IMPROVING THE METHODOLOGY FOR ENSURING CONTINUITY OF SCIENTIFIC APPROACHES IN TEACHING ATOMIC NUCLEAR PHYSICS

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Abstract. *The Schrodinger equation for the motion of microparticles in spherical symmetric potential field, the hydrogen atom: quantum numbers, energy spectrum, orbital impulse momentum and its spatial quantization, the selection rule for quantum transitions in simulator programs to expand the quantum mechanical imagination of students of higher education institutions. Radiation spectrum of hydrogen atoms. The width of the surfaces is modeled and the advantages of the developments and the methodology of using them are highlighted in this article.*

Keywords: *Schrodinger equation for the main constant state of the hydrogen atom, potential energy of the electron which is bound to the nucleus and its graph, solution of the Schrodinger equation for the hydrogen atom and energy surfaces, ionization energy, orbital, head and magnetic quantum numbers, their accepted values, determination of atomic states, explanation of the spectrum of hydrogen atom on the basis of quantum mechanics, selection rule, mechanical and magnetic moment of electron, gyromagnetic ratio, Boron magneton.*

In quantum mechanics, the position of electron in hydrogen atom is determined by three quantum numbers: n-principal quantum number, ℓ-orbital quantum number, m-magnetic quantum number. The orbital quantum number n illustrates not only energy values of the electron, but also diameter of electron orbit.

The orbital quantum number determines the shape of the orbit, namely the degree of ellipticity, the magnetic quantum number indicates the spatial orientation (position) of the electron orbit.

Quantum mechanics has clarified the quantization of the pulse moment of electron in the Boron theory of the atom. In Boron theory, the quantization of energy is derived from the quantization of the momentum of the electron, in quantum mechanics it is derived from the solution of the Schrodinger equation which is independent of the quantization of the momentum. The n values of the impulse momentum corresponds to the energy of electron at En energy surface. Impulse momentum does not accept arbitrary values, accepts discrete (assigned) values which is defined the following formula:

$$L = h\sqrt{\ell(\ell+1)} \quad (1)$$

ℓ is the orbital quantum number in this formula, namely, it takes n values to n-1:

$$\ell = 0, 1, 2, \ldots, \quad n-1 \qquad (2)$$

The impulse momentum of electron affects the eccentricity of elliptical orbit, namely, the shape of the orbit. The electron with the same energy, different impulse momentum, rotates along different elliptical orbits with the same major axis length but different eccentricities. Hence, there are orbits corresponding to each value of ℓ.

In quantum mechanics, it is fixed that the S-state for the atomic state corresponds to ℓ=0 value of the orbital quantum number, the R-state for n=1, and the d-state for ℓ=2. The next states are illustrated f, g, h letters. Namely, atomic states are represented by letters in the Latin alphabet.

The magnetic quantum number ml accepts certain conditions of the impulse moment vector L of electron which multiple h under the influence of external magnetic field and shows the placed order. Namely, the projection of the momentum on the Z direction is determined by the following expression:

$$L_{\ell z} = hm_{\ell} \quad (3)$$

Here, ml=is the magnetic quantum number, it takes integer values from ℓ to 0 through + l, namely

$$m_{\ell} = -\ell, -(\ell - 1), \ldots, -1, 0, +1, \ldots, (\ell - 1), +\ell$$

assumes a total of 2ℓ+1 value. Hence, the impulse momentum vector of the electron in Fig. 2 can be placed in space taking to 2 ℓ+1 states.

Each value of the electron energy in hydrogen atom which is determined by formula (3), corresponds to several wave functions, they differ from each other by the quantum numbers l and m. Let's discuss a case where n = 2 as an example. The orbital quantum number l can have a value of 0 or 1, according to the condition (5). When ℓ=0 (S-state), the magnetic quantum number ml takes only 0 according to the condition (6). In this case, the mechanical impulse momentum of the electron is also equal to zero. In this case, the field in the space where the electron exists, has spherical symmetry. Namely, the nucleus is surrounded by a round electron cloud of certain thickness. The dense areas of the electron cloud correspond to the first Boron radius of the electron orbit (r_1=0,53.10^{-10}м) Fig.2 (a). In quantum mechanics the concept of "orbit" of electron loses its meaning. But quantum mechanics can provide information about the probability of electron being recorded in which point of space. In Figures 2 (a, b, v), graphs which describing the density of the probability of recording of the electrons at the points at r distance from the nucleus in the 1S, 2R, and 3d states are given.

As can be seen from the figures, the geometric positions of the points which the electron can be recorded with the greatest probability correspond to the 1,2,3-Boron orbits. When the orbital quantum number is l=1 (R-state), three m=-1; m=0; m=1 values of the magnetic quantum number correspond to three directions of the impulse momentum (Fig. 1 (a)). In this case, the value of the vector L will be:

$$L = \hbar\sqrt{\ell(\ell+1)} = \hbar\sqrt{2}$$

If ℓ= 2 (d-condition Fig.3 b)), five states of the L vector can be observed corresponding to the values of m=-2; m=-1; m=-0; m=1; m=2.

When l = 3 (f -state), there are seven states of L, and so on.

The more than one case corresponds to one energy surface in atom is called surface variation (deterioration).

The number of states with the same energy is called the multiplication of variation. In hydrogen and atoms like hydrogen, the main stable state with n=1 is considered the unstabilized state. However, if we take account the spin of the electron, it follows that the n=1 state in the hydrogen atom is also considered twice variated. We will stop after that. The surface with a quantum number n=2 is fourfold variated, in this case the orbital quantum number is a state with ℓ = 0 (ml = 0) and three states ℓ=1 (m_{ℓ} =0, ±1). The next surfaces with n=3 and n=4 are variated

9 and 16 times respectively (Table 1). We should take account the spin of the electron, multiply the multiplication of variation to two in order to determine the number of general conditions in atom. We will consider in the next lecture that this is derived from Pauli exclusion principle.

Table 1

Principal quantum number, n	Orbital quantum number, ℓ	Magnetic quantum number, ℓ	Determination of condition	The multiplication of variation (by orbital impulse momentum)
1	0	0	1S	1
2 2	0 1	0 0, ±1	2S 2P	1 3 } 4
3 3 3	0 1 2	0 0, ±1 0, ±1, ±2	3S 3P 3d	1 3 5 } 9
4 4 4 4	0 1 2 3	0 0, ±1 0, ±1, ±2 0, ±1, ±2, ±3	4S 4P 4d 4f	1 3 5 7 } 16

The relationship between the orbital mechanical moment and the magnetic moment of electron is as follows:

$$P_m = \gamma L \quad (8)$$

Here we know from the course of electromagnetism that γ is called the gyromagnetic ratio, it can be determined by the formula γ=e/2m. If we put the abovementioned expression of γ and (4) formula of L to (8), we will take the following expression:

$$p_m = \frac{e}{2m}\hbar\sqrt{\ell(\ell+1)} = \mu_Б\sqrt{\ell(\ell+1)} \quad (9)$$

Here, the measurement $\mu_Б = \frac{e\hbar}{2m} = 0{,}927\cdot 10^{-23}\ \frac{J}{Tl}$ is called Boron magneton.

The expression (9) above shows that the quantization of the magnetic moment P_m is derived the quantization of the mechanical moment L, as well.

The component of the orbital magnetic moment in the direction of the external magnetic field is defined as follows:

$$P_{mz} = \gamma L_z = \frac{e}{2m}\hbar m_\ell = \mu_Б m_\ell$$

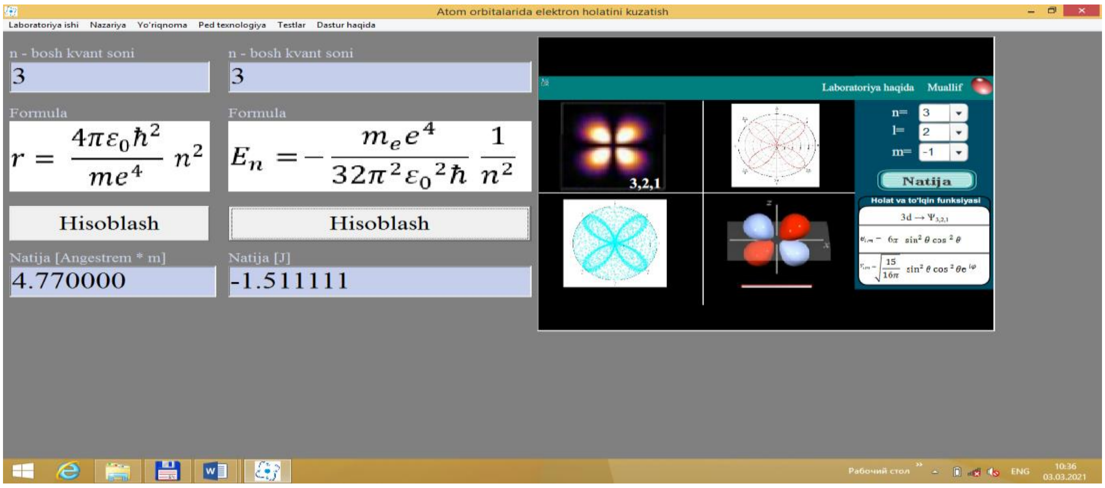

Figure 1. The main stable state of the hydrogen atom

Here ml is the magnetic quantum number. Since the mechanical moment and the magnetic moment are antiparallel, because their electron's charge is negative, namely, they are in opposite directions, and their position in space is quantized. For example, both moments are zero in the S-state (ℓ=0, m=0). The quantization of the mechanical and magnetic moments of electron in space had to be confirmed in practice. Such experiment was conducted in 1922 by German physicists Otto Stern and Walter Gerlach.

Quantum numbers n, $\ell$and m_ℓ give opportunity to us to fully describe the formation of releasing (absorption) spectrum of hydrogen atom which is derived from Boron theory.

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