^2}{mR}. \qquad (3)$$

Whereas

$$2\pi R = n\lambda = n\frac{h}{p}, \qquad (4)$$

And equating differently directed forces (3), we get:

$$R = \frac{4n^2}{4z-1}\frac{\varepsilon h^2}{\pi m e^2} = \frac{4n^2}{4z-1}R_Б. \qquad (5)$$

The ionization potentials sum of two electrons of a shell is equal (according to the virial theorem) to the total kinetic energy of these electrons.

Therefore, taking in consideration (4) and (5), we get:

$$e(\varphi_1 + \varphi_2) = 2\frac{p^2}{2m} = \frac{(4z-1)^2}{8n^2}\frac{e^2}{8\pi\varepsilon R_{\text{Б}}} = \frac{(4z-1)^2}{8n^2}\cdot 13{,}6 \text{эВ}. \tag{6}$$

At *п=1* expressions (5) and (6) expectedly convert into formulae (1).

Let's use expression (6) to determine main quantum numbers of negative ions in the ground state:

$$n^2 = \frac{(4z-1)^2 \cdot 13{,}6}{8(\varphi_1 + \varphi_2)}. \tag{7}$$

The available experimental information about ionization potentials and electron affinity of univalent atoms make it possible to obtain formulae evaluation. In a case under study the nucleus (or atom core) charge is equal to unity (*z=1*).

Computing results concerning parameters of ions (and neutral atoms comparative data [2]) are given in the table 2.

Table 2

Parameters of negative ions of univalent atoms

Ion of atom	Electron affinity, eV	$\varphi_1+\varphi_2$, eV	n_i (n_a)	$n \approx N_1/N_2$	R_i/R_B	R_a/R_B
Li⁻	0,62	6,01	1,60 (1,593)	8/5	3,40	2,52
Na⁻	0,548	5,686	1,64 (1,632)	5/3	3,59	2,65
K⁻	0,502	4,841	1,778 (1,775)	7/4	4,21	3,13
Cs⁻	0,472	4,365	1,872 (1,875)	15/8	4,67	3,49
Rb⁻	0,486	4,662	1,812 (1,81)	9/5	4,37	3,26

Calculations show the perfect coincidence of main quantum numbers of negative ions and of corresponding atoms - column n_i (n_a). Though radius of electron shell of negative ions are much more, than of corresponding atoms (penultimate and last columns tab. 2). Comparative data for neutral atoms, as it was mentioned, were taken from [2].

Thus, the main quantum number of negative ions, as well as univalent atoms in the ground state, is fractional number.

This result is extremely important, as once again it confirms the conclusion made in articles [1-3] about physics of fractional main quantum number and about harmonic unity of atom spectrum.

Bright illustration of these properties is, for example, the lithium atom, which in the ground state of outer shell electron has main quantum number equal to fraction *8/5*. In excited states this fraction is prolonged by a sequence of fractions, increasing by unity: *13/5, 18/5, 23/5* etc. Now it became evident, that the negative ion, as well as atom of lithium, is characterized by the same main quantum number - *8/5*.

To complete this item let's briefly discuss a «surprising» property of hydrogen atom, which can be both univalent and divalent.

For example, the molecule of diborane B_2H_6, contains six hydrogen atoms, four of which behave as univalent, and two - as divalent.

It follows from the structural formula of a molecule:
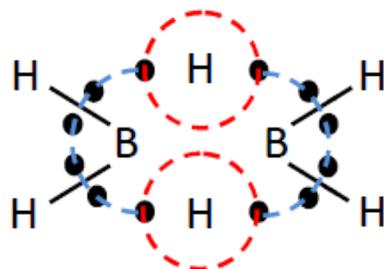
Four hydrogen atoms (on the right and on the left) interact with boron atoms as univalent atoms in an «ordinary» way, namely, the sole electron of each hydrogen atom is actually built in outer electron shell of boron atom.

At the same time, two hydrogen atoms (at centre) interact both with left-hand, and with the right-hand parts of a molecule, joining it as a whole. Such hydrogen atom a possibility is owing to its ring shell containing just two resonance antinodes located in opposite parts relative to a nucleus. On the one hand, for connection the hydrogen atom can utilize its sole electron, and on the other hand, can grasp an outer shell electron of other atom by means of a vacant shell antinode.

The connection by means of hydrogen atom is named as «banana» bond.

4. Quantum numbers of two and three outer shell electrons

It is possible, assuming $z=2$, to apply formulae (4), (5) for the analysis of properties of divalent atoms with two outer shell electrons:

$$R = \frac{4n^2}{7} R_Б. \tag{8}$$

$$n^2 = \frac{49 \cdot 13,6}{8(\varphi_1 + \varphi_2)} = \frac{83,3}{\varphi_1 + \varphi_2}. \tag{9}$$

These formulae evaluation is interesting to consider in comparison with the results of study of hydrogen-like ions (with a charge of atom core $z=2$ and one outer shell electron):

$$R = \frac{n^2}{z} R_Б, \tag{10}$$

$$n^2 = \frac{z^2 \cdot 13,6}{\varphi_z}, \tag{11}$$

Similarly to comparison of parameters of atoms and negative ions showed in tab. 2. At $z=2$ formulae (10), (11) take the form:

$$R = \frac{n^2}{2} R_Б, \tag{12}$$

$$n^2 = \frac{54,4}{\varphi_2}. \tag{13}$$

The results of calculations using formulae (8), (9) and (12), (13) are shown in tab. 3.

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Table 3

Parameters of divalent atoms and its ions

Atom	φ_2, eV	$\varphi_1+\varphi_2$, eV	n_a (n_i)	$n \approx N_1/N_2$	R_a/R_B	R_i/R_B
Be	18,21	27,53	1,74 (1,73)	7/4	1,73	1,49
Mg	15,03	22,674	1,92 (1,90)	17/9	2,10	1,81
Ca	11,87	17,981	2,15 (2,14)	15/7	2,64	2,29
Sr	11,026	16,718	2,23 (2,22)	9/4	2,84	2,47
Ba	10,00	15,81	2,30 (2,33)	7/3	3,01	2,63

The received values of main quantum number of atoms are very close to those of positive ions - column n_a (n_i), how it was at comparison given in tab. 2, for univalent atoms and their negative ions.

At the same time, the radiuses of atoms and of positive ions differ less (about 15 %), than the radiuses of atoms and of negative ions, which differ from each other by one third.

Similarly it is possible to compare parameters of ions with two outer shell electrons and appropriate hydrogen-like ions with one outer shell electron.

For example, let's make such comparison for trivalent atoms.

In this case atom core charge is *z=3*.

So formulae (5) and (6) for a positive ion with two outer shell electrons get form:

$$R = \frac{4n^2}{11} R_Б. \qquad (14)$$

$$n^2 = \frac{205,7}{\varphi_2 + \varphi_3}. \qquad (15)$$

The parameters of an ion with one outer shell electron, or hydrogen-like ion (twice ionized trivalent atom), are determined by formulae (10), (11) at *z=3*

$$R = \frac{n^2}{3} R_Б, \qquad (16)$$

$$n^2 = \frac{122,4}{\varphi_3}. \qquad (17)$$

The results of calculations and comparative data are shown in tab. 4.

Here *In-* and *Al-* ions (with different degree of ionization) have close values of main quantum number, while for other ions these values are less close. The radiuses of electron shells of ions have more close values, than it was in previous examples.

Below we shall still return to the discussion of these computing results.

To complete the analysis of one-dimensional electron shells, we shall consider shells of trivalent atoms with three outer shell electrons.

This is the greatest number of electrons, which can form one-dimensional (ring) electron shell of atom. At greater number of electrons a shell forms volumetric structures.

Table 4.

Parameters of singly and doubly ionized trivalent atoms

Atom	φ_3, eV	$\varphi_2+\varphi_3$, eV	n_{i1} (n_{i2})	$n\approx N_1/N_2$	R_{i1}/R_B	R_{i2}/R_B
B	37,92	63,07	1,806 (1,797)	9/5	1,185	1,076
Al	28,44	47,26	2,09 (2,075)	23/11	1,583	1,435
Sc	24,75	37,64	2,34 (2,224)	7/3 (9/4)	1,987	1,648
Y	20,5	32,73	2,507 (2,444)	5/2	2,286	1,99
La	19,17	30,6	2,59 (2,527)	13/5 (5/2)	2,446	2,128

Let's remind, that special conditions of quantum Hall effect experiments (*2D* - electron gas in semiconductor at low temperature) give an opportunity, under strong magnetic field, to gain ring resonances (*1D Ψ* - function) with participation of more than three electrons [4].
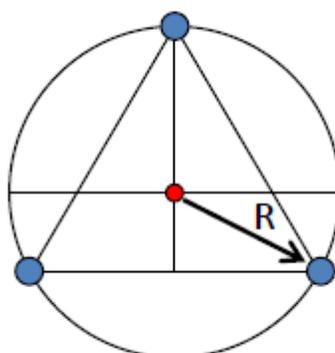
Fig. 2. Outer one-dimensional (ring) electron shell of a trivalent atom.

Let's assume, that outer shell electrons experiencing a Coulomb repulsion settle down at equal from each other distances and, thus, form equilateral triangle, as it is shown in fig. 2. Then the centripetal force acting on each electron will comprise attractive force of a nucleus (core) and force of electrostatic repulsion of two other electrons of a shell. At the same time, the centrifugal force acting on each of these electrons is formed by resonant interaction simulating electrons motion and balances the centripetal force:

$$F_{цс} = \frac{3e^2}{4\pi\varepsilon R^2} - \frac{e^2}{4\pi\varepsilon\sqrt{3}R^2}, \qquad F_{цб} = \frac{mv^2}{R} = \frac{p^2}{mR}. \tag{18}$$

Taking into consideration that

$$2\pi R = n\lambda = n\frac{h}{p}, \tag{19}$$

and equating differently directed forces (18), similarly to formulas (5) and (6) deduction, we obtain:

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$$R = \frac{3n^2}{9-\sqrt{3}}\frac{\varepsilon h^2}{\pi m e^2} \approx 0,413 n^2 R_{Б}. \qquad (20)$$

The total of ionization potentials of outer shell (three electrons) is equal (according to virial theorem) to a kinetic energy of these electrons. Therefore, in consideration of (19) and (20), we receive:

$$e(\varphi_1 + \varphi_2 + \varphi_3) = 3\frac{p^2}{2m} = \frac{(9-\sqrt{3})^2}{3n^2}\frac{e^2}{8\pi\varepsilon R_{Б}} \approx \frac{17,61 \cdot 13,6}{n^2} \approx \frac{239,5}{n^2} \, эB. \qquad (21)$$

The calculations results for R and n using formulas (20), (21) and comparative characteristics of ions of trivalent atoms (taken from tab. 4) are represented in tab. 5.

Table 5

Parameters of outer shell electrons of trivalent atoms and its ions

Atom	$\varphi_1+\varphi_2+\varphi_3$, eV	n_a (n_{i1},n_{i2})	$n \approx N_1/N_2$	R_a/R_B	R_{i1}/R_B	R_{i2}/R_B
B	71,366	1,83 (1,806; 1,797)	9/5	1,386	1,185	1,076
Al	53,244	2,121 (2,09; 2,075)	23/11	1,858	1,583	1,435
Sc	44,2	2,328 (2,34; 2,224)	7/3 (9/4)	2,238	1,987	1,648
Y	39,11	2,475 (2,507; 2,444)	5/2	2,529	2,286	1,99
La	36,21	2,572 (2,59; 2,527)	13/5 (5/2)	2,732	2,446	2,128

The parameters of atoms and ions obtained proceeding from different models, as it is clear from the tab.5, harmonize with each other.

Each kind of atoms, being in the ground state or in an ionized state, demonstrates close values of a main quantum number, though its outer shells radiuses essentially and naturally differ.

On the other hand, *the same model* (for example, for three outer electrons with atom core charge *z=3*) gives determinate values of a main quantum number and radius of a shell for each kind of atoms, that demonstrates influential of atomic cores on these parameters.

Hence, the atomic core affects not only the radius of outer electron shell, but also emission spectrum determining harmonic unity of atom.

These properties are brightly shown by atoms with most simple core structure. On the contrary, many-electron cores get more and more numerous emission frequencies. Therefore in quite a number of cases it becomes difficult to relate fractional value of a main quantum number of one-dimensional electron shell to this or that proximate common fraction.

Besides in atom actually there are multilateral interactions of all constituent particles. But we simplify these composite processes by using resulting Ψ-function.

Nevertheless, the obtained calculation accuracy at the description of interaction of such a great number of atomic constituent particles is satisfactory. Visual and logical from the physical point of view model of one-dimensional (ring) outer shells of atoms consisting of 1, 2 and 3 electrons, in whole, has shown its high efficiency.

5. Many-electron spherical shells

Bose condensation of electrons in atomic electron shells means that electrons in each shell have the same energy, and sit around nucleus on an equipotential surface. Thus, if in a shell there are more than three electrons, then spherical shell structure is more energy-optimal than a ring structure. Accordingly quantum-mechanical wave function used for the description of shell electrons will be either one-dimensional, or two-dimensional.

In these conditions the Schrodinger equation describing a Bose condensate of atomic electron shell is reduced to a wave equation.

Really, the Schrodinger equation for stationary states looks like [5]:

$$\frac{\hbar^2}{2m}\nabla^2\Psi + [E - U(x, y, z)]\Psi = 0, \tag{22}$$

Where $U(x, y, z)$ - potential energy of a particle.

When atom electron is at sphere or ring shell ($U(x, y, z) = const$), the difference in brackets of the equation (22) becomes constant magnitude.

Besides, the kinetic energy of atomic electron is equal (according to the virial theorem) to the half modulus of negative potential energy of this electron. Therefore difference in brackets of Schrodinger equation is also equal to electron kinetic energy.

Thus, the equation (22) acquires the form of usual wave equation with space phase factor k:

$$\frac{\hbar^2}{2m}\nabla^2\Psi + \frac{p^2}{2m}\Psi = 0, \quad \nabla^2\Psi + k^2\Psi = 0, \quad k = \frac{p}{\hbar} = \frac{2\pi}{\lambda}, \quad \lambda = \frac{h}{p}. \tag{23}$$

The electron motion in atom, as well as motion of a free electron, is characterized by wave length $\lambda = h/p$, that was already applied at the analysis of atomic one-dimensional ring electron shells.

The spatial configuration of electron shells is determined not only by electron wave properties described by the equation (23), but also by mutual electrostatic repulsion. In article [2] the experimental proofs were given that electrons in atomic many-electron shell sit rather uniformly distributed on spherical (equipotential) surface. Therefore, the total of ionization potentials of electron shell provided to be equal (in view of virial theorem) to the energy of charged sphere of same radius.

Let's give further proofs in favor of this deduction.

Electron shell radius can be determined in different ways. In article [2] it was made proceeding from ionization potential of the last electron of a shell.

In particular, for noble gases (N=8) the formula looks like:

$$R = \frac{8e}{8\pi\varepsilon\varphi_8}. \tag{24}$$

This formula evaluation is interesting to compare with other method of calculations. For example, let's determine shell radius by means of balance analysis of forces acting on electron in atom structure.

In an outer shell having N electrons on each electron acts equal centripetal force of electrostatic field and centrifugal force, counterpoising it.

Similarly to (18) the formulas for these forces look like:

$$F_{\text{цс}} = \frac{Ne^2}{4\pi\varepsilon R^2} - \frac{1}{2}\frac{Ne^2}{4\pi\varepsilon R^2} = \frac{Ne^2}{8\pi\varepsilon R^2}, \quad F_{\text{цб}} = \frac{mv^2}{R} = \frac{p^2}{mR}. \tag{25}$$

Here is taken into consideration that the electrons of a spherical shell, repelling from each other, make resultant force, which attenuates nucleus (core) attraction roughly twice, acting just as charged sphere.

Hereinbefore we have seen that even for a shell having only three electrons a mutual repulsion essentially decreases the attractive force (18) that is characterized by coefficient $1 - (1/3)^{1/2} = 0,422$ rather close to 0,5.

As the conditional kinetic energy of an electron fits average of ionization potentials of electron shell, from equality of forces (25) comes out:

$$\frac{Ne^2}{8\pi\varepsilon R^2} = \frac{p^2}{mR} \quad \left(\frac{p^2}{2m} = \frac{e\sum\varphi_i}{N}\right), \quad \frac{R}{R_Б} = \frac{N^2}{2}\frac{13,6}{\sum\varphi_i}. \tag{26}$$

For noble gases (N=8) the formula (26) acquires the form:

$$\frac{R}{R_Б} = \frac{435,2}{\sum\varphi_i}. \tag{27}$$

The computing results for electron shells radiuses (27) and comparative data [2] (formula (24) evaluation) are displayed in the table 6.

<div align="right">Table 6</div>

Atomic outer electron shell characteristics of noble gases

Atom	$\sum\varphi_i$, eV	$\varphi_{im}=$ $\sum\varphi_i/N$ eV	R/R_B	φ_8, eV	R/R_B [2]	φ_8/φ_{im}
10 (Ne)	953,89	119,24	0,456	239,1	0,455	2,005
18 (Ar)	577,64	72,2	0,753	143,4	0,759	1,986
36 (Kr)	508,16	63,52	0,856	126	0,863	1,984
54 (Xe)	484,43	60,55	0,898	126	0,863	2,081

Thus, the calculation of shells radiuses using other method has given very close values to obtained earlier quantities.

At first sight such proximity of radiuses of completely filled spherical electron shell and of an ion outer shell with only one electron is pretty strange. But actually this closeness is caused by oppositely directed influential factors.

On the one hand, there is a well-defined experimental regularity $\varphi_{im}=\sum\varphi_i/N \approx \varphi_8/2$ (last column of tab. 6), that is, the mean value of ionization potentials of atomic outer shell is twice less than ionization potential of the last electron of this shell. But, as ionization potential corresponds to conditional kinetic energy of an electron, so centrifugal forces acting on electron in these cases will also differ twice.

On the other hand, the centripetal force created by an electric field, when electron is in a many-electron spherical shell, is twice less than force acting on a sole electron.

Thus, at the same radius a centripetal force and centrifugal force are balanced irrespective of whether the shell is completely filled or contains only one electron.

Actually we have got one more weighty confirmation of correctness of calculations made in article [2] and also of the fact that many-electron shells in atom really have the spherical form.

It means that electrons in atom do not move in probabilistic mode, but all the time sit on spherical shell surface.

Otherwise we would not observe these legitimacies.

What about quantum numbers of electrons in atomic shells?

In case of ring electron shell the main quantum number is determined by number of wavelengths of electron going into perimeter of circle. For example, the main quantum number of last electron of outer shell is determined by formula (11), which at *z=8* gives simple expression:

$$n^2 = \frac{870,4}{\varphi_8}, \qquad n = \frac{2\pi R}{\lambda} = \left(\frac{870,4}{\varphi_8}\right)^{1/2}. \tag{28}$$

But the wave process in a spherical shell should be accordingly characterized by two parameters, because, as against a ring shell, it develops not in one dimension, but in two dimensions - on a sphere surface.

Whether characteristics of many-electron shell are in some way bound with the main quantum number of last electron of a shell (28), that is, when other electrons are removed?

Again we shall make use of Schrodinger equation (23).

Solution of wave equation on sphere comes to so-called spherical harmonics:

$$\Psi = [A\cos m\varphi + B\sin m\varphi]P_n^m(\cos\theta) = [C\sin(m\varphi + \gamma)]P_n^m(\cos\theta),$$

$$C = \sqrt{A^2 + B^2}, \quad \gamma = arctg\frac{A}{B}. \tag{29}$$

Here are excluded functions which tend to infinity on poles of sphere.

It is also necessary to keep in mind that number *n* in Legendre function notation $P_n^m(cos\theta)$ just coincides with a symbol of main quantum number.

Thus, the oscillations have two components - in azimuth reference (as usual trigonometric functions) and along meridians in polar coordinates (associated Legendre functions of the first kind). The form of function in meridians direction depends on number of spatial periods, going in other direction - along sphere equator.

However not all depends on function (29).

As it was already mentioned above, the decisive influence on electron shells formation affects mutual Coulomb repulsion of electrons. Therefore from the set of possible harmonics (29) are selected such parameters of wave process, which provide the most spaced-apart allocation of electrons on a spherical surface.

In particular, completely filled electron shell having eight electrons it is logical to describe as harmonic

$$\Psi = (C\sin 2\varphi)P_3^2(\cos\theta). \tag{30}$$

The function (30) gives four antinodes in an azimuth direction (two periods) and two antinodes in a polar direction (one point of zero-line intersection on equator), that as a result gives eight antinodes. There electrons of completely filled shell aspire to sit.

At definition of antinodes number it is convenient to use a rule, according to which associated Legendre functions $P_n^m(cos\theta)$ vanish *(n-m)* of times on segment (-1, +1). Some functions are shown in a fig. 3.

The uniform distribution of electrons (and of a wave function antinodes) on a spherical shell signifies that the azimuth and polar components of phase factor in many-electron shell have close modulus.

As phase factor (23) is proportional to momentum

$$k = \frac{2\pi}{\lambda} = \frac{p}{\hbar}, \qquad \left(\lambda = \frac{h}{p}, \qquad h = 2\pi\hbar\right), \tag{31}$$

so

$$k^2 = k_\varphi^2 + k_\theta^2 = \left(\frac{p}{\hbar}\right)^2, \qquad k_\varphi \approx k_\theta \approx \frac{k}{\sqrt{2}}, \qquad p_\varphi \approx p_\theta \approx \frac{p}{\sqrt{2}}. \tag{32}$$
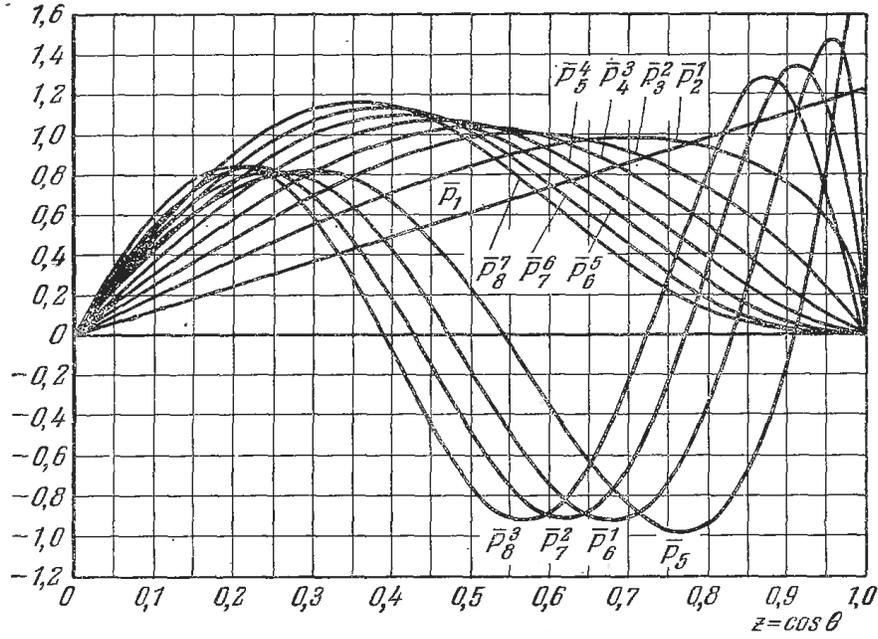
Fig. 3. Normalized associated Legendre functions of the first kind [6].

On the other hand, how it was mentioned for many-electron outer shells of noble gases, the kinetic energy and accordingly square of electron momentum in a filled shell is twice less, than it is relative to the last electron of a shell (it follows from $\varphi_{im}=\Sigma\varphi_i/N \approx \varphi_8/2$).

Therefore, subject to (32), we get:

$$k_8 = \frac{p_8}{\hbar}, \qquad p \approx \frac{p_8}{\sqrt{2}}, \qquad p_\varphi \approx p_\theta \approx \frac{p_8}{2}, \qquad k_\varphi \approx k_\theta \approx \frac{k_8}{2}. \tag{33}$$

Thus, the phase factor components orthogonal each other making wave process in spherical electron shell appear approximately twice less, than phase factor in a ring shell with the last eighth electron (when others seven electrons are removed from a shell). The quantum numbers of these two components of wave process in a spherical shell, which are equal to product of phase factor (33) and radius of sphere

$$n_\varphi = \frac{2\pi R}{\lambda_\varphi} = k_\varphi R, \qquad n_\theta = \frac{2\pi R}{\lambda_\theta} = k_\theta R, \qquad n_\varphi \approx n_\theta \approx \frac{k_8 R}{2} = \frac{n}{2}, \tag{34}$$

also appears to be approximately twice less than main quantum number of the last electron of a shell (28).

The relation (34) once more indicates that the interactions in a microcosm can occur both on basic frequencies and on harmonic components.

For intra-atomic interactions it is shown in the full measure.

The existing theory wrongly describes each electron of a shell by a special set of quantum numbers. Actually, all electrons of a shell are described by single wave function, though the electrons are located separately. They are in antinodes of universal function describing Bose condensate of the electron shell.

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To some extent this property of Bose condensates determines success of so-called «one-electron approximation», which is used to describe many-electron systems (it was still mentioned in famous Feynman lectures [7]).

The detailed study of Bose Condensates of atomic electron shells will enable deeper to understand legitimacies of intra-atomic interactions and inter-atomic bonds.

6. Summary

Neither Bohr atom theory, nor quantum theory of atom, existing already many decades, on objective reasons could not give adequate atom description, as were based on false initial concept of microcosm (and atom, in particular).

First of all, atomic electrons form Bose condensates in ring and spherical shells, and consequently the electrons of each shell should be described by a single wave function.

Secondly, nonlinear resonant microcosm properties are in full shown in atom, that's why intra-atomic interactions occur not only on basic frequencies, but also on harmonic components. So the main quantum number can be both integer and fraction.

Aren't these conclusions too peremptory?

Whether there are sufficient grounds for radical theory revision?

One can understand incipient internal protest of some readers, who have spent a lot of time and labor making a careful study of «modern scientific representations», and who now should question its authenticity.

We (as well as present students) were told that if we were able to solve complicated quantum mechanics equation, we could answer practically any question about microcosm.

But now it became clear that even the atom theory (main «achievement» of the quantum mechanics) has appeared artificial and false construction.

For me this «enlightenment» has come not suddenly. It has taken three decades of laborious but simultaneously fascinating research.

At the first stage (1986-1991) the model of an electron structure as a rotating layer of an electromagnetic field was suggested, which has enabled to understand the mutual dependence of all electron parameters. The origin of a «mysterious» fine structure constant became clear: it is a characteristic of the rotating soliton - ratio of electromagnetic field layer thickness to a diameter of gyration. The smallness of the fine structure constant determines also small ratio of electrostatic field energy of electron to its total energy-mass.

The results of this research stage were published in the article in a popular scientific magazine «Heretic», January, 1991 [8].

At the second stage (1991-2002) it was necessary, first of all, to understand, how it becomes possible the gyration of electromagnetic soliton, because «usual» transverse electromagnetic wave in vacuum cannot rotate.

Actually the question is about how to extend the theory of electromagnetic field over fundamental particles theory. It has become possible only by means of Maxwell model, which in due time has facilitated the founder of the electromagnetic theory to receive famous system of equations.

The analysis has shown that gyration of a thin layer of electromagnetic field is possible only with presence of longitudinal electromagnetic field component. It arises in soliton structure and transcends its limits.

For many decades there are heated debates, whether longitudinal electromagnetic field really exists. Maxwell equations describe only transverse electromagnetic field, but the Maxwell model enables to comprehend the generation of longitudinal electromagnetic field, which actually is one of the basic foundations of the Nature.

We can observe only constant component of longitudinal electromagnetic field, which is perceived as electrostatic field (electric charge) of fundamental particles. At the same time, the variable component of longitudinal electromagnetic field forms standing waves around particles, providing interaction between them.

Thus, the microcosm is literally filled with improbable quantity of real oscillations and waves. First of all, it is frequencies of nucleons (atom nucleus) and electrons, coupled with its harmonic components due to nonlinear soliton nature.

The particles interaction on harmonic components results in «strange» ratios of fundamental particles masses [9].

- Ratio of masses of baryons Ω^- (1672 MeV) and Λ^o (1115 MeV) is 3/2.
- Meson $D^\pm$ mass (1869,4 MeV) exceeds proton mass almost twice.
- Ratio of masses of mesons $F^\pm$ (1971 MeV) and $K^\pm$ (493,67 MeV) is about four.
- Ratio of masses of meson B^o (5274,2 MeV) and baryon Ξ^o (1314,9) is also four.

The nucleons frequency is determined not by real mass, but by some effective mass of quarks (≈ 332 *MeV*). Accordingly the dominant frequency of a microcosm - Main Frequency of the Universe (MFU) is $1,60 \cdot 10^{23}$ Hz.

Electron mass $m \approx (2/5) \cdot (m_n - m_p)$, and its frequency is $2,47 \cdot 10^{20}$ Hz.

Dominant influence of MFU (≈ 332 *MeV*) in microcosm is shown, in particular, in effective interactions on harmonic components:

The **muon** frequency is 1/3 MFU,

The **tauon** frequency exceeds MFU about 6 times.

Slight deviation of real masses from above stated values are caused by action of proper neutrino (electron, muon and tauon), that actually gave an opportunity to calculate these neutrinos masses [9].

Some mesons effective mass practically coincides with their effective mass, owing to what these mesons decay mainly to photons. Such particles interact with nucleons on harmonic components being direct experimental proof of correctness of above mentioned MFU value (average effective mass of nucleons quarks):

Mass of π^o - meson (134,96 MeV) makes 2/5 MFU (≈ 332 *MeV*);
Mass of η^o - meson (548,8 MeV) makes 5/3 MFU;
Mass of K^o - meson (497,67 MeV) makes 3/2 MFU;
Mass of $F^\pm$ - meson (1971 MeV) makes almost 6 MFU.

Let's note that these mesons frequencies correspond to half of their masses, as the meson consists of two quarks.

The complication of masse series of fundamental particles is determined by the fact that many fundamental particles, as well as «main» particles - proton and neutron, have discrepancies between their effective masses (frequencies) and real masses owing to diversity of internal interaction energy.

Besides, fundamental particles theory assumes that there is an opportunity of integrating in one particle of quarks with greatly differing masses (frequencies). Such «combinations», apparently, also can complicate fundamental particles masse series [10].

The results of the second research stage were published in 2002 in monograph «Vacuum dynamics and soliton theory of fundamental particles» [9].

At the third stage (2002-2017) the further study of a nonlinear resonant microcosm was carried out that has enabled to outline more complete representations [11-13].

The most important result of this research phase (in 2014), undoubtedly, has become the discovery of experimental legitimacies proving a Bose condensation in atomic electron shells [1-3].

In basis of «condensation» process there are resonant interactions, including, interactions on harmonic components. That is why, for example, outer electrons of hydrogen-like atoms in unexcited basic state are characterized by fractional main quantum numbers [2]:

Atom	Li	Na	K	Cs	Rb	Ag	Pt	Tl
$n \approx N_1/N_2$	8/5	5/3	7/4	15/8	9/5	4/3	5/4	3/2

Similar regularities are observed in atomic excited states.

So, main quantum numbers of lithium atom in excited states «prolong» the basic state (8/5) by series of fractions increasing by unity: 13/5, 18/5, 23/5, 28/5, 33/5 etc.

The more complicated is atom nucleus (core), generating in surrounding space multiple oscillations, the more is a number of various harmonic components, on which occur resonances of atomic electron shells.

Fractional main quantum numbers of sodium atom in excited states include, among others, sequences of numbers:

8/3, 11/3, 14/3, 17/3 … etc.
22/7, 29/7, 36/7, 43/7 … etc.

The excited states of potassium atom are characterized, in particular, by sequences of fractional main quantum numbers:

14/5, 19/5, 24/5, 29/5 … etc.
23/7, 30/7, 37/7, 44/7 … etc.

As of many-electron shells, the electrons there are located on spherical equipotential surfaces and, thus, have the same energy state, forming resonant Bose condensate. The total of ionization potentials of a shell with high precision fits (subject to virial theorem) with energy of charged sphere, which charge is equal to an aggregate charge of electrons of a shell and with radius equal to radius of a shell.

This regularity was already confirmed by above mentioned analysis of outer electron shells of noble gases atoms [2] and backed by calculations in this article.

Atom	R/R_B	Calc. $\Sigma\varphi_i$, eV	Exper. $\Sigma\varphi_i$, eV	Calc./Exper.
Ne	0,455	956,48	953,89	1,003
Ar	0,759	573,39	577,64	0,993
Kr	0,863	504,29	508,16	0,992
Xe	0,863	504,29	484,43	1,041

Compelling confirmation of nonlinear resonant microcosm nature and its visual evidence presents the quantum Hall effect [4].

It is difficult to overestimate importance of quantum Hall effect experiments, as they actually are the direct proof of a resonant Bose condensation of electrons on one-dimensional ring «trajectories», just as it occurs on ring electron shells of atoms.

Moreover, in special conditions of quantum Hall effect experiments (*2D* - electron gas in a semiconductor at low temperature) an opportunity arises, under a strong magnetic field, to get ring resonances (described by *1D Ψ* - function) with the participation of more than three electrons.

Electrons on semiconductor Fermi level are included in a common ring resonance which radius depends on magnitude of applied magnetic field. These ring trajectories of electrons in external magnetic field ($R \sim 10^{-8} m$) are almost by two orders of magnitude larger, than atomic electron shells ($R \sim 10^{-10} m$), and consequently resonances on harmonic components similar to intra-atomic resonances with fractional main quantum numbers are most convenient to be observed.

It is important, that the number *п* in both cases physically means the same – number of electron wavelengths going into a ring trajectory, and is estimated by the same formula

$$n = 2\pi R / \lambda. \tag{35}$$

For quantum Hall effect this analog of a main quantum number can be expressed as a simple ratio [4]:

$$n = \frac{W_F}{P_B B}. \tag{36}$$

Here P_B - Bohr magneton,

B - magnetic induction of external field,

W_F - Fermi level of the semiconductor,

Fractional numbers п can be observed, as it was already mentioned, in two cases.

First, it occurs under very strong magnetic field, when perimeter of an electron orbit (circumference) in a plane, perpendicular to magnetic field, appears to be less than electron de Broglie wavelength (depends on a Fermi level of the semiconductor).

In other words, proper - fractional quantum Hall effect in this case takes place, when one de Broglie wavelength includes more than one electron trajectory circumference, so the number *п* becomes less than unity (1/3, 2/5, 3/7 etc., that is, three circumferences make one wavelength; five circumferences make two wavelengths; seven circumferences make three de Broglie wavelengths etc.).

Secondly, the fractional number *п* can be observed when a resonance occurs on harmonic component (as against resonances on basic frequencies). For example, the improper - fractional quantum Hall effect with *п* = 4/3 takes place on the third harmonic, when four wave lengths of this harmonic make an electron trajectory circumference.

All these resonances can be seen in the perfect experimental graphs given in the Nobel lecture [14]. It is also possible easily to ascertain that numbers п marked in figure by integer and fractional numbers are proportional to value of magnetic field, as it follows from the above mentioned formula (36).

Besides fig. 4 shows that each resonance is accompanied by drop of longitudinal resistance of a sample. The reason for that is resonance Bose condensation in 2D electron gas (in limits of each ring trajectory and in all set of contiguous ring trajectories in this part of a sample), that gives to this resonance area properties of a superconductor [4].
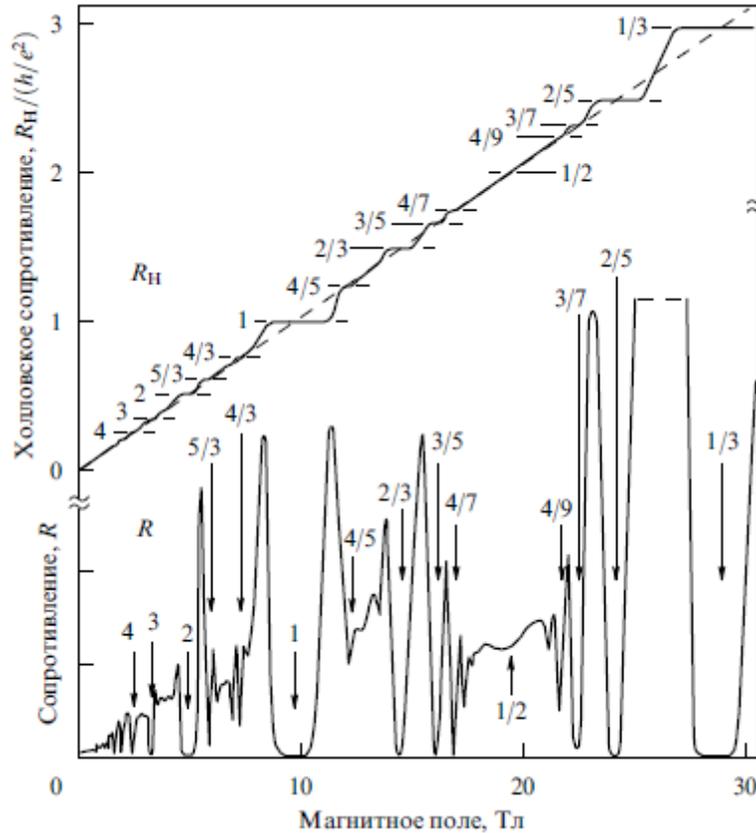
Fig. 4. The quantum Hall effect in 2D electron gas in modulated - doped heterostructure GaAs/AlGaAs with ultrahigh mobility [14].

Quantum Hall effect experiments outcome, as well as characteristics of atomic electron shells (particularly atomic radiation spectrums), confirm presence in a microcosm of great number of real oscillations and waves. Simultaneously it is possible to consider these experiments as practical methods of detection of longitudinal electromagnetic waves.

Let's remind, that in basis of nonlinear properties of a microcosm, which become apparent due to interactions on harmonic components, lays the soliton nature of fundamental particles [9].

The results of research of nonlinear resonant properties of microcosm attract growing interest, both of reading public - amateurs of physics, and specialists. In particular, the steady raising of citation indexes of publications devoted to the new microcosm concept evidences it.

The new conception of nonlinear resonant microcosm makes its way. But it is only the start of the work; there is still a great extent of examinations to be done.

Here are some fields of research:

The theory of rotating soliton and, in particular, the description of longitudinal electromagnetic field should have radical improvements of mathematical methods of analysis and of mathematical modeling of these phenomena.

Quantum theory in whole, fundamental particles theory and atom theory should be re-examined in view of resonant character of interactions in microcosm and in view of nonlinear effects.

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The theory of superconductivity (and superfluidity) should proceed from a resonant nature of Bose condensation, and the theory of interatomic interactions (including chemistry) should be reconsidered in view of the fact that atomic electron shells are resonant Bose condensates.

There is a progressive tendency of gradual awareness of existing atom theory falseness that creates favorable conditions for reconsideration of out-of-date ideas about microcosm nature in whole [15-16].

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