VORTEX-FRACTAL-RING MODEL OF HYDROGEN ATOM

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Abstract: *This paper is an attempt to attain a better model of the nature's structure using a vortex-ring-fractal theory. The aim of this paper is the vortex-ring-fractal modeling of the hydrogen atom, which is not in contradiction to the known laws of nature. We would like to find some acceptable quantum model of the hydrogen atom as levitating model with a ring structure of the proton and a ring structure of the electron. It is known that planetary model of hydrogen is not right. The quantum model is too abstract. Our imagination is that the hydrogen atom is a levitation system of the ring proton and the ring electron.*

Keywords: *structure of hydrogen atom, quantum model of the hydrogen, vortex-ring-fractal theory*

1 Introduction

Fractals seem to be very powerful in describing natural objects on all scales. Fractal dimension and fractal measure are crucial parameters for such description. Many natural objects have self-similarity or partial-self-similarity of the whole object and its part [10].

Most of our knowledge of the electronic structure of atoms has been obtained by the study of the light given out by atoms when they are exited. The light that is emitted by atoms of given substance can be refracted or diffracted into a distinctive pattern of lines of certain frequencies and create the line spectrum of the atom. The careful study of line spectrum began about 1880. The regularity is evident in the spectrum of the hydrogen atom. The interpretation of the spectrum of hydrogen was not achieved until 1913. In that year the Danish physicist Niels Bohr successfully applied the quantum theory to this problem and created a model of hydrogen. Bohr also discovered a method of calculation of the energy of the stationary states of the hydrogen atom, with use of Planck's constant *h*. Later in 1923 it was recognized that Bohr's formulation of the theory of the electronic structure of atoms to be improved and extended. The Bohr's theory did not give correct values for the energy levels of helium atom or the hydrogen molecule-ion, H_2^+, or of any other atom with more than one electron or any molecule. During the two-year period 1924 to 1926 the Bohr description of electron orbits in atoms was replaced by the greatly improved description of wave mechanics, which is still in use and seems to be satisfactory. The discovery by de Broglie in 1924 that an electron moving with velocity *v* has a wavelength $\lambda = h/m_e v$ [4]. The electron is not to be thought of as going around the nucleus, but rather as going in and out, in varying directions, so as to make the electron distribution spherically symmetrical [4].

2 The spin of the electron

It was discovered in 1925 that the electron has properties corresponding to its spin *S*. It can be described as rotating about an axis of a ring structure of the electron [25]. The spin of the electron is defined as angular momentum [21]:

$$\vec{S} = m_e(\vec{r}_e \times \vec{v}_e) \tag{1}$$

For the spin on axis z:

$$|S_z| = N\frac{m_e}{N} r_e v_e = \frac{1}{2}\frac{h}{2\pi} \tag{2}$$

where m_e is the mass of the electron, r_e is the radius of the electron and N is number of substructures inside the structure of the electron. The torus structure with spin ½ can oscillate with $n\lambda$ [25] (see Fig.1, Fig.2, and Fig.3):

$$2\cdot 2\pi r_e = n\lambda \qquad 2\pi r_e = \frac{n}{2}\lambda \tag{3}$$

$$r_e = \frac{\lambda}{4\pi} \tag{4}$$

$$|S_z| = N \frac{m_e}{N} r_e v_e = m_e \frac{\lambda}{4\pi} v_e = \frac{1}{2} \frac{h}{2\pi} \tag{5}$$

$$\lambda = \frac{h}{m_e v_e} \tag{6}$$

where v_e is rotation velocity of the electron [25] (see Fig.5). It is the similar result as de Broglie discovered.

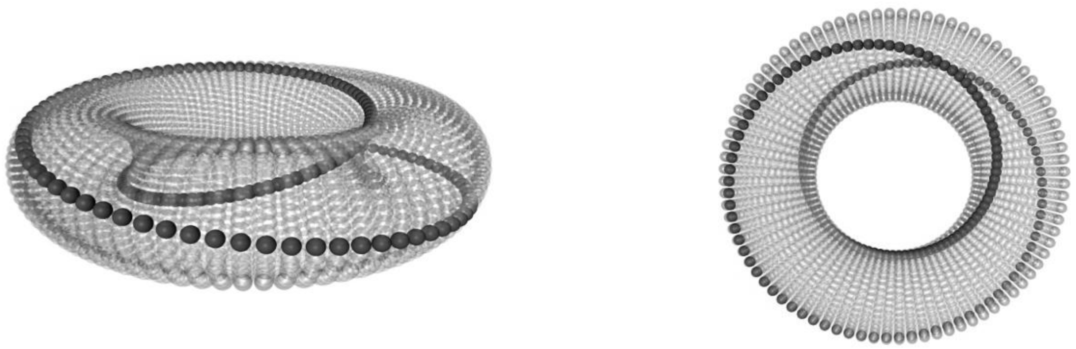
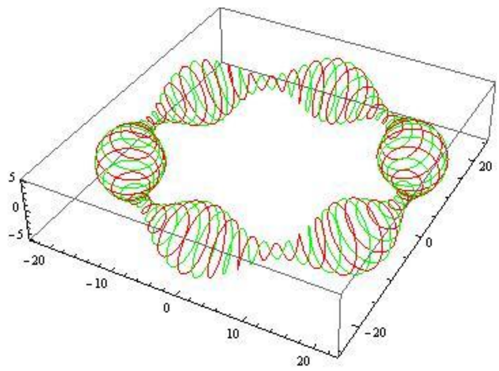


Fig. 1 The torus structure with spin ½



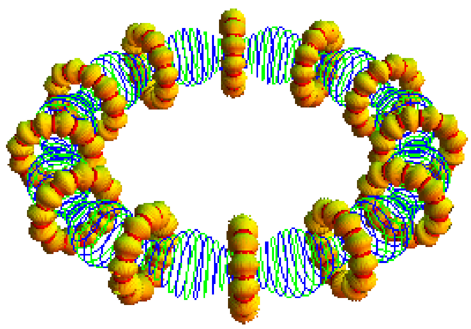


Fig. 2 The vortex structure with spin ½

Fig. 3 The fractal structure with spin ½

3 The model of hydrogen with a levitating electron

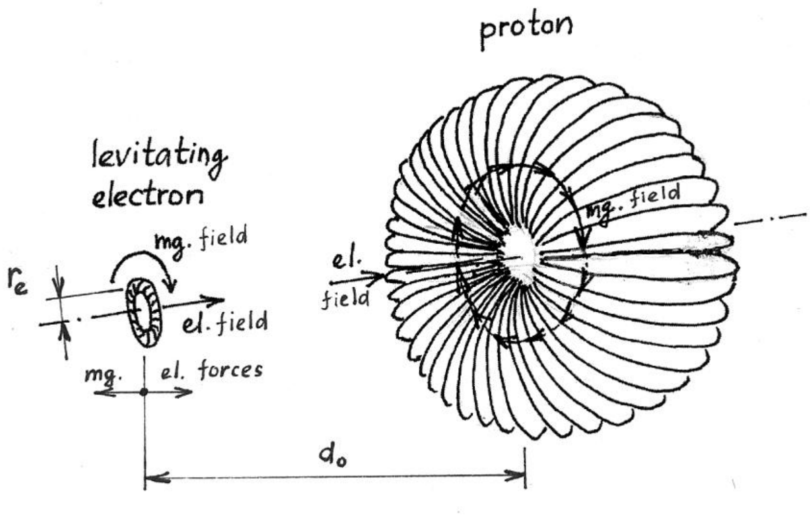


Fig. 4 The levitating electron in the field of the proton (the fractal structure model of hydrogen **H** is simplified [18]).

The new model of the hydrogen atom with a levitating electron was introduced in [18], [23]. There is attractive (electric) force F_+ and (magnetic) repellent force F_- :

$$F = F_+ - F_- = \frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d^2} - \frac{d_o^2}{d^4}\right) \tag{7}$$

The hydrogen atom can have the electron on left side or on right side [23]. The attractive force F+ is Coulomb's force. The repellent force F_- is caused with magnetic fields of the proton and the electron (see Fig.4). A distance between the electron and the proton in (7) is *d*. The electron moves between point d_1 and point d_2 (see Fig.8 and Fig.9). The energy E_i required to remove the electron from the ground state to a state of zero total energy is called ionization energy. The energy of the hydrogen atom in the ground state is *E*= – 13.6 eV. The negative sign indicates that the electron is bound to the nucleus and the energy 13.6 eV must be provided from outside to remove the electron from the atom. Hence 13.6 eV is ionization energy E_i for hydrogen atom. Calculation of ionization energy from (7) was introduced in [22]:

$$E = -E_i = -\frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d} - \frac{d_o^2}{3d^3}\right) = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{d}\left(1 - \frac{d_o^2}{3d^2}\right) \tag{8}$$

The quantum number *n* that labels the electron radii r_{en} also labels the energy levels. The lowest energy level or energy state, characterized by *n=1*, is called the ground state. This state is described in equations (7) and (8). Higher energy levels with *n>1* are called excited states. For excited states we using postulates [22] and presuppose following equations (9) and (10):

$$F_n = F_+ - F_- = \frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d^2} - \frac{n^2 d_{on}}{d^4}\right) = \frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d^2} - \frac{n^4 d_o^2}{d^4}\right) = \frac{e^2}{4\pi\varepsilon_o}\frac{1}{d^2}\left(1 - \frac{n^4 d_o^2}{d^4}\right) \tag{9}$$

$$E_n = -E_{in} = -\frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d} - \frac{n^2 d_{on}}{3d^3}\right) = -\frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d} - \frac{n^4 d_o^2}{3d^3}\right) = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{d}\left(1 - \frac{n^4 d_o^2}{3d^2}\right) \tag{10}$$

where

$$d_{on} = n^2 d_o \tag{11}$$

To calculate quantum model of hydrogen we use radius r_e of the electron, which was derived in [14], [15], [17]:

$$r_e = \frac{\mu_o e^2}{4\pi^2 m_e}\frac{v_o^2}{v_e^2} \tag{12}$$

for

$$v_o = \frac{c}{\sqrt{2}} \qquad v_o^2 = \frac{c^2}{2} = \frac{1}{2\varepsilon_o \mu_o} \tag{13}$$

$$r_e = \frac{\mu_o e^2}{4\pi^2 m_e}\cdot\frac{v_o^2}{v_e^2} = \frac{\mu_o e^2}{4\pi^2 m_e}\cdot\frac{c^2}{2v_e^2} = \frac{e^2}{8\pi^2\varepsilon_0 m_e}\cdot\frac{1}{v_e^2} \tag{14}$$

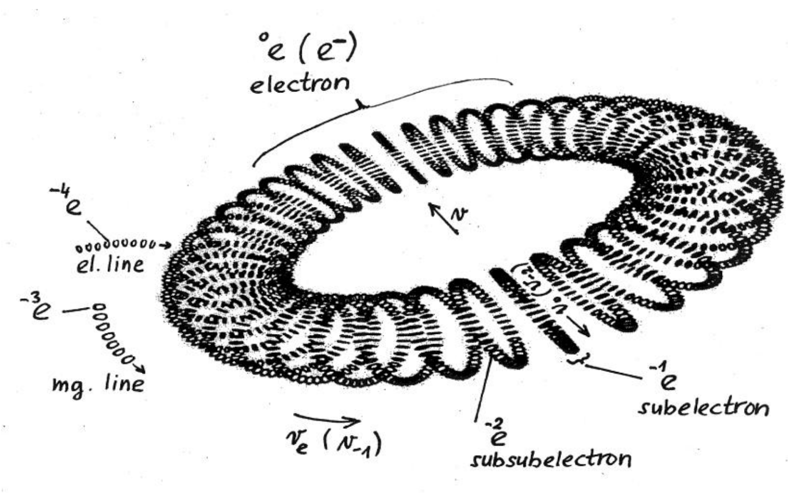


Fig.5 Vortex-fractal ring structure of the electron [15], [17]

The radius r_e of the electron in (14) was derived from the balance of Coulomb's force and centripetal force [24]. On a circumference of a circle with r_e (see Fig.4 and Fig.5) have to be n of a half-wavelength as defined in (3) and (6): $n\lambda/2=nh/2m_e v_e$ (n is quantum number) [23]:

$$2\pi r_e = 2\pi \frac{\mu_o e^2}{4\pi^2 m_e} \frac{v_o^2}{v_e^2} = \frac{\mu_o e^2}{2\pi m_e} \frac{c^2}{v_e^2} = \frac{e^2}{4\pi\varepsilon_o m_e} \frac{1}{v_e^2} = n\frac{\lambda}{2} = n\frac{1}{2}\frac{h}{m_e v_e^2} \quad (15)$$

$$\frac{e^2}{2\pi\varepsilon_o} \frac{1}{v_e} = nh \quad (16)$$

where v_{en} is velocity of the electron if the electron has distance d_{on} and minimum energy E_{on} on level n:

$$v_{en} = \frac{1}{n} \frac{e^2}{2\pi\varepsilon_o h} = \frac{1}{n}\frac{\alpha}{\pi} c \quad (17)$$

For $n=1$ on the ground state the electron has maximal velocity v_{emax} and has rotational energy E_r:

$$v_{e\max} = \frac{e^2}{2\pi\varepsilon_o h} = \frac{\alpha}{\pi} c \cong 697 km/s \quad (18)$$

where α is the couple constant:

$$\alpha = \frac{e^2}{2\varepsilon_o hc} \quad (19)$$

$$\frac{c}{\pi v_{e\max}} = \frac{2\pi\varepsilon_o hc}{e^2} = \frac{1}{\alpha} \approx 137.036 \quad (20)$$

Energy E_r of rotation of the electron if we use (17):

$$E_{rn} = \frac{1}{2} \frac{m_e}{N} N \cdot v_{en}^2 = \frac{1}{n^2} \frac{m_e e^4}{8\pi^2 \varepsilon_o^2 h^2} \quad (21)$$

For quantum number $n=1$

$$E_{io} = \frac{m_e e^4}{8\varepsilon_o^2 h^2} \approx 13.6 eV \quad (22)$$

$$E_r = \frac{E_{io}}{\pi^2} \cong \frac{13.6 eV}{\pi^2} \cong 1.36 eV \quad (23)$$

Equation (10) for:

$$d = d_{on} = n^2 d_o \quad (24)$$

$$E_n = -\frac{e^2}{4\pi\varepsilon_o} \frac{1}{d} \left(1 - \frac{n^4 d_o^2}{3d^2}\right) = -\frac{e^2}{4\pi\varepsilon_o} \frac{1}{n^2 d_o} \frac{2}{3} \quad (25)$$

We have the same size of energy if we multiply (25) by ¾ and (21) by π^2 and then we can derive distance d_o:

$$E_{no} = -\frac{1}{n^2} 13.6 eV = -\frac{1}{n^2} \frac{m_e e^4}{8h^2 \varepsilon_o{}^2} = -\frac{e^2}{4\pi\varepsilon_o} \frac{1}{n^2 d_o} \frac{2}{3} \cdot \frac{3}{4} = -\frac{1}{n^2} \frac{m_e e^4}{8\pi^2 \varepsilon_o{}^2 h^2} \cdot \frac{\pi^2}{1} \quad (26)$$

$$d_o = \frac{\varepsilon_o h^2}{\pi m_e e^2} = r_B \quad (27)$$

The Bohr radius r_B has the same size as the distance $d_o \approx 5.29 \cdot 10^{-11} m$ [4] in our vortex-fractal-ring model [18], [23]. The radiation which is emitted by the hydrogen atom is produced when the electron undergoes a transition from a higher-energy stationary state (with quantum number n_2) to a lower-energy state (with quantum number n_1). The frequency f of the emitted photon is given by the equation:

$$\Delta E = hf = \frac{hc}{\lambda} = \frac{m_e e^4}{8h^3 \varepsilon_o^{\ 2}} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) = E_{io} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \tag{28}$$

The line spectrum of hydrogen atom (Balmer series for $n_1=2$) is on Fig.6:

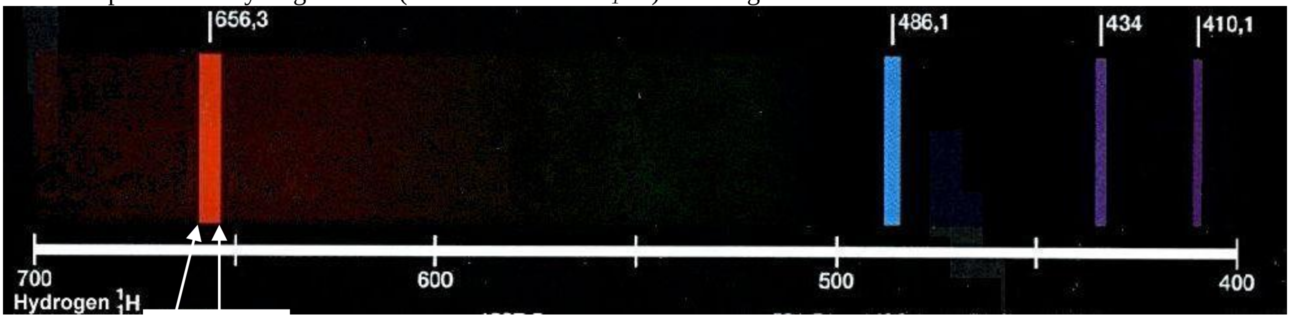
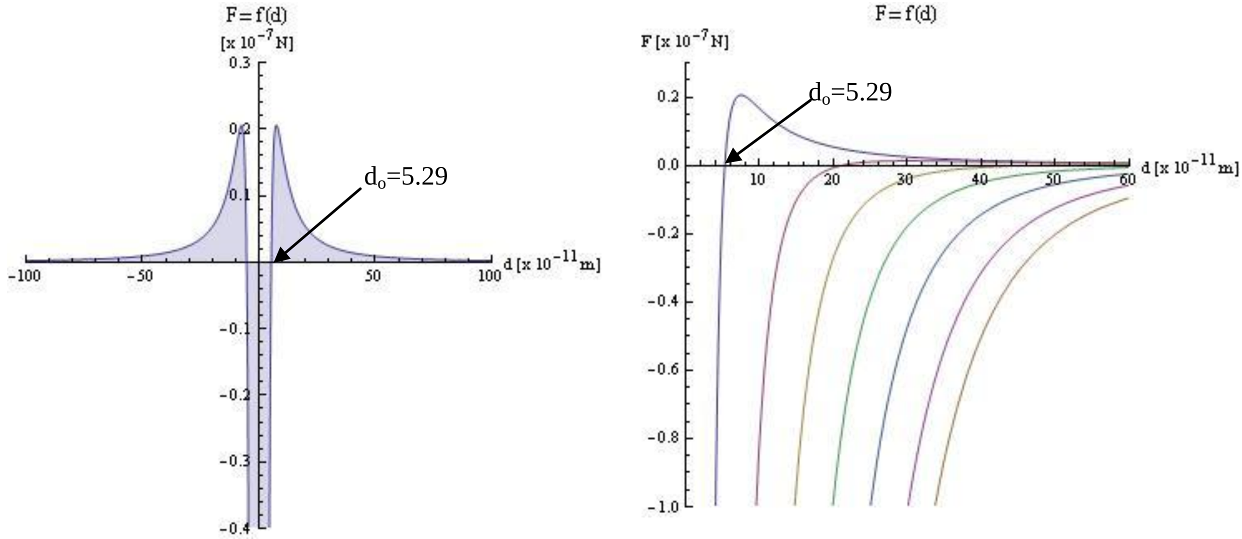


Fig.6 The line spectrum of hydrogen atom

Hydrogen has simplest spectrum. This spectrum consists from a number of series of lines. Balmer series with its wavelength λ [wavelength is in *nm*] is on Fig.6.

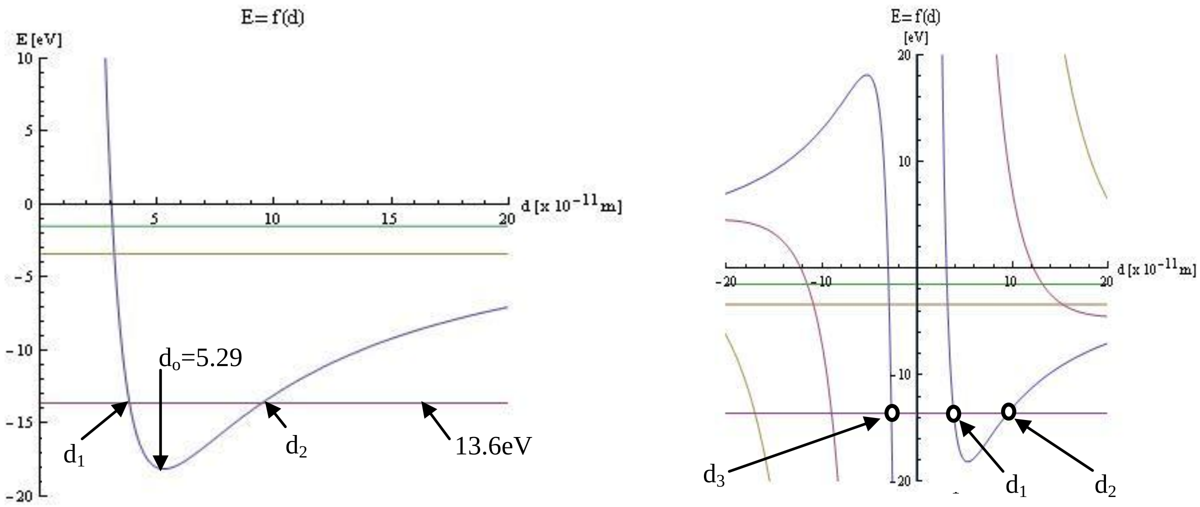


a) b)

Fig.7 The force *F* between the electron and the proton depending on their distance *d*

a) for quantum number $n=1$, see equation (7)

b) for quantum number $n=\{1, 2, 3, 4, 5, 6, 7\}$, see equation (9)



a) b)

Fig.8 The ionization energy *E* of hydrogen depending on the distance *d*

a) for quantum number $n=1$, see equation (8)

b) for quantum number $n=\{1, 2, 3\}$, see equation (10)

Radius r_e of the electron can be calculated with using equations (14) and (18):

$$r_{en} = \frac{e^2}{8\pi^2\varepsilon_0 m_e}\cdot\frac{1}{v_e^2} = \frac{e^2}{8\pi^2\varepsilon_0 m_e}\frac{4n^2\pi^2{\varepsilon_0}^2 h^2}{e^4} = \frac{n^2\varepsilon_0 h^2}{2e^2 m_e}\cdot\frac{\pi}{\pi} \tag{29}$$

$$r_{en} = \frac{\pi}{2}n^2 d_o = \frac{\pi}{2}d_{on} \tag{30}$$

and the diameter D_e of the electron is:

$$D_{en} = 2r_e = \pi n^2 d_o = \pi d_{on} \tag{31}$$

For $n=1$:

$$r_e = \frac{\pi}{2}d_o \tag{32}$$

$$D_e = \pi d_o \tag{33}$$

To calculate distances d_1, d_2, and d_3 we must solve the cubic equation (see Fig.8):

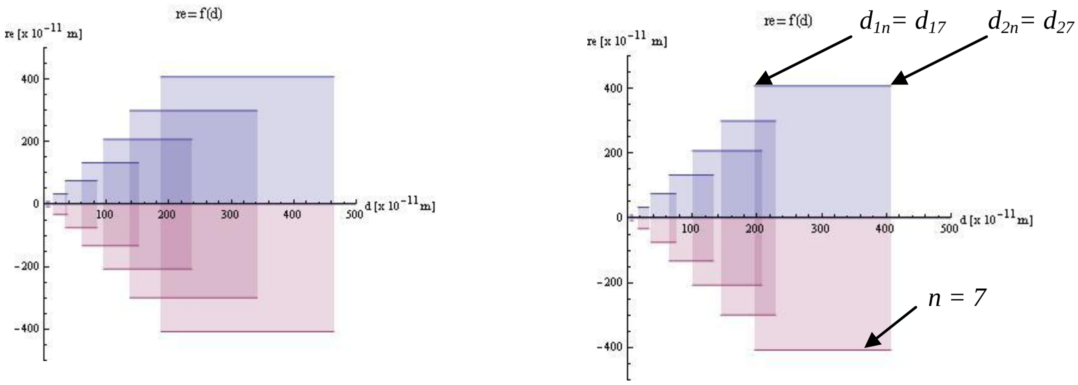
$$E_n = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{d}\left(1-\frac{n^4 d_o^2}{3d^2}\right) = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{n^2 d_o}\frac{1}{2} = -13.3eV \tag{34}$$

The cubic equation from (34) is:

$$3d^3 - 6n^2 d_o d^2 + 2n^6 d_o^3 = 0 \tag{35}$$

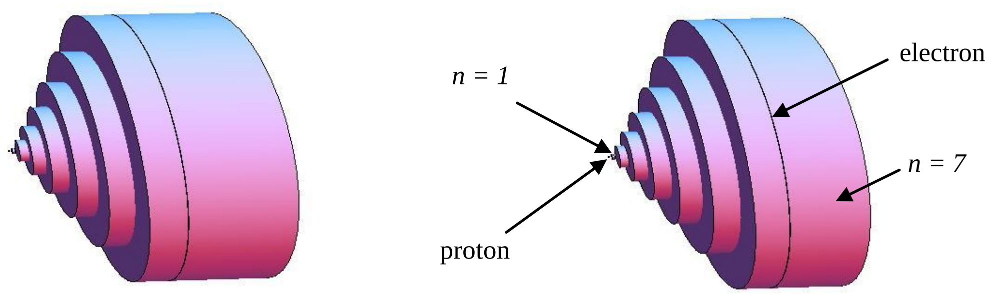
If we include the rotation energy E_{rn} from (21) of the electron to (34) we receive cubic equation:

$$-\frac{e^2}{4\pi\varepsilon_o}\frac{1}{d}\left(1-\frac{n^4 d_o^2}{3d^2}\right) = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{n^2 d_o}\frac{1}{2} - \frac{e^2}{4\pi\varepsilon_o}\frac{1}{n^2 d_o}\frac{1}{2}\frac{1}{\pi^2} \tag{36}$$



a) b)

Fig.9 The position and size of the electron depending on the distance *d* and quantum number *n*
a) for quantum number $n=\{1, 2, 3, 4, 5, 6, 7\}$ and equation (35)
b) for quantum number $n=\{1, 2, 3, 4, 5, 6, 7\}$ and equation (37)



a) b)

Fig.10 The position and size of the electron depending on the distance *d* and quantum number *n*
(3D quantum model of the hydrogen atom wit different *n*)
a) for quantum number $n=\{1, 2, 3, 4, 5, 6, 7\}$ and equation (35)
b) for quantum number $n=\{1, 2, 3, 4, 5, 6, 7\}$ and equation (37)

It leads to cubic equation:

$$3(\pi^2+1)d^3-6\pi^2n^2d_od^2+2\pi^2n^6d_o^3=0 \tag{37}$$

Solution equation (36) for *n=1*:

$$d_1=3.82124*10^{-11},\ d_2=9.48242*10^{-11},\ d_3=-2.72366*10^{-11} \tag{38}$$

Solution equation (37) for *n=1*:

$$d_1=3.99670*10^{-11},\ d_2=8.30853*10^{-11},\ d_3=-2.69858*10^{-11} \tag{39}$$

Figure 11 explains a particle structure of the photon and a wave behavior of the light ray, which consists from more photons arranged in the series (a sequence or a string of vortex pairs). A vortex pair is created from “bath” vortex V_B an a “tornado’ vortex V_T with flow of energy *E*.

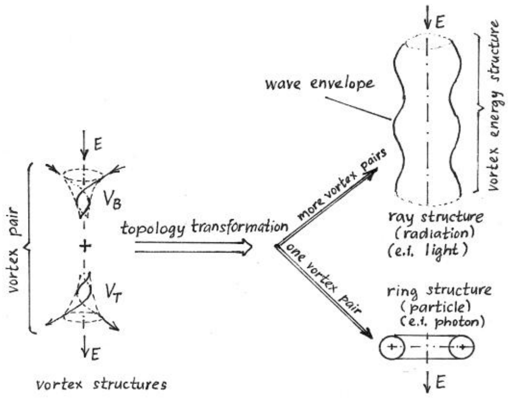


Fig.11 Structure of light as a ring particle or a wave energy structure

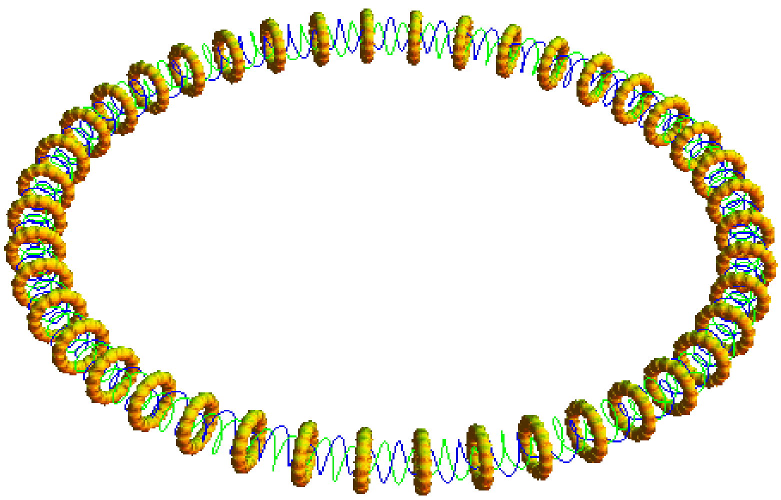


Fig.12 Vortex-fractal ring structure of the electron with 42 subeletrons

4 Conclusions

The exact analysis of real physical problems is usually quite complicated, and any particular physical situation may be too complicated to analyze directly by solving the differential equations or wave functions. Ideas as the field lines (magnetic and electric lines) are for such purposes very useful. A physical understanding is a completely nonmathematical, imprecise, and inexact, but it is absolutely necessary for a physicist [1]. It is necessary combine an imagination with a calculation in the iteration process. Our approach is given by developing gradually the physical ideas – by starting with simple situations and going on more and more complicated situations. But the subject of physics has been developed over the past 200 years by some very ingenious people, and it is not easy to add something new that is not in discrepancy with them. The vortex model (see Fig.4 and Fig.5) of the electron was inspired by vortex structure in the PET-bottle experiment with one hole connector ($3 souvenir toy, Portland, Oregon 2004) [13], our connector with 2 or 3 holes [7], [12] and levitating magnet "levitron" (physical toy). The "ring theory" is supported by experiments in [5] and [6] too. Now we realize that the phenomena of chemical interaction and, ultimately, of life itself are to be understood in terms of electromagnetism, which can be explain by vortex-ring-fractal structure in different state of self-organization inside gravum [22].

The electron structure is a semi-fractal-ring structure with a vortex bond between rings. The proton structure is a semi-fractal-coil structure. The proton is created from electron subsubrings e^{-2} and positron subsubrings υ^{-2} which can create quarks *u* and *d* [24]. This theory can be called shortly "ring" theory. It is similar name like string theory.

In the covalent $_{\text{bond}}$ pair of electrons oscillate and rotate around a common axis. There are two arrangements of hydrogen: with a left and a right side orientation of the electron in their structure. Very important is symmetry and self-organization of real ring structures.

Perhaps the decreasing width $\Delta\lambda_{2n}$ of spectrum lines on Fig.6 (as $\Delta\lambda_{23} = \lambda_a - \lambda_b$) depends on energy E_{io} in (22), (28) and kinetic energy E_r in (23). This energy can vary in the interval $\{E_a, E_b\}$ for $\{\lambda_a, \lambda_b\}$ and $\Delta E_\lambda = E_b - E_a = E_{io}/(20\pi^2) = E_r/20 = 0.069eV$ (for $n_1=2$ a different size $n_2>n_1$). It can be caused by precession of the electron.

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References

[1] Feynman R.P., Leighton R.B., Sands M.: The Feynman Lectures on Physics, volume I, II, III Addison-Wesley publishing company, 1977
[2] Duncan T.: Physics for today and tomorrow, Butler & Tanner Ltd., London, 1978
[3] Huggett S.A., Jordan D.: A Topological Aperitif, Springer-Verlag, 2001
[4] Pauling L.: General Chemistry, Dover publication, Inc, New York, 1988
[5] Mauritsson Johan: online.itp.ucsb.edu/online/atto06/mauritsson/
[6] Lim, T.T.: serve.me.nus.edu.sg/limtt/
[7] Ošmera P.: Vortex-fractal Physics, Proceedings of the 4th International Conference on Soft Computing ICSC2006, January 27, 2006, Kunovice, Czech Republic, 123-129
[8] Ošmera P.: Evolution of Complexity in Li Z., Halang W. A., Chen G.: Integration of Fuzzy Logic and Chaos Theory; Springer, 2006 (ISBN: 3-540-26899-5)
[9] Ošmera P.: The Vortex-fractal Theory of Universe Structures, CD Proceedings of MENDEL 2006, Brno, Czech Republic (2006) 12 pages.
[10] Ošmera P.: Electromagnetic field of Electron in Vortex-fractal Structures, CD Proceedings of MENDEL 2006, Brno, Czech Republic (2006) 10 pages.
[11] Ošmera, P.: The Vortex-fractal Theory of Universe Structures, Proceedings of the 4th International Conference on Soft Computing ICSC2006, January 27, 2006, Kunovice, Czech Republic, 111-122
[12] Ošmera P.: Speculative Ring Structure of Universe, Proceedings of MENDEL 2007, Prague, Czech Republic (2007), 105-110.
[13] Ošmera P.: Vortex-ring Modelling of Complex Systems and Mendeleev's Table, WCECS2007, proceedings of World Congress on Engineering and Computer Science, San Francisco, 2007, 152-157
[14] Ošmera P.: From Quantum Foam to Vortex-ring Fractal Structures and Mendeleev's Table, New Trends in Physics, NTF 2007, Brno, Czech Republic, 2007, 179-182
[15] Ošmera, P.: Vortex-fractal-ring Structure of Electron, Proceedings of the 6th International Conference on Soft Computing ICSC2008, January 25, 2008, Kunovice, Czech Republic
[16] Ošmera P.: Evolution of nonliving Nature, Kognice a umělý život VIII, Prague, Czech Republic, (2008), 231-244
[17] Ošmera, P.: The Vortex-fractal-Ring Structure of Electron, Proceedings of MENDEL2008, Brno, Czech Republic (2008) 115-120
[18].Ošmera, P.: The Vortex-fractal Structure of Hydrogen, Proceedings of MENDEL2008, Brno, Czech Republic (2008) 78-85
[19] Ošmera, P.: Vortex-fractal-ring Structure of Molecule, Proceedings of the 4th Meeting Chemistry and Life 2008, September 9-11, Brno, Czech Republic, (2008), Chemické listy (ISSN 1803-2389), 1102-1108
[20] Ošmera, P.: Structure of Gravitation, Proceedings of the 7th International Conference on Soft Computing ICSC2009, January 29, 2009, Kunovice, Czech Republic, 145-152
[21] Ošmera, P, Rukovanský, I.: Magnetic Dipole Moment of Electron, Journal of Electrical Engineering, No 7/s, volume 59, 2008, Budapest, Hungary, 74-77
[22] Ošmera, P.: The Vortex-fractal Structure of Hydrogen, Proceedings of MENDEL2009, Brno, Czech Republic (2009) extended version on CD
[23] Ošmera P.: Vortex-ring fractal Structures of Hydrogen Atom, WCECS2009, proceedings of World Congress on Engineering and Computer Science, San Francisco, 2009, 89-94
[24] Osmera P.: Vortex-ring-fractal Structure of Atoms, journal IAENG, Engineering Letters, Volume 18 Issue 2, 2010, 107-118, Advance Online Version Available: http://www.engineeringletters.com/issues_v18/issue_2/index.html