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Scattering on nucleons of elementary nucleon molecules (“atoms”)

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Abstract

The experiments on the *scattering* of particles and waves in matter, carried out since the time of Rutherford, gave rise to a *nuclear model* of an *atom*.

Nevertheless, they did *not provide* convincing evidence that each atom has *one scattering site*, moreover, in the form of a superdense *atomic nucleus*.

In view of the new concept of the structure of atoms developed by the author, according to which atoms are molecular-like formations, the Rutherford *theory* of *scattering* of particles in matter has been revised and replaced by a new one.

How this was done is shown here.

1. Introduction

This video is an additional to the other ones already posted on YouTube devoted to various aspects of the *discoveries* that were made in the framework of a *new physical theory* – the Wave Model (WM), which is based on the axioms of *dialectics*.

According to one of the axioms, *all objects* and *phenomena* in the Universe have a wave nature (most, I think, do not doubt it) and, hence, *obey* the universal ("classical") *wave equation*.

Analyzing *solutions* of the equation, we have come to the *discovery* that all *atoms* of the periodic table, *except* for a *protium* (the simplest *single-nucleon hydrogen atom)* are *elementary* (nuclear-free) *nucleon molecules* whose *nodal structure* is *identical* to the nodal structure of *standing waves* in a spherical space.

And *true atoms* are only *nucleons* (*proton* and *neutron*) and *protium.* We call all them *nucleons* or *hydrogen atoms*.

Elementary nucleon molecules are *multinodal* (that is, *multicenter*) formations in *each node* of *which* there are *nucleons* (two, as a rule, but no more), in comparison with *ordinary molecules* of modern physics and chemistry, in each node of which, *as believe*, there is an *atom* (with all its *nucleons* in the *nucleus*).

Compared with the *ordinary molecules*, in which the *interatomic bonds* are of *electromagnetic* nature, the *internucleon bonds* in the *elementary nucleon molecules* (which "*atoms*" are) are determined by a *strong* ("nuclear") *interaction*.

Thus, according to the *Wave Model* (WM) (consisting of the Dynamic Model of Elementary Particles and the Shell-Nodal Atomic Model), an *atom* is an *elementary nucleon molecule*.

The *center* of *mass* of the nucleon *in each node* of such an atom oscillates with an *amplitude* of the order $1.4 \cdot 10^{-13}$ *cm* and a *frequency* of $1.8 \cdot 10^{18}$ s^{-1}, forming by this a certain *dynamic spherical space*, the radius of the *volume* of which is equal to the amplitude of the oscillations.

Just these specific *dynamic spaces* of individual nucleons in an atom are those *areas*, each of which is responsible for the observed feature of scattering of incident particles by the atom.

With the *discovery* of the shell-nodal (*molecule-like*) structure of atoms, we naturally *ran into a problem* of the need to *create* an appropriate *theory* of *scattering* of incident particles by *substances composed* of such "*atoms*", which has been done by us.

The author's article of 2008 [1] is devoted to this particular problem, and the present video is based on it.

2. Scattering by Rutherford

Investigations of scattering of α-*particles* by atoms of matter started by Geiger and Marsden [2], as well as scattering of β-particles carried out by Crowther [3] were continued by Rutherford [4], who ultimately suggested that in the *centre* of the atom there is a *very small* area (*nucleus*), compared to the size of the atom, where *almost all* of its *mass* is *concentrated*.

Thus, he concluded that there is only *one* physical *point* in the atom, scattering particles incident on the atom.

Of fundamental importance in Rutherford's theory is the position that the scattering force was simply an electrostatic repulsion from a *hypothetical nucleus*, which has a *positive* electric *charge* "*uniformly distributed*" over the surface of the nucleus.

Rutherford's idea gave rise to a single-centre *nuclear model* of the atom and the *scattering theory* suitable for this model.

However, *what* is such a *charge*? What is this "*uniformly distributed*"? Unknown form of matter? Physics did not know and still do not have an answer to these questions.

Rutherford's formula for α-*particles* scattering has the form

$$dN = nN\left(\frac{Ze^2}{M\upsilon^2}\right)^2 \frac{d\Omega}{\sin^4\frac{\vartheta}{2}} \qquad (1)$$

where N is the number of α-*particles* incident per a second on the surface of scattered leaf,

dN is a mean number of α-particles scattered at the angle ϑ within a solid angle of $d\Omega$,

n is the number of scattering nuclei in 1 cm^3,

M is the mass of an α-particle and υ is its speed at the large distance from a nucleus,

Ze is the charge of the nucleus.

The experimental data showed that deflection of α-particles does not obey completely to this formula. Rutherford noted [4] in this regard: "*The large and small angle scattering could not then be explained by the assumption of a central charge of the same value*".

But further, he wrote:
"*Considering the evidence as a whole, it seems simplest to suppose that the atom contains a central charge distributed through a very small volume, and that the large single deflections are due to the central charge as a whole, and not to its constituents...*»

Thus, based on all the data accumulated by then related to scattering in matter and the resulting assumption of the existence of a tiny atomic nucleus, Rutherford put forward both the *theory* of *scattering* of incident particles in matter and the *nuclear model* of an *atom*, which were accepted, and, over time, fully developed, exist till now.

Analyzing the *results* of all the data on the *scattering* of particles and waves in matter carried out by Rutherford and his followers, it should be noted the following:

Firstly, they all only state the fact that atoms have sites for scattering of particles.

Secondly, Rutherford's theory is based on the concept of the *coulomb* (electrostatic) *nature* of *scattering*, and, hence, describes only *scattering* of *charged* particles, such as α-*particles* and *protons*. It does *not describe neutron scattering*; knowing of this is most important for applied atomic physics, atomic technology, etc.

Thirdly, the nature of *mass* and *electric charge* was a great *puzzle* of that time (and still remains so). Accordingly, it makes no sense to speak about the "*uniformly distributed*" charge, *unknowing* what the *charge* is.

Forth, there is no unambiguous understanding of what means the deflection (or scattering) of particles on an atom if the particles at the same time behave like *wave formations*.

Fifth, all these experiments *did not* provide conclusive evidence that every atom has only *one scattering site*.

In general, all the data obtained by Rutherford [4, 5] and others show that it is unconvincing to talk about the *confluence* of all nucleons in an atom in one superdense *drop-nucleus*.

3. Scattering by the Wave Model

The *scattering center* was identified by *Rutherford* with an extremely small *positively* charged *solid nucleus* (about 10^{-13} *cm* in size), where, as he suggested, almost the entire mass of the atom (except electrons) is concentrated. For some reason he wasn't embarrassed that the density of such a hypothetical formation should have incredibly high value, about 10^{14} g/cm^3.

The discovery of the *shell-nodal* (molecular-like, non-nuclear) *structure* of *atoms* in the framework of the *Wave Model* (WM) [6–8] required the creation of a theory of scattering of elementary particles by components-nucleons located in the nodes of such atoms. This was done and first published in 1996 [9].

Data on *scattering cross-sections* of *neutrons* for almost all elements of the periodic table, and scattering of short X-rays, obtained in the framework of the new theory of scattering, turned out to be completely consistent with experimental data. We will show this.

In the light of the WM, atoms are *elementary nucleon molecules*. The *centers* of *scattering* of incident particles and waves in them are *individual nucleons*, constituents of such "atoms", *located* in the *nodes* of their nucleon shells. A size of the nucleons has the order of the Bohr radius, *e.g.*, $r_p = 0.528421703 \times 10^{-8}\, cm$ [10].

The *center* of *mass* of the nodal *nucleon* performs *radial oscillations* in the *node* with an *amplitude* of the order of $1.4 \cdot 10^{-13}$ *cm* and a *frequency* of $1.8 \cdot 10^{18}\, s^{-1}$, which cover the *volume* of *spherical space*, the *cross-section* of which has a *radius* equal to the *amplitude* of the oscillations.

As follows from our studies, just this *dynamic space* is a *scattering area* of the nucleon, which is erroneously identified in physics with a mystic *solid* "*nucleus*".

As you know, by definition, the *probability* of *scattering* is determined by the following ratio,

$$dw = -\frac{dN}{N} \tag{2}$$

where N is the *number* of particles *impinging* on a thin foil sheet, and dN is the *number* of *scattered* particles; the sign "–" indicates that dN is the loss of particles from the total flow [9].

Probability (2) is proportional to the *thickness* of the material layer *dx passed* by the beam particles:

$$-\frac{dN}{N} = \alpha dx \tag{3}$$

where $\alpha = dw / dx$ is the *density* of *probability* of scattering. Hence, the *scattering law* has the form

$$N = N_0 e^{-\alpha x} \tag{4}$$

In accordance with the *shell-nodal* atomic model [6-8, 11], *incident* particles are *scattered* on nucleons *located* in *nodes*. The *number* of the nodes is approximately equal to *half* the *atomic weight* (relative *atomic mass*).

An incident particle is *scattered* mainly on *one nucleon* of the *node* to which the particle approaches.

The nucleon of *each node* has relative freedom of movement within its *potential volume*. The center of mass of a nucleon *oscillates* in the node with the amplitude

$$\Psi = \frac{A_m}{z_{m,n}} = \frac{r_0}{z_{m,n}} \sqrt{\frac{2hR}{m_0 c}} \qquad (5)$$

where $h = 2\pi m_e \upsilon_0 r_0 = 6.6260693(11) \cdot 10^{-27}\ erg \cdot s$ is the Planck constant,

$R = \dfrac{R_\infty}{(1 + m_e / m_0)} = 109677.5833\, cm^{-1}$ is the Rydberg constant,

$r_0 = 0.5291772108(18) \cdot 10^{-8}\ cm$ is the Bohr radius,

$c = 2.99792458 \cdot 10^{10}\ cm \cdot s^{-1}$ is the speed of light,

$z_{m,n}$ are roots of Bessel functions [12].

The first maximum of the *kinetic* component of the spherical function of zero order ($z_{m,n} = b'_{0,1} = 2.79838605$) determines the *displacement* of the following value

$$\Psi = 3.219483546 \cdot 10^{-13}\, cm \tag{6}$$

According to (5), a specific scattering sphere corresponds to each root $z_{m,n}$. For example, if $z_{m,n} = a'_{0.1} = 4.49340945$, which corresponds to the maximum of the potential component of the zero-order spherical function, we have

$$\Psi = 2.005016 \cdot 10^{-13}\, cm$$

Zeros of the *potential* and *kinetic* components of the zero-order Bessel spherical functions are, *respectively*,

$$z_{0,n} = \pi n \qquad \text{and} \qquad z_{0,n} = \frac{\pi}{2}(2n-1) \tag{7}$$

Due to the very high *frequency* of *pulsations* of the nucleon spherical *shell* [7], displacement (5) determines the spherical *volume* of *oscillations* of the *center* of *mass* of the nucleon [13]. A sphere, confining this volume, is the sphere of the center of mass of the nucleon. It is the *core* (nucleus) of *scattering* of the *nucleon*.

The *cross-section* of the *scattering sphere*,

$$\sigma_n = \pi\Psi^2 \tag{8}$$

is the *measure* of *scattering* of particles and waves.

Let the *effective area* of the center of *scattering* is equal to σ_n, then the *total scattering area* of microparticles by atoms of the *metal foil* is

$$S_{tot} = A_{ef}\sigma_n nSd \tag{9}$$

where A_{ef} is the *number* of nucleons in an atom participating in scattering of particles or waves, n is the *concentration* of atoms, S is the *area* of the foil, and d is its *thickness*.

The *density* of *probability* of scattering is determined as

$$\alpha = -\frac{\Delta N}{Nd} = \frac{S_{tot}}{Sd} = A_{ef}\sigma_n n \tag{10}$$

hence, the *specific density* of probability of scattering is

$$\alpha_s = \frac{\alpha}{\varepsilon_0 \varepsilon} = \frac{A_{ef}\sigma_n n}{A_r m_0 n} = \frac{A_{ef}}{A_r}\frac{\sigma_n}{m_0} \tag{11}$$

where A_r is the *relative* atomic mass, ε_0=1g/cm^3 is the *absolute unit* of *density*, ε is the relative density.

If one introduces an *element* of the *scattering mass* $\Delta m = \varepsilon_0 \varepsilon s x$ in terms of the *specific thickness* of *scattering*,

$$x_s = \frac{\Delta m}{s} = \varepsilon_0 \varepsilon x \tag{12}$$

the *law* of *scattering* (4) takes the form

$$N = N_0 e^{-\alpha_s x_s} \tag{13}$$

The effective *number* of *nucleons*, scattering incident particles or waves, is determined by the *degree* of their *mutual overlap* in the *foil matter* and by the *character* of their collective *interaction* with incident particles and waves.

Ignoring the overlap, we have $A_{ef} = A_r$.

In the case when the scattering object is an atomic volume, *probability density* of *scattering* should be proportional to the *relative atomic mass*, $\alpha \sim A_r$,

If scattering occurs on an *atomic area*, then $\alpha \sim A_r^{2/3}$; if it is realized on an *atomic line*, then $\alpha \sim A_r^{1/3}$.

Such an *approximate estimation* allows writing a series of *possible* values of the *effective number* of *nucleons* participating in the scattering of incident particles or waves:

$$A_{ef} = A_r, \quad A_r^{2/3}, \quad A_r^{1/3} \tag{14}$$

With due account of (5) and (8), the *effective section* of scattering *per atom* will be defined by the formula

$$\sigma_{ef} = A_{ef}\sigma_n = \pi A_{ef}\left(\frac{A_m}{z_{m,n}}\right)^2 \tag{15}$$

In the case of *scattering of waves* of a relatively *short length* (with respect to the size of a nucleon), the *volume* scattering will prevail, so that we should accept $A_{ef} = A_r$. Then, the *specific density* of *scattering* (11) takes the form

$$\alpha_s = \frac{\sigma_n}{m_0} = \frac{\pi}{m_0}\left(\frac{A_m}{z_{m,n}}\right)^2 \tag{16}$$

Hence, for the maximum of the first kinetic shell, $z_{m,n} = b'_{0,1}$ (see (6)), we have

$$\alpha_s = 0.1955\, g^{-1}\cdot cm^2 \tag{17}$$

The obtained value *precisely coincides* with the *experimental* one of $\alpha_s = 0.2\, g^{-1}\cdot cm^2$ holding practically for all targets in the case of *short* X-rays [14]. The good *agreement* of (17) with the experimental data indicates on the validity of the theoretical approach presented.

For the case of *scattering of particles*, the atomic plane of scattering manifests itself. Accordingly, the *effective section* of *scattering* per *atom* is equal to

$$\sigma_{ef} = \pi A_r^{2/3} \left(\frac{A_m}{z_{m,n}} \right)^2 \tag{18}$$

Effective roots $z_{m,n}$ *depend* on the structure of *nucleonic shells* and on the *energy* of incident particles or *intensity* of waves directed to the space of the being investigated matter.

In spite of the above uncertainty, it is reasonable to *compare theoretical cross-sections* calculated by formula (18) with the *experimental* data.

Table 1 presents such data: the *average* values obtained *experimentally* [15] for the *Maxwell* spectrum of *neutrons* σ_{tot} (energy from 0 to about 14 *MeV*, and the mode of the *energy* is only 0.75 *MeV*), and *calculated* by formula (18) σ_{ef} for the roots of the Bessel functions lying within the central part of the experimental value (in barn, $1 barn(b) = 10^{-24} cm^2$).

Since scattering is a *mass process*, experiment determines an *effective value* of the *scattering cross-section* corresponding to the *mean value* of a series of *roots* of Bessel functions.

Table 1. Scattering cross-sections data for the Maxwell spectrum of neutrons

Experiment [15]		Calculated data by Eq. (18)		
Element	σ_{tot}, *b*	σ_{ef}, *b*	$z_{m,n}$ [12]	$z_{m,n}$ value
1	2	3	4	5
$_{2}$He	1.0 ± 0.7	1.11	$j_{0,1}$	2.40482556
$_{3}$Li	1.4 ± 0.3	1.604	$j_{0,1}$	2.40482556
$_{4}$Be	7 ± 1	8.129	$j'_{1/2,1}$	1.16556119
$_{6}$C	4.8 ± 0.2	5.420	$y_{1/2,1}$	1.57079633
$_{7}$N	10 ± 1	10.90	$j'_{1/2,1}$	1.16556119
$_{8}$O	4.2 ± 0.3	4.776	$j'_{1,1}$	1.84118378
$_{9}$F	3.9 ± 0.2	3.761	$y'_{0,1}$	2.19714133
$_{10}$Ne	2.4 ± 0.3	2.135	$y'_{1/2,1}$	2.97508632
$_{11}$Na	4.0 ± 0.5	4.271	$y'_{0,1}$	2.19714133
$_{12}$Mg	3.6 ± 0.4	3.699	$j_{0,1}$	2.40482556
$_{13}$Al	1.4 ± 0.1	1.287	$b'_{1,1}$	4.22227640
$_{14}$Si	1.7 ± 0.3	1.737	$y'_{1,1}$	3.68302286
$_{15}$P	5 ± 1	5.100	$y'_{0,1}$	2.19714133
$_{16}$S	1.1 ± 0.2	1.159	$y_{1/2,2}$	4.71238898
$_{17}$Cl	16 ± 3	20.257	$j'_{1/2,1}$	1.16556119
$_{18}$Ar	1.5 ± 0.5	1.476	$a'_{0,2}$	4.49340946

Experiment [15]		Calculated data by Eq. (18)		
Element	σ_{tot}, *b*	σ_{ef}, *b*	$z_{m,n}$ [12]	$z_{m,n}$ value
1	2	3	4	5
$_{19}$K	1.5 ± 0.3	1.455	$a'_{0,2}$	4.49340946
$_{21}$Sc	24 ± 2	23.73	$j'_{1/2,1}$	1.16556119
$_{22}$Ti	4 ± 1	3.799	$y'_{1/2,1}$	2.97508632
$_{23}$V	4 ± 1	4.475	$b'_{0,1}$	2.79838605
$_{24}$Cr	3.0 ± 0.5	3.18	$a'_{2,1}$	3.34209366
$_{25}$Mn	2.3 ± 0.3	2.353	$y_{0,2}$	3.95767842
$_{26}$Fe	11 ± 1	10.99	$j'_{1,1}$	1.84118378
$_{27}$Co	7 ± 1	6.677	$j_{0,1}$	2.40482556
$_{28}$Ni	17.5 ± 1	15.6	$y_{1/2,1}$	1.57079633
$_{29}$Cu	7.2 ± 0.7	8.41	$y'_{0,1}$	2.19714133
$_{30}$Zn	3.6 ± 0.4	3.54	$y_{2,1}$	3.38424177
$_{31}$Ga	4 ± 1	3.868	$a'_{2,1}$	3.34209366
$_{32}$Ge	3 ± 1	3.023	$j_{1,1}$	3.83170597
$_{33}$As	6 ± 1	5.787	$b'_{0,1}$	2.79838605
$_{34}$Se	11 ± 2	10.83	$a'_{1,1}$	2.08157598
$_{35}$Br	6 ± 1	5.344	$y'_{1/2,1}$	2.97508632
$_{36}$Kr	7.2 ± 0.7	8.066	$j'_{3/2,1}$	2.46053557

Experiment [15]		Calculated data by Eq. (18)		
Element	σ_{tot}, *b*	σ_{ef}, *b*	$z_{m,n}$ [12]	$z_{m,n}$ value
1	2	3	4	5
$_{37}$Rb	12 ± 2	11.42	$a'_{1,1}$	2.08157598
$_{38}$Sr	10 ± 1	10.42	$y_{1,1}$	2.19714133
$_{39}$Y	3 ± 2	3.24	$y_{5/2,1}$	3.95952792
$_{40}$Zr	8 ± 1	8.535	$j'_{3/2,1}$	2.46053557
$_{41}$Nb	5 ± 1	4.683	$a'_{2,1}$	3.34209366
$_{42}$Mo	7 ± 1	6.824	$b'_{0,1}$	2.79838605
$_{44}$Ru	6 ± 1	5.93	$j'_{2,1}$	3.05423693
$_{45}$Rh	5 ± 1	5.007	$a'_{2,1}$	3.34209366
$_{46}$Pd	3.6 ± 0.6	3.656	$y_{0,2}$	3.95767842
$_{47}$Ag	6 ± 1	5.855	$j_{1/2,1}$	3.14159265
$_{48}$Cd	7 ± 1	6.829	$y'_{1/2,1}$	2.97508632
$_{49}$In	2.2 ± 0.5	2.284	$j_{2,1}$	5.13562230
$_{50}$Sn	4.9 ± 0.5	4.667	$j'_{5/2,1}$	3.63279732
$_{51}$Sb	4.3 ± 0.5	4.266	$j_{1,1}$	3.83170597
$_{52}$Te	5 ± 1	4.897	$j'_{5/2,1}$	3.63279732
$_{53}$J	3.6 ± 0.5	3.648	$j'_{3,1}$	4.20118894
$_{54}$Xe	4.3 ± 0.4	4.205	$y_{0,2}$	3.95767842

Experiment [15]		Calculated data by Eq. (18)		
Element	σ_{tot}, *b*	σ_{ef}, *b*	$z_{m,n}$ [12]	$z_{m,n}$ value
1	2	3	4	5
$_{55}$Cs	20 ± 10	19.59	$j'_{1,1}$	1.84118378
$_{56}$Ba	8 ± 1	7.668	$y'_{1/2,1}$	2.97508632
$_{57}$La	15 ± 5	14.17	$y'_{0,1}$	2.19714133
$_{58}$Ce	9 ± 6	8.784	$b'_{0,1}$	2.79838605
$_{63}$Eu	8 ± 1	7.784	$j'_{2,1}$	3.05423693
$_{68}$Er	15 ± 4	16.04	$y'_{0,1}$	2.19714133
$_{69}$Tm	7 ± 3	6.977	$a'_{2,1}$	3.34209366
$_{70}$Yb	12 ± 5	13.08	$j'_{3/2,1}$	2.46053557
$_{72}$Hf	8 ± 2	8.173	$j_{1/2,1}$	3.14159265
$_{73}$Ta	5 ± 1	5.208	$y_{0,2}$	3.95767842
$_{74}$W	5 ± 1	5.264	$y_{0,2}$	3.95767842
$_{75}$Re	14 ± 4	13.73	$j'_{3/2,1}$	2.46053557
$_{76}$Os	11 ± 1	10.77	$y_{3/2,1}$	2.79838605
$_{78}$Pt	10 ± 1	9.69	$y'_{1/2,1}$	2.97508632
$_{79}$Au	9.3 ± 1	9.25	$j'_{2,1}$	3.05423693
$_{80}$Hg	20 ± 5	20.17	$a'_{1,1}$	2.08157598
$_{81}$Tl	14 ± 2	14.61	$j'_{3/2,1}$	2.46053557
$_{82}$Pb	11 ± 1	11.4	$y_{3/2,1}$	2.79838605
$_{83}$Bi	9 ± 1	9.099	$j_{1/2,1}$	3.14159265

In *modern atomic* theory, the *effective parameter* of *scattering* $L = \sqrt{\sigma_{ef} / \pi}$, determines the *effective radius* of the *atomic nucleus*.

In the *shell-nodal* atomic model [8] (which takes into account the dynamic behavior of elementary particles [10]), the *effective parameter* of *scattering L*, as follows from (18), is associated with the *number of nucleons* in the *atom* A_r and the *scattering sphere* of the *nucleon*,

$$L = \sqrt{\frac{\sigma_{ef}}{\pi}} = A_r^{1/3} \frac{A_m}{z_{m,n}} \tag{19}$$

The *scattering sphere* (volume) of the nucleon is defined by the *amplitude* $\Psi = A_m / z_{m,n}$ (5) of *pulsations* of its center of mass. The latter has an associated character, and the *rest mass* of a nucleon (like all elementary particles, in accordance with the DM) *does not exist.*

Consequently, the *concept* of a solid atomic *nucleus* (moreover, of the incredibly gigantic density) does not make sense. Just as it makes no sense to speak, as mentioned above, about the "*central charge distributed through a volume…",* without knowing what the charge is [16, 17].

Experimentally, the atomic cross-section of scattering is determined by the formula,

$$\sigma_{tot} = \frac{1}{nd} \ln\left(\frac{I_0}{I}\right) \tag{20}$$

where I_0 and I are intensities of flows of *incident* and *passed* particles or waves, d is the thickness of a target.

On the basis of (18) and (20) (see also (5)), we find the experimental radius of the *nucleon* sphere of scattering,

$$\Psi = A_r^{-1/3}\left(\frac{\sigma_{tot}}{\pi}\right)^{1/2} \tag{21}$$

which is in good agreement with the scattering theory presented here.

In the case of a *neutron flux*, experiments confirm, with a certain degree of approximation, the following equality:

$$\sigma_{tot} = A_r^{2/3}\sigma_n \tag{22}$$

The latter is also consistent with the scattering theory based on the WM.

4. DISCUSSION

Let us now compare two fundamentally different formulas for scattering obtained by two different scattering theories, Rutherford's formula (1) (for α-particles) and formula of the WM (18) (for particles and short X-rays):

$$(1) \qquad \frac{dN}{N} = nd\sigma = n\left(\frac{Ze^2}{M\upsilon^2}\right)^2 \frac{d\Omega}{\sin^4(\vartheta/2)} \qquad \text{and} \qquad \sigma_{ef} = \pi A_r^{2/3}\Psi^2 = \pi A_r^{2/3}\left(\frac{A_m}{z_{m,n}}\right)^2 \qquad (18)$$

As we see, the number of scattered particles, according to formula (1), strongly depends on the scattering angle ϑ (*angle* between *incident velocity* and *final velocity* of α-particles) and rapidly increases with decreasing ϑ.

Formula (1) allows us to calculate the *effective scattering cross-sections* for α-particle on the *Coulomb field* of a nucleus with the charge Z*e*, *differential* $d\sigma/d\Omega$ and *integral* $\sigma(\vartheta > \vartheta_0)$:

$$(23) \qquad \frac{d\sigma(\vartheta)}{d\Omega} = \left(\frac{Ze^2}{M\upsilon^2}\right)^2 \frac{1}{\sin^4(\vartheta/2)}, \qquad \int_\Omega \frac{d\sigma(\vartheta)}{d\Omega} d\Omega = \int_{\vartheta_0}^{\pi}\int_0^{2\pi} \frac{d\sigma(\vartheta)}{d\Omega} \sin\vartheta d\vartheta d\varphi \qquad (23\alpha)$$

If in Rutherford's formula (1), keeping all other conditions, change only the angle ϑ, then there should be

$$dN \cdot \sin^4(\vartheta/2) = const \tag{24}$$

This conclusion was *checked* in the *first* place. A more or less satisfactory agreement of the experimental results with the requirements of the theory (24) was obtained, however, not for all cases. This can be seen, in particular, on the example of data obtained from an experiment with a *gold* foil, presented in Table 2 [18].

Table 2. Scattering of α-particles by gold leaves

$\vartheta°$	$1/\sin^4(\vartheta/2)$	dN	$dN \cdot \sin^4(\vartheta/2)$
150	1.15	33.1	28.8
135	1.38	43.0	31.2
120	1.79	51.9	29.0
105	2.53	69.5	27.5
75	7.25	211	29.1
60	16.0	477	29.8
45	46.6	1435	30.8
30	223	7800	35.0
15	3445	132000	38.4

An agreement with condition (24) took place mostly in cases of scattering in leaves of *heavy* metals and not too fast α-particles (with an energy of not more than 20 *MeV*), and in addition, not for all angles. At small angles there are most significant deviations from the value of the constant (24).

Deriving formula (1), Rutherford *believed* that the *scattering centres* are atomic *nuclei*. That is, he *suggested* that *each atom* has only *one scattering centre*. Therefore, in formula (1), *n* is the *number* of *scattering nuclei* in 1 cm^3.

But this does not follow *from nowhere* and has *not* yet been *confirmed*, quite convincingly, *experimentally*. With the same success, each of the nucleons that make up the atoms could be considered as a scattering centre, if only Rutherford have assumed (as an alternative) that nucleons are located separately from each other in the inner space of the atom (being, of course, strongly connected with each other).

Common sense rebels against the *accepted concept*, according to which *all nucleons* in an atom are, allegedly, in a *densely pac*ked extremely small physical volume – at one physical point (nucleus).

So, we see that a theoretical design that takes into account a single-centre (nuclear) model of an atom is extremely *inconclusive.*

On the contrary, the formula of the WM (18) for the effective scattering cross section contains the relative atomic mass A_r , i.e., the number of nucleons in an atom is given. This indicates that effective scattering cross sections for each of the nucleons present in the atom are taken into account in this formula.

The experimental data presented in Table 1 confirm the *correctness* of *formula* (18), and, therefore, the *fundamental concepts* on the basis of which this formula was derived. These are the *wave nature* of the *origin* and *behaviour* of all particles and the *shell-nodal structure* of atoms.

The *amplitude* of *vibrations* of the centre of mass of the nucleon in the atomic node $\Psi = A_m / z_{m,n}$ in formula (18) (about 10^{-13} *cm*, (6)), where $z_{m,n}$ are roots of the Bessel functions, points to this. Since it is the result of *solving* the *wave equation*.

As mentioned above, analysis of a large number of *scattering events* recorded for α-particles on *gold* (see Table 2) quite satisfactory *confirmed* the *angular dependence* predicted by equality (24) for all angels *except* for *small* ones.

But for *aluminum*, a *lighter* metal, Rutherford found the *opposite feature*: scattering at *small angles* obeyed to equality (24), but at *large angles* did not.

Rutherford deduced that events with *large* or *small angle* scattering depend on the mass and, therefore, the size of the nucleus. The α-particles more frequently closer approach to the *heavier* nuclei, sometimes hitting them, *than* to the *lighter* ones. This is only a *verbal* explanation, the *mass* or *size* of the *nuclei* is *not included* in the Rutherford *formula* (1).

Significant difference between the scattering cross-sections on *light* and *heavy* metals, for example, *Al* and *Au* (see Table 1 for low-energy *neutrons*), is logically *explained* within WM thanks to the *parameter* A_r contained in formula (18):

Al ⇨ $\boldsymbol{A_r}$ = 26,9815, Ψ=2.133767898·10^{-13} *cm*, σ_{ef} = **1.287** *b* (σ_{exp} = 1.4 ± 0.1)

Au ⇨ $\boldsymbol{A_r}$ =196,96657, Ψ=2.949790094·10^{-13} *cm*, σ_{ef} = **9.25** *b* (σ_{exp} = 9.3 ± 0.1)

5. CONCLUSION

The *data presented* and many *other* data, have already been *published* (see also [19, 20]), *convincingly testify* to the *adequacy* of the *shell-nodal structure* of atoms, that atoms indeed are *elementary nucleon molecules*.

In accordance with the *Dynamic Model*, all *elementary particles* (including *nucleons*) are *pulsing* spherical microformations.

In accordance with the *Shell-Nodal* (molecular-like) *model*, *atoms* are *elementary nucleon molecules*, in each node of which there are *two coupled* nucleons.

Taking into account the aforementioned *discoveries*: the wave molecular-like *structure* of *atoms* and the structure and *behaviour* of their components – *nucleons*, the *new scattering theory* (as part of the WM) was *developed*.

Within the framework of *this theory*, s*cattering cross-sections* are calculating logically *flawlessly* and *simply*.

All obtained *data* are completely consistent with *experimental* data. They *confirm* the correctness of the *concept*, according to which each *nucleon*, a *component* of *elementary nucleon molecules* (“atoms”), located in the node of the molecule, contributes to the *scattering* of particles incident on the substance.

Lack of *knowledge* at the time of Rutherford (and now too) of the above features on the *structure* of *matter* at the *atomic* and *subatomic* levels (discovered *quite recently* thanks to the WM) led to the *hypothesis* (postulate) that almost the *entire mass* of an atom is concentrated in a *tiny volume* in its *centre*.

The latter, consisting of *superdense nucleons* closely adjusted to each other, began to be considered as a *single entity*, “*nucleus*”, responsible for scattering.

Since then as the *hypothesis* was put forward and accepted, the *hypothetical nucleus* began to be considered in physics, without any doubt, as a *real* object. And a new section in physics has appeared - *nuclear physics*.

Accordingly, *all theories* of *atomic* and *nuclear* physics, as well as the theory of *elementary particles*, began to develop on the basis of the hypothesis on the existence of a *superdense* tiny "*nucleus*" in the centre of an atom and, accordingly, on the existence of *superdense* particles – *nucleons*.

Finally, concluding, it should be recognized that modern *nuclear* model of an atom is *doubtful* and needs to be *revised* [21].

This concerns also the *Standard Model* of elementary particles [22].

Really, the adoption of a nuclear model of the structure of atoms led, as a result, to the adoption of the *size* of *nucleons* of the order of 10^{-13} *cm* and their *fantastically* incredible *density* of the order of 10^{14} g/cm^3, which is very *doubtful* and *illogical*. Common sense does not accept this.

6. ADDITIONAL COMMENTS

What is really responsible for scattering on an "atom"?

The *center* of *mass* of the nodal *nucleon* (in an "*atom*"), whose *size* is about $0.528 \cdot 10^{-8}$ *cm* [10], performs *radial oscillations* in the *node* with an *amplitude* of the order of $1.4 \cdot 10^{-13}$ *cm* and a *frequency* of $1.8 \cdot 10^{18}\, s^{-1}$, covering the *volume* of *spherical space*, the *cross-section* of which has a *radius* equal to the *amplitude* of the oscillations.

Just this dynamic space, which encompasses the region of vibrations of the mass centre of a nucleon, is that area that determines the character of scattering of a particle incident on an atom of matter.

The *volume* of this *oscillation space*, whose radius is five orders of magnitude smaller than the *radius* of the *proton itself* r_p (resulting from the WM), *i.e.*, equal to $2.65 \cdot 10^{-5} r_p$, was subjectively accepted and is still considered in modern physics as a *solid* "*nucleus*" of the simplest *hydrogen atom* (protium), called a *proton*.

The *wave origin* and, accordingly, the *wave behaviour* of the particles *determine* not only the feature of particle *scattering* by the substance, but also *other phenomena* observed in nature.

In particular, I would like to *draw* the *attention* of readers to the *discovery* of the phenomenon of the *microwave background radiation* of *hydrogen atoms*, which is observed in nature as the *cosmic* microwave background [23, 24].

It is also worth paying special attention to the *discoveries* of the *true nature* of the so-called "*anomaly*" of the *electron magnetic moment* and the nature of the *Lamb shift* [25 – 27].

All the above four phenomena were *examined* and explained taking into account the *continuous oscillations* of the centre of mass of the particles and their *wave shells*.

Thus, a *revisio*n of known *physical phenomena* on the *basis* of the *concepts* of the *Wave Model* has led to a number of *fundamental discoveries*.

A *new view* at the structure of elementary particles and atoms *casts doubt* on the *key conceptions* of *chemistry*, in particular, on the *role* of *electrons* in the formation of *chemical bonds*. This is an extremely important *consequence*.

Namely, as follows from the Wave Model, the *main role* in the formation of the *geometrical form* of *ordinary molecules*, that is, the *spatial arrangement* of *bonds* in them, belongs to *internucleon bonds* of interacting “atoms”, but not to electrons.

Bonds between various “atoms” (which are *elementary nucleon molecules*) are realized only *along* the directions of *strong internucleon bonds* existed in both interacting “atoms”. *Electrons* are responsible only for the *strength* of these *bonds* [28].

Another important *consequence* is the concept of *atomic orbitals*, as well as the *hybridization* of these orbitals, the groundlessness of the introduction of which was convincingly shown in [29, 30] and other works of the author.

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