From the atom of hydrogen to the molecule of water

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Abstract. Properties of atoms are largely determined by the structure of their electron shells. However, the standard model does not allow determine this structure exactly. Fractal descriptions of Nature are very promising. New theory VFRT (vortex-fractal-ring-theory) can solve this lack. Theory VFRT works with fractal annular structure of the electron, the proton and the neutron, and can describe the inner structure of atomic nuclei. This theory assumes that the arrangement of electron shells arises from the structure of the atomic nucleus. Electrons are not in orbit around the atomic nucleus, but each electron levitates with the corresponding proton of the nucleus. The levitation bond is formed by an electromagnetic vortex structure. The atomic nucleus can be built from the ring protons and neutrons.

Introduction

The classical approach in particle physics is based on the fact that the electron has charge, mass, etc. but does not have a structure. The electron is calculated as point particles having magnetic properties. First and second ionization energies are described in [1] and fractal physics is described in [2]. Theory VFRT [3] offers the electron as fractal particle with a toroidal (ring) shape, which is formed by annular fractal substructures connected to each other by vortex electromagnetic fields.

1. Inner and outer spin

In the ring structure of the particles it is possible to unambiguously define their own (inner) spin of each particle. It is based on the direction of rotation of the ring and the direction of rotation of its ring substructures (see Fig. 1).

Direction of rotation of substructures is identical to the direction of electric field lines. It determines the direction of electrical energy flow in the axis of rings. Electrons, protons and neutrons have the same inner spin. In atoms the same direction of the flow of energy allows to assemble the particles on a common axis. Antiparticles have the opposite inner spin (see Fig.1 and Fig.2).

Fig. 1 Inner spins of electron and positron

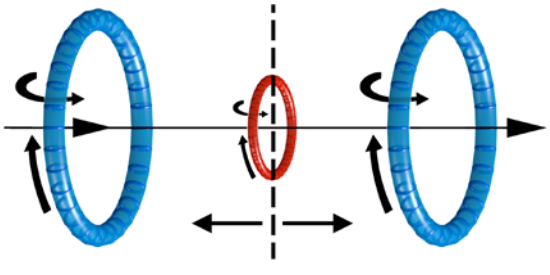

Fig. 2 Outer spins of 2 electrons (spin-out, spin-in)

In addition to own inner spin of rings, which we call "internal", we can define the spin of "external", which determines the spin relationship between two ring particles.

All three rings in Fig 2 have the same inner spins. Electric field lines passes through in the same direction. Relative to each other they have the opposite outer spins. From the perspective of the middle ring (proton), we see the energy going out (spin-out) from the electron on the left and going into the central ring (spin-in). When we look from the middle ring of the proton to the ring electron on the right, we see the energy output from the middle ring (spin-out) and the energy entering the right ring (spin-in).

Thus we see that two particles with the same inner spin can have the opposite outer spins (a different perspective from the proton to two electrons). For the construction of the atoms is crucial to have the structure of atomic nuclei. Therefore, we will determine the external spin from the perspective of the proton. The left and right levitating electrons have the opposite outer spins (see Fig. 2). It is Pauli‘s exclusion principle. Elementary particles with opposite outer spins can attract each other regardless of the sign of their charges, if there is common flow of energy through them.

2. Levitation of the electron

The electron levitates with the proton at a distance which is determined by a balance between attractive (electrical) and repulsive (magnetic) forces and with magnetic influence of the neutron.

The position of the electrons in the electron shells, however, is not determine only by forces of the corresponding proton, but also by other influences like force effect of other electrons in the surrounding shells and the forces of attraction of the other positive protons and magnetic fields of neutrons inside of the atom.

In a new ring model of the hydrogen atom with a levitating electron there is attractive Coulomb’s force $F+$ and repellent magnetic force $F-$ between the proton and the electron:

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

where d is a distance between the electron and the proton, n is quantum number.

For levitating distance $d = d_o = 5.29\ 10^{-11}$m and $n = 1$ [3] is $F = 0$. Eq. 1 is valid for point electrons and protons. For the electron with radius r_e :

$$F = F_+ - F_- = \frac{e^2}{4\pi\varepsilon_o}\left(\frac{d}{\sqrt{(d^2 + r_e^2)^3}} - \frac{dn^2 d_o}{\sqrt{(d^2 + r_e^2)^4}}\right). \tag{2}$$

The hydrogen atom can have special levitation state (F=0) with d=0. Size of the hydrogen atom is determined by radius of the electron r_e =2.6 10^{-11} m (see Eq. 13). This unusual levitation with $d=0$ has the atom of helium, too. There is magnetic repellent influence of two neutrons (see Fig .3).

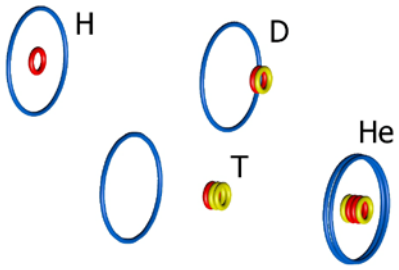

Fig.3 Levitation electrons in the hydrogen atom, deuterium, tritium and the helium atom

Ionization energy E_{io} which must be added to the electron of the hydrogen to be free:

$$E_{io} = \frac{e^2}{4\pi\varepsilon_o}\int_d^\infty\left(\frac{1}{d^2} - \frac{n^2 d_o}{d^3}\right)dd = \frac{e^2}{4\pi\varepsilon_o}\left[-\frac{1}{d} + \frac{n^2 d_o}{2d^3}\right]_d^\infty = -\frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d} - \frac{n^2 d_o}{3d^2}\right). \tag{3}$$

For $n=1$ and $d=d_o$ is E_{io}:

$$E_{io} = -\frac{e^2}{4\pi\varepsilon_o}\left(\frac{1}{d_o} - \frac{d_o}{2d_o^2}\right) = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{d_o}\frac{1}{2} \approx -27.2\frac{1}{2}eV \approx -13.6eV \tag{4}$$

3 Quantum model of the electron

On the circumference of the double loop with the radius r_e [3, 4] have to be n of de Broglie's wavelengths λ (n is quantum number) which are created by N sub-electrons with mass m_e/N:

$$2 \cdot 2\pi r_e = 4\pi\frac{e^2}{8\pi\varepsilon_o m_e}\frac{1}{v_{en}^2} = n\lambda = n\frac{h}{m_e v_{en}} = n^2\frac{h}{m_e v_{e-\max}}, \tag{5}$$

where v_{en} is velocity of the sub-electron with mass m_e/N and on quantum level n:

$$v_{en} = \frac{1}{n}\frac{e^2}{2\varepsilon_o h} = \frac{1}{n}v_{e-\max} \tag{6}$$

.

For $n=1$ on the ground state the electron has maximal rotational velocity $v_{e\text{-}max}$:

$$v_{e-\max} = \frac{e^2}{2\varepsilon_o h} \cong 2180 km/s \tag{7}$$

.

Energy E_{rn} of rotation of the electron on quantum level n:

$$E_{rn} = \frac{1}{2}\frac{m_e}{N}N \cdot v_{en}^2 = \frac{1}{n^2}\frac{m_e e^4}{8\varepsilon_o^2 h^2} \approx \frac{1}{n^2}13.6eV \tag{8}$$

.

Energy E_{io} in Eq. 3 for levitation distance d_{on} on level n [3, 4]:

$$d = d_{on} = n^2 d_o \tag{9}$$

$$E_{io} = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{d}\left(1 - \frac{n^2 d_o^2}{2d^2}\right) = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{n^2 d_o}\frac{1}{2} = -\frac{1}{n^2}13.6eV\,. \tag{10}$$

Energy E_{io} of ionization is in balance with kinetic energy E_{rn} of rotation. For the levitation distance d_o in the hydrogen molecule-ion H_2^+:

$$E_{rn} = -\frac{1}{n^2}13.6eV = -\frac{1}{n^2}\frac{m_e e^4}{8\varepsilon_o^2 h^2} = -\frac{e^2}{4\pi\varepsilon_o}\frac{1}{n^2 d_o}\frac{1}{2} \tag{11}$$

$$d_o = \frac{\varepsilon_o h^2}{\pi m_e e^2} = r_B \tag{12}$$

The Bohr radius r_B has the same size as the distance d_o = 5.29 10^{-11}m in our vortex-fractal-ring model [3]. The distance D between the two protons in H_2^+ is $D = 2d_o$ = 10.6 10^{-11}m.

For n=1 the radius r_e of the electron is:

$$r_{e1} = \frac{e^2}{8\pi\varepsilon_0 m_e}\cdot\frac{1}{v_{e-\max}^2} = \frac{e^2}{8\pi\varepsilon_0 m_e}\cdot\frac{4\varepsilon_o^2 h^2}{e^4} = \frac{1}{2}\frac{\varepsilon_o h^2}{\pi m_e e^2} = \frac{1}{2}d_0 = 2.645\cdot 10^{-11} m \tag{13}$$

The calculated radius of the hydrogen atom is in the range of experimentally measured values: 2.5 – 2.8 x 10^{-11} m. The electron is not orbiting the proton but it is a system of fractal substructures of the electron which rotate around the proton with the double-loop structure [3].

For higher n the electron can be wrapped into L double loops ($1 <= L <= n$). This wrapped electrons (see Fig.4) with $L=n$ can have a smaller radius r_{ew} :

$$r_{enw} = \frac{n^2}{2L}d_0 = \frac{n^2}{L}r_{e1} = \frac{n^2}{n}r_{e1} = nr_{e1} \tag{14}$$

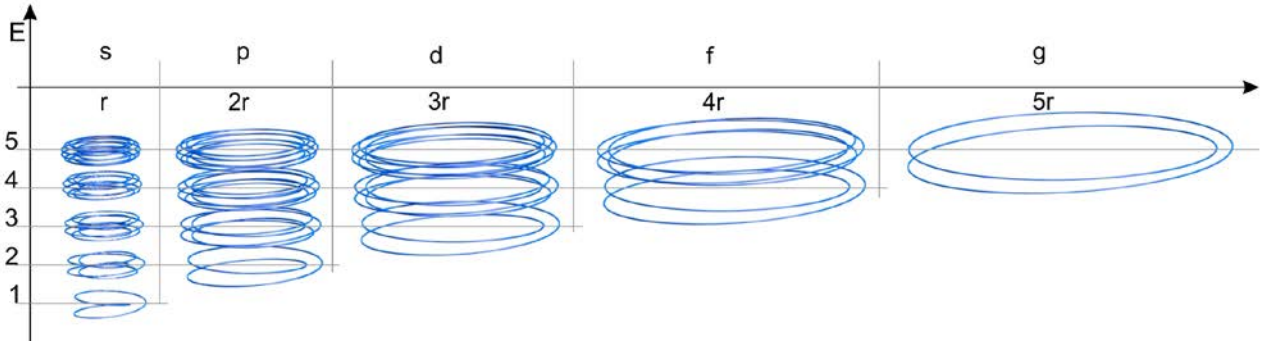

Fig.4 Wrapped electron double-loops with quantum number from *n=1* to *n=5*

4. Nuclei of atoms

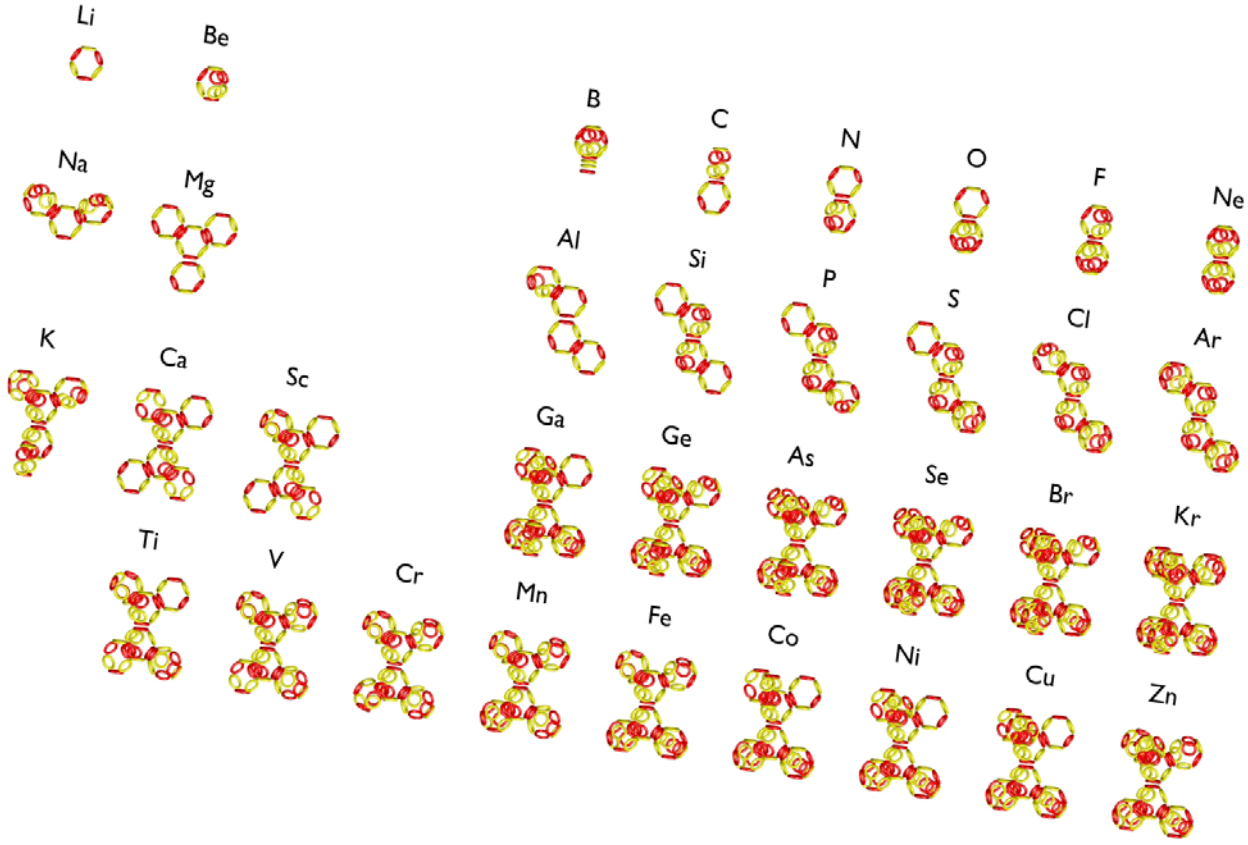

Fig.5 Nuclei of atoms from Li to Kr (red rings are protons, yellow rings are neutrons)

The atomic nucleus can be built from the ring protons and neutrons using the following rules [3]:

1. The proton cannot be directly connected with the proton, except for two parallel protons with the same axis that are connected together by nuclear forces.
2. Next proton with a different axis can be connected via the coupling neutron to another proton.
3. On one axis can be maximally two protons and two neutrons and two electrons with opposite outer spins.
4. Next one or two neutrons can be inserted between two parallel protons to form isotopes.

It seems that the combination of these four basic rules can create any real structure of the nucleus. Nucleons in the nucleus are not arranged in the shells as in case of electrons, but form spherical substructures with a maximum of 10 nucleons. Nuclear forces can bind only a small number of neighboring nucleons. Spherical substructures of the nucleus (GS globe sub-structures) are sequentially occupied by pairs of proton-neutron with 2, 3, and 4 pairs (see Fig.5). These GSs

are connected via two parallel protons into more complex units. GS with a maximum occupation of nucleons is an extremely stable part of the nucleus. They create the atom with a completely filled electron levels (in nobel-gases).

Direction changes of first ionization energies [1] follow changes in the spherical substructures GS in Fig.5. There is relationship between the size of ionization energy and the structure of nucleus.

5. Molecules

To the chemical bonds belongs a covalent bond between atoms in the molecule of hydrogen. Both equally rotating electrons with opposite outer spins are bound together by a common vortex electromagnetic field see Fig.6).

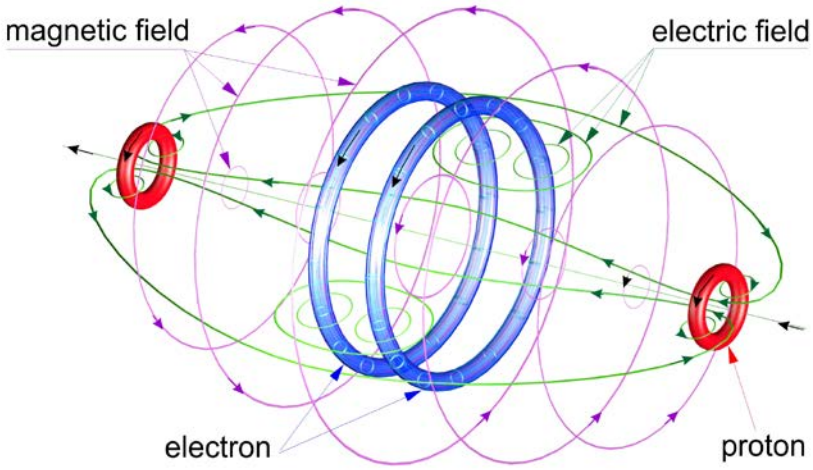

Fig.6 Covalent bond in the hydrogen molecule

At covalent bonds we can distinguish two types of bonds, bond σ and π bond (see Fig. 7). Bond sigma σ consists of two electrons with the same radius and π bond consists of two unequal radii of electrons. Different radii of electrons affect the levitation distance (see Fig.7).

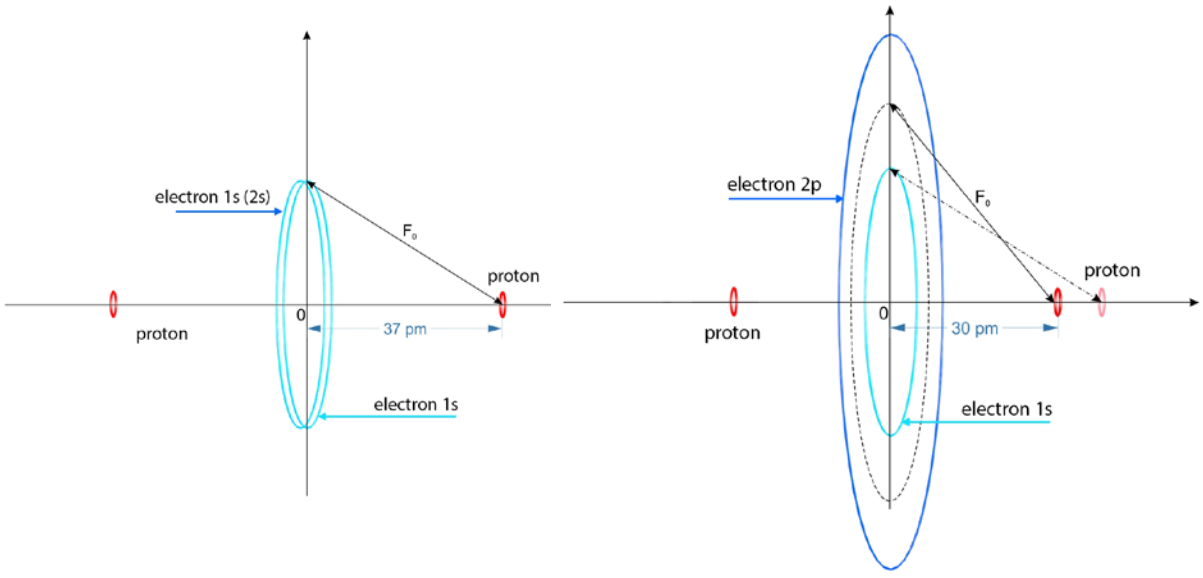

Fig.7 Covalent bond σ and π

Current knowledge shows the water molecule by several models. We know from experiments the exact distances between the hydrogen atoms and the oxygen atom, and their mutual angle. None of these models is able to explain the size of the distance and this angle.

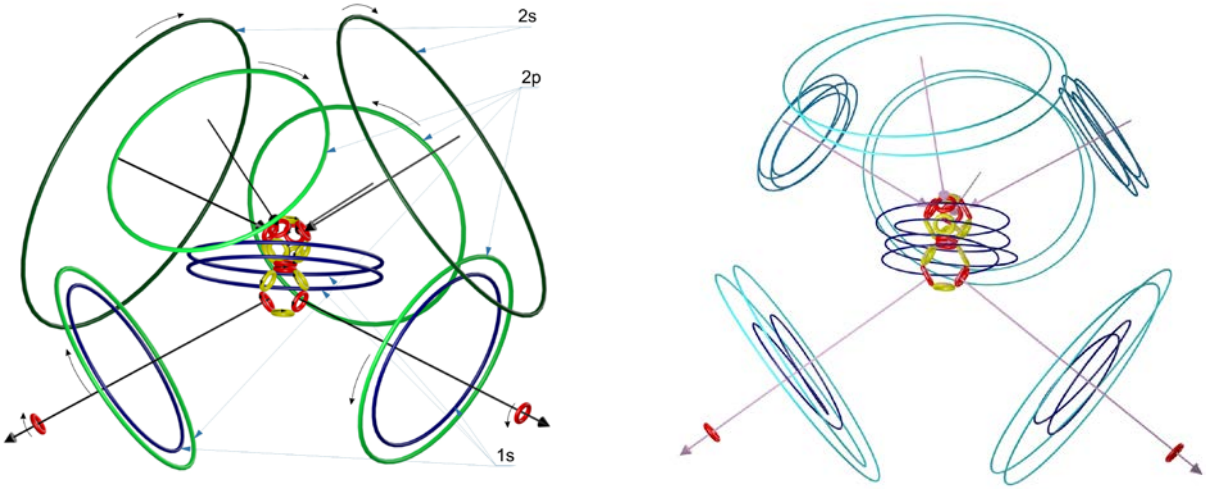

Fig. 8 Models of water molecule with unwrapped and wrapped electrons (red rings are protons, yellow rings are neutrons, blue and green rings are electrons)

VFRT theory can view the structure of the nuclei of oxygen. Now we are able to understand and explain the position of the individual electrons in the shells of the oxygen atom and the hydrogen atoms. In Fig. 8, the angle between the hydrogen atoms is not 120 °, because additional attractive forces acting between the pairs of bound electrons and two protons are not included.
Animation of water molecule can be found on https://youtu.be/TrlnHqBvnl8

Summary

Theory VFRT (vortex-ring-fractal theory) is a new and original view of elementary particles and the structure of atomic nuclei, atoms and molecules. Its basics are simple for understanding through comprehensive topological structure that does not need for their description very complicated mathematical apparatus. This theory, based on the use of the vortex, fractal and ring structures, interconnects all the current knowledge, based on quantum theory and quantum fractal theory. VFRT is trying to achieve some progress in understanding the phenomena related to the physics of elementary particles and atomic structures that we have not been able to clarify within existing theories. It allows us to understand the fundamental physical and chemical reasons for the stability and reactivity of atoms and molecules. VFRT gives us a tool that helps us explain phenomena so far unexplained and meet new laws, phenomena and processes that we are not able in detail to know. We believe that this theory will allow us expand our horizons of knowledge and push the frontiers of knowledge.

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[4] More about VFRT theory can be found on http://www.pavelosmera.cz/public/public.html