Coulombic Energy Replaced by Electromagnetic Energy in Bohr's Theory Makes Atomic Physics Simple and Sensible

Raji Heyrovska

Academy of Sciences of the Czech Republic (emeritus), Email: rheyrovs@hotmail.com

Abstract

Over a century ago Bohr arrived at the conclusion that the ground state energy of hydrogen is half the Coulombic energy, which is negative. As hydrogen is the most abundant element in the Universe, it implies that the energy of the Universe is predominantly negative. Since this is strange, the author found that on replacing the Coulombic energy by electromagnetic energy, the energy is in fact positive. This modification of Bohr's theory gave rise to many interesting results, showing that atomic physics is much simpler and more meaningful.

1. Introduction:

"I used to wonder how it comes about that the electron is negative. Negative-positive—these are perfectly symmetric in physics. There is no reason whatever to prefer one to the other. Then why is the electron negative? I thought about this for a long time and at last all I could think was "It won the fight!" ***- Albert Einstein (March 1879 - April 1955)****."*

Bohr's planetary model of a hydrogen atom consists of an electron (e^-) of unit negative charge (-e) and mass m_e orbiting (with velocity v) a nuclear proton (p^+) of unit

positive charge (+e) and mass m_p at a distance of the Bohr radius (a_B). The ground state energy (E_H) as the sum of the kinetic energy ($m_e v^2/2$) and Coulombic energy ($-e^2/\kappa a_B$) amounts to half the Coulombic energy, which is negative (see [1] for all the details),

$$E_H = - (1/2)(e^2/\kappa a_B) \qquad (1)$$

where $\kappa = 4\pi\varepsilon_0 = 1/k$ is the vacuum electric constant and k is the Coulomb constant [2].

The ground state de Broglie wavelength [1, 3], $\lambda_{dB} = 2\pi a_B$, Planck's constant (h) and the angular momentum ($h/2\pi$), [1, 4] are related by the equation,

$$h = m_e v \lambda_{dB} = m_e \alpha c (2\pi a_B) \qquad (2)$$

where $v = \alpha c$ and α is the fine structure constant [5].

2. Hydrogen as an atomic condenser. The negative sign for the energy of hydrogen in equation (1) implies that the energy of the Universe is dominantly negative! This shows that there is some conceptual error in the assumptions in equation (1). So, it was suggested by the author [6, 7] that on considering hydrogen as an atomic condenser with two unit opposite charges (-e, +e) separated by a distance a_B, the electromagnetic energy is given by equation (1) but has a positive sign,

$$E_H = (1/2)(e^2/\kappa a_B) \qquad (3)$$

where κa_B is the capacity. Equation (2) holds between the Planck constant and a_B. Since electron and proton are particles with charge as well as magnetic momenta, the Coulombic attractive force is balanced by the opposing magnetic force and the particles are kept at the equilibrium distance, a_B. So, Bohr's planetary model is not necessary.

3. Ionization potential as the difference in potentials of the electron and proton.

The ionization potential (I_H) of hydrogen is given by,

$$I_H = E_H/e = (1/2)(e/\kappa a_B) \quad (4)$$

I_H can be considered [7] as the mean of the potential of the proton ($I_p = e//\kappa a_p$) and of the electron ($I_e = -e//\kappa a_e$) at ionization, where $a_B = a_e + a_p$, the sum of the electrostatic radii, a_e and a_p, respectively, of the electron and proton. Thus,

$$I_H = (1/2)(e/\kappa a_B) = (1/2)(e/\kappa)[(1/a_p) - (1/a_e)] \quad (5)$$

Since $a_B = a_e + a_p$ and $(1/a_B) = (1/a_p) - (1/a_e)$ from equation (5), one obtains the Golden quadratic equation for the ratio,

$$(a_e/a_p)^2 - (a_e/a_p) - 1 = 0 \quad (6a)$$

$$(a_e/a_p) = (1+5^{1/2})/2 = 1.618 ..= \phi \quad (6b)$$

$$a_e = a_B/\phi \text{ and } a_p = a_B/\phi^2 \quad (6c)$$

Equation (6b) gives the solution as $(a_e/a_p) = \phi$, the Golden ratio, a mathematical constant, found in many spontaneous creations of Nature [8]. Equations (6c) are the two Golden sections of the Bohr radius. This shows that the atom is a unique construction of Nature!

The above results gave rise to a cascade of many interesting results showing that the Golden ratio based ionic radii and or atomic radii are perfectly additive in chemical bonds. This enabled arriving at the structures at the atomic level of many small as well as large inorganic, organic and biological molecules. The collected work can be found in [9-15].

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