

# On the "Quantum mechanics" of Hydrogen

Dimiter G. Stoinov & Dilian D. Stoinov, 1784, Sofia, BULGARIA  
e-mail: [dgstoinov@gmail.com](mailto:dgstoinov@gmail.com)

A theory is proposed to explain the spectrum of hydrogen, which is largely a continuation of the classical theory of Bohr and Sommerfeld. Formulas for calculating the length of spectral lines are derived. It can be asserted with a high degree of certainty that the theory thus proposed agrees with the accumulated experimental data.

## 1. Introduction

Quantum mechanics is a major branch of modern theoretical physics, even synonymous with modern physics. At least that is the scientific and public opinion for the most part. But there are also dissenters. For example, in his book "The Character of Physical Law" Richard Feynman wrote „I can boldly say that nobody understands quantum mechanics" [1]. Also one of the critics of modern quantum mechanics is academician Asen Datsev [2].

Our goal for many years has been to seek an answer to the question: What is electricity and magnetism? In our works [3-5], our point of view is presented in response to the question posed in this way. We gained the courage to tackle this difficult problem of quantum mechanics when we obtained equation (1) in [6]. It turned out that the interaction strength between the hydrogen atomic nucleus and the shell electron depends on the fine structure constant  $\alpha$ .

$$F \approx \frac{e^2}{r^2} \left( 1 + \frac{\dot{r}}{\alpha c} \right) \quad (1)$$

Moreover, to some extent we are engaged in this problem, as we have personally discussed this topic with Academician Datsev.

The differential equation derived based on equation (1) in [7] is

$$\frac{d^2 \rho}{d\varphi^2} + \frac{e^2}{\alpha c M} \frac{d\rho}{d\varphi} + \rho = \frac{m_e e^2}{M^2} \quad (2)$$

The solution of the differential equation (2) is given in [5]. It is shown how our theory agrees with the current quantum mechanics of hydrogen.

In [8], however, a decisive step forward was made and a new, so-called resonance formula was proposed to calculate its spectral lines.

Here, in this new work of ours, we introduce a new hypothesis for calculating longer wavelength spectral lines as well. For example, waves from the spectrum of light and infrared waves.

## 2. Orbit equation

As a result of solving the differential equation (2), the following equation for the orbit of the electron was obtained [5,6].

$$r = \frac{p}{1 + \varepsilon e^{-b\varphi} \cos(\sqrt{1-b^2} \varphi + \gamma)} \quad (3)$$

where

$$b = \frac{\hbar}{2M} \text{ is the so-called attenuation parameter}$$

$$p = \frac{M^2}{m_e e^2} \text{ is a focal parameter}$$

$$\varepsilon = \frac{1}{\sqrt{1-b^2}} \sqrt{1 + \frac{2EM^2}{m_e e^4}} \text{ is the eccentricity of the orbit} \quad (4)$$

$$\gamma = \text{arctg} \left( \frac{b}{\sqrt{1-b^2}} \right)$$

Here  $\hbar$  is Planck's constant,  $M$  is the angular momentum,  $m_e$  is the mass of the electron, and  $E$  is its energy.

The type of orbit is shown in Fig.1. Point O means fixed focus [7]. Point P – initial position of perihelion. If  $\varphi$  is chosen so that the line OP corresponds to an angle  $\varphi = 0$ , then the orbit reaches its subsequent perihelion not at an angle  $2\pi$ , but at an angle  $\sqrt{1-b^2} \varphi = 2\pi$ , i.e. at an angle

$$\varphi = \frac{2\pi}{\sqrt{1-b^2}} > 2\pi \quad (5)$$

Thus, there is motion of the perihelion in the sense of its circular rotation, to which corresponds an angle of magnitude according to equation (6).

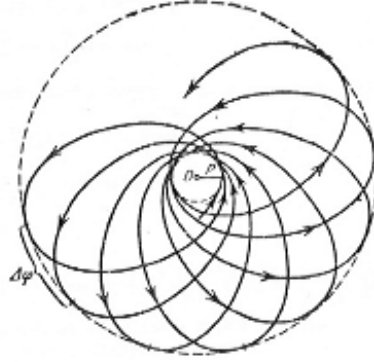


Fig. 1. Perihelion and aphelion move along two concentric circles with center point O, where is the nucleus of the hydrogen atom. While the electron is rotated by an angle  $2\pi$  the major axis of the orbit se turns on an angle  $\Delta\varphi$

### 3. Kinematic part

If we assume that  $\dot{\varphi} = \omega$  from equation (3) is the full angular velocity electron along a precessing orbit, then angular velocity  $\omega_{or}$ , for closing the elliptical orbit will be

$$\omega_{or} = \omega \sqrt{1-b^2} \quad (7)$$

And if angular velocity (7) is subtracted from the full angular velocity  $\omega$ , the angular velocity of precession will also be determined, namely

$$\omega_{pr} = \omega \left( 1 - \sqrt{1-b^2} \right) \quad (8)$$

In fact, the total angular velocity of the electron on a precessing orbit  $\omega$  is the sum of the angular velocity on an elliptical orbit and the angular velocity of precession

$$\omega = \omega_{or} + \omega_{pr} \quad (9)$$

### 4. Major axis hypothesis

In our opinion, the direction in which a given spectral line is emitted is directly related to the direction of the major axis of the ellipse, i.e. the direction of the major axis determines the direction in which a particular spectral line is emitted. But as the ellipse rotates, the direction of this axis is constantly changing, so the direction of the emitted spectral line is also changing. Visually, this can be compared to a shooter standing on a rotating platform and firing. If the direction in which he shoots is constantly changing, the effect of his shooting will not be there. Obviously, to have an effect, the direction in which it shoots must be repeated, respectively the direction in which the given spectral line is emitted must be repeated. This condition is fulfilled if there is a certain dependence between the

precession rate and the intervals of the emitted spectral line. In the particular case, this condition is fulfilled if there is a resonance between the precession angular velocity  $\omega_{pr}$  and the orbital angular velocity  $\omega_{or}$ . The ratio between these two velocities must be expressed in integers numbers, viz

$$\frac{\omega(1-\sqrt{1-b^2})}{\sqrt{1-b^2}} = \frac{n}{m} \quad (10)$$

where  $n=1,2,3, \dots$  is a principal quantum number and  $m = 1,2,3,\dots$  is an auxiliary quantum number.

If equation (10) is solved in terms of the radical  $\sqrt{1-b^2}$  the so-called resonance condition will result

$$\sqrt{1-b^2} = \frac{m}{m+n} \quad (11)$$

The resonance relations (11) are given in Tab 3. (See below "Table of resonance relations").

### 5. Calculating perihelion closure time

As noted above, the orbit of the electron reaches its subsequent perihelion not at an angle, but at a larger one according to equation (5). This means that, the perihelion closure time is greater than the elliptical orbit closure time. It also means that the angular velocity of precession  $\omega_{pr}$  is less than the angular velocity  $\omega$  of the electron.

To determine the angular velocity of precession means to determine the frequency, respectively the angular velocity of the emitted spectral lines.

The motion of the electron along a precessing orbit can be visualized with two motions - as if first it describes an elliptical orbit and then the axis of this orbit is rotated by an angle  $\Delta\phi$ . That is why the time  $T_{scp}$  for the perihelion closes will be

$$T_{scp} = T_{or} + T_{pr} \quad (12)$$

where  $T_{or}$  and  $T_{pr}$  can be determined if equations (7) and (8) are taken into account,

$$T_{or} = \frac{2\pi}{\omega\sqrt{1-b^2}} \quad (13)$$

$$T_{pr} = \frac{\Delta\phi}{(1-\sqrt{1-b^2})} = \frac{2\pi}{\omega\sqrt{1-b^2}} \quad (14)$$

i.e. the time  $T_{or}$  to close the orbit and the time  $T_{pr}$  to rotate the major axis by an angle are the same. Therefore

$$T_{scp} = 2T_{or} = 2 \frac{2\pi}{\omega\sqrt{1-b^2}} \quad (15)$$

Now, if we go back to angular velocity we get that the angular velocity  $\omega_{scp}$  to close the perihelion is twice less of angular velocity  $\omega$  of the electron

$$\omega_{scp} = \frac{\omega}{2}\sqrt{1-b^2} \quad (16)$$

The perihelion closure angular velocity (16) is the most important kinematic characteristic of the hydrogen atom. It determines the frequency for emitting the spectral lines. We will show below that it has a relation and is equal to the Rydberg constant..

### 6. "b" diagram

The diagram (Fig.1) shows how some of the mechanical characteristics of the atom change, depending on the damping parameter "b", for example, the angular velocity  $\omega$ , the focal parameter  $p$ , etc.

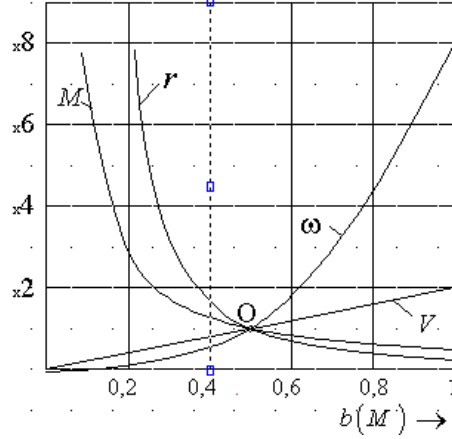


Fig.1. Mechanical characteristics of the hydrogen atom, in dependence from the damping parameter "b" At point O the atom is located in ground state with energy  $E_0 = -13,6 \text{ eV}$

where;

$$\begin{aligned}
 M &= \frac{\hbar}{2b} \text{ is the kinetic momentum} \\
 r &= \frac{r_0}{4b^2} \text{ is current orbit radius} \\
 V &= 2bV_0 \text{ is average peripheral speed} \\
 \omega &= 8b^3\omega_0 \text{ is the average angular velocity}
 \end{aligned} \tag{17}$$

$a$ ,  $r_0$ ,  $V_0$ , and  $\omega_0$  are the corresponding values of these parameters in the ground state of the atom.

### 7. Determination of the excitation energy $\Delta E$ . Energy diagram

It is most likely that the atom is in a ground state in which the electron moves in a circular orbit. In this state, it does not lose energy and cannot radiate. But in real conditions it is surrounded by a huge number of atoms. Therefore, as a result of encounters with them, his energy is constantly changing. In fact, he can acquire any amount of energy. It can even be destroyed, i.e. to be ionized. However, we are interested in states in which the integrity of the atom is preserved, i.e. states in which the electron moves along a closed precessing orbit.

The boundary conditions for the electron of the hydrogen atom to move along a closed orbit are that the eccentricity of the orbit (4) be within the limits  $0 \leq \varepsilon < 1$ , i.e. condition to be met

$$0 \leq \frac{1}{\sqrt{1-b^2}} \sqrt{1 + \frac{2EM^2}{m_e e^4}} \leq 1 \tag{18}$$

where  $M$  and  $E$  are the current values of the kinetic momentum and total energy. If all terms of equation (18) are squared, we get

$$0 \leq \frac{1}{1-b^2} \left( 1 + \frac{2EM^2}{m_e e^4} \right) \leq 1$$

and after bringing both sides of the inequality under a common denominator and making some transformations we will have

$$-1 \leq \frac{2EM^2}{m_e e^4} \leq -b^2$$

Let this equation be solved in terms of the total energy  $E$

$$-\frac{1}{2} \frac{m_e e^4}{M^2} \leq E \leq \frac{1}{2} \frac{m_e e^4}{M^2} - b^2$$

Now if it is considered that  $M = \hbar/2b$  the above equation will take the form

$$-\frac{1}{2} \frac{m_e e^4}{\hbar^2} 4b^2 \leq E \leq \frac{1}{2} \frac{m_e e^4}{\hbar^2} - 4b^4$$

This equation can be further simplified by considering that the expression  $m_e e^4 / 2\hbar^2$  represents the energy of the atom in ground states

$$E_0 = \frac{1}{2} \frac{m_e e^4}{\hbar^2} \quad (19)$$

and the limits within which the total energy may vary will be as follows

$$-4b^2 E_0 \leq E \leq -4b^4 E_0 \quad (20)$$

The energy diagram of the hydrogen atom is shown in Fig. 3. The values of the damping parameter  $b$  are plotted on the abscissa, and the energy level on the ordinate. At point  $O$ , the atom is in the ground state with energy according to (19). The line  $E_{qe} = E_{min}$  is the line of minimum energy. At energy, the electron's orbit is circular and it is unable to radiate. This energy, taking into account (20) is

$$E_{min} = -4b^2 E_0 \quad (21)$$

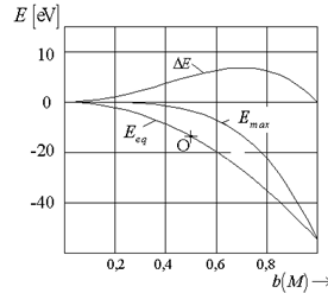


Fig.3. Energy diagram of the hydrogen atom. At point  $O$  when  $b = 1/2$  the atom is in the ground state with  $E = -13,6 \text{ eV}$

The line  $E_{max}$  defines the upper limit of the atom's energy at which it begins to lose its stability. This maximum energy to which it can be excited according to (20) is

$$E_{max} = -4b^4 E_0 \quad (22)$$

At energy bounded between the lines  $E_{min}$  and  $E_{max}$  the atom is in an excited state, moving along a precessing orbit, and in this state it can emit certain spectral lines. The excitation energy is defined as the difference between the maximum (22) and the minimum (21)

$$\Delta E = E_{max} - E_{min} = 4b^2 (1 - b^2) E_0 \quad (23)$$

## 8. Resonance formula

Above, the perihelion closing angular velocity (16), the electron velocity  $\omega = 8b^3 \omega_0$  according to (17), and the radical value  $\sqrt{1 - b^2}$  according to (11) were determined. So that for the velocity to close the perihelion will be obtained

$$\omega_{scp} = 8b^3 \frac{\omega_0}{2} \frac{m}{m+n} \quad (24)$$

Let us now move from angular velocity to wavelength. A general form of the so-called resonance formula will be obtained

$$\lambda_0 = \frac{4\pi c}{8b^3 \omega_0} \frac{m+n}{m} \quad (25)$$

where  $\omega_0$  is the average angular speed of the electron (so-called Bohr speed),  $c$  is the speed of light,  $n$  and  $m$  are the quantum numbers, and  $\lambda_0$  is the length of the basic "quantum" spectral lines.

### 9. The kinematic meaning of Rydberg's constant

In equation (16), we obtained that the angular speed  $\omega_{scp}$  for perihelion closure, i.e. the the angular speed at which the spectral lines is emitted are twice less of the Bohr speed of the electron in the ground state. This speed given in [10] is  $\omega_0 = 4,13 \cdot 10^{16} \text{ s}^{-1}$ , and  $\omega_0/2 = 2,065 \cdot 10^{16} \text{ s}^{-1}$  would have to be the perihelion closing angular speed. When we first obtained this result in [11], we were pleasantly surprised. It turned out to be almost equal to the Rydberg constant, For

example,  $R = 1,0973731 \cdot 10^7 \text{ m}^{-1}$ , and expressed in angular speed

$$R = 2,0685 \cdot 10^{16} \text{ s}^{-1}.$$

### 10. Why is it necessary to bring the atoms into spectral analysis mode?

The resonance formula (25) predicts a huge number of spectral lines with length . It is understood that the damping parameter  $b$  can have different values, and also the quantum numbers  $m$  and  $n$  can take an unlimited number of values. Therefore, in spectral analysis, the substance whose emission spectrum is to be studied must be brought into an excited state. It is also important to note that after the ionization stage, the majority of atoms will be in a state with the attenuation parameter  $b = 1/2$ . In this way, the number of emitted spectral lines will be limited. For example, at  $b = 1/2$  the resonance formula (25) will take the form for calculating the spectral lines of hydrogen in spectral analysis mode.

$$\lambda_0 = \frac{4\pi c}{\omega_0} \frac{m+n}{m} \quad (26)$$

### 11. Calculation of the lengths of the base spectral lines $\lambda_0$

If we proceed from the Bohr velocity and equation (26), the following formula will be obtained to calculate the length of the base spectral lines

$$\lambda_0 = \frac{4\pi c}{\omega_0} \frac{m+n}{m} = 912,80 \cdot 10^{-10} \frac{m+n}{m} [\text{m}]$$

If we proceed from the Rydberg constant

$$\lambda_0 = \frac{4\pi c}{R} \frac{m+n}{m} = 911,27 \cdot 10^{-10} \frac{m+n}{m} [\text{m}]$$

According to our research, it would very good the formula where was used calculate the base spectral lines to be

$$\lambda_0 = 911,50 \cdot 10^{-10} \frac{m+n}{m} [\text{m}] \quad (27)$$

In Appendix A [12] when calculating the baseline spectral lines of we use this formula.

### 12. Limits

The limits, in which the resonance relations can be changed, and also some of the other mechanical parameters are shown in Table. 1. Also given are the limits in which the angular velocity

of perihelion closure (16), the excitation energy (23) and the length of the emitted spectral lines change.

Table 1. Boundaries on spectral relations and spectral lines

Normal resonance $m > n$	Reverse resonance $m < n$
$1 > \sqrt{1-b^2} > 1/2$	$1/2 > \sqrt{1-b^2} > 0$
$1 > \frac{m}{m+n} > 1/2$	$1/2 < \frac{m}{m+n} < 1$
$\frac{\omega_0}{2} > \omega_{scp} > \frac{\omega_0}{4}$	$\frac{\omega_0}{4} > \omega_{scp} > 0$
$911.5 < \lambda_0 < 1800 \text{ [\AA]}$	$1800 < \lambda_0 < \infty \text{ [\AA]}$
$0 < \Delta E < 10.2 \text{ eV}$	$10.2 < \Delta E < 13.6 \text{ eV}$

### 13. Collection of waves of the same direction and close frequency. Beat

The resonance formula (27) predicts spectral lines, but only in the range of ultraviolet rays, but not those in the region of light and infrared rays. So when the question arose before us, how these rays of this longer wavelength are formed, it became clear that these longer waves are derivatives of the waves according to (27), for example, overtones, as indicated in [8]. Here we will try to justify the formation of these waves.

As is known, when oscillations of the same direction and close frequency are collected, new oscillations of pulsating amplitude arise as a result. Such a fluctuation is called "beat". In our opinion, light and infrared waves are "beat" waves.

If the period of oscillation of one "beat" wave is  $T_\omega = 2\pi/\omega$ , and the difference between the angular velocities of the two waves is  $\Delta\omega$ , then the period of oscillation of the amplitude of the "beat" wave will be  $T_{\Delta\omega} = 2\pi/\Delta\omega$ . In such a case, the ratio between the periods  $T_{\Delta\omega}$  of and  $T_\omega$  will be

$$\frac{\omega}{\Delta\omega} = j \quad (28)$$

where is  $j$  the so-called beat factor.

Therefore, the formula for calculating the beat wavelengths will be

$$\lambda_j = \lambda_0 \times j \quad (29)$$

where  $\lambda_j$  is the beat wavelength,  $\lambda_0$  is the base spectral line length, and  $j$  is the beat factor.

Here the question arose as to what numerical values the beating factor should have. Only whole numbers are given for it in the spectral line tables [12], but there is no reason for them to be a fraction or an irrational number. Therefore, it can be assumed that a single baseline spectral line may be the source of a large number of beat waves. Thus, on the one hand, there is a limited number of base (quantum) spectral lines, and on the other hand, a huge number of beat spectral lines. So there is another question about distribution. In our opinion, also we may assume that the distribution of beating waves obeys Planck's law.

### Table of resonance relations

According to the theory thus proposed, the emission of a certain spectral line occurs when the resonance condition according to equation (11) is fulfilled. These resonance relations are given in Table.2. Of particular importance here is the resonance ratio 1/2. It occurs when the two quantum numbers are the same  $m = n$ . The special thing in this case is that the angular velocity with which the electron travels in an elliptical orbit (7) and the angular velocity of precession (8) are the same. In this case, the electron supposedly moves along a precessing elliptical orbit, but in fact it is always at the perigee of this orbit and its real motion is circular, and in this state it cannot emit spectral lines.

It should also be noted that at a resonance ratio of 1/2 the excitation energy (23) is about  $\Delta E = 10,2 eV$ . It is the upper limit of radiation.

Also, the resonance ratio divides the resonance class into two groups; a normal resonance at , where the precession angular velocity is less than the orbital angular velocity, and a reverse resonance at which the precession angular velocity is greater than the orbital angular velocity. In this connection, it should be noted that the spectral lines of the reverse resonance are "fuzzy". They are characterized by a large precession angle. Their intensity is low and they are not of interest for spectral analysis. Only the spectral lines at the normal resonance are important!

The following must be said about the meaning of the quantum numbers: The principal quantum number  $n$  determines the number of revolutions of the perihelion that are needed to repeat again the direction in which the given spectral line is emitted. For example, for  $n = 1$  the radiation direction it is repeated when rotating the perihelion by an angle  $\varphi = 2\pi$ , i.e. broadcast on each new lap. For  $n = 2$ , in order to repeat the same direction of radiation, two rounds of perihelion are needed should, i.e.  $\varphi = n \times 2\pi = 2 \times 2\pi$  etc.

The auxiliary quantum number  $m$  determines the number of directions in which the given spectral line is emitted until the perihelion is rotated to the required angle  $\varphi = n \times 2\pi$ .

Table 2. Resonance relations.

$m$	$n$											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/10	1/11	1/12	1/13
2	2/3	1/2	2/5	1/3	2/7	1/4	2/9	1/5	2/11	1/6	2/13	1/7
3	3/4	3/5	1/2	3/7	3/8	1/3	3/10	3/11	1/4	3/13	3/14	1/5
4	4/5	2/3	4/7	1/2	4/9	2/5	4/11	1/4	4/13	2/7	4/15	1/4
5	5/6	5/7	5/8	5/9	1/2	5/11	5/12	5/13	5/14	1/3	5/16	5/17
6	6/7	3/4	2/3	3/5	6/11	1/2	6/13	3/7	2/5	3/8	6/17	1/3
7	7/8	7/9	7/10	7/11	7/12	7/13	1/2	7/15	7/16	7/17	7/18	7/19
8	8/9	4/5	8/11	2/3	8/13	4/7	8/15	1/2	8/17	4/9	8/19	2/5
9	9/10	9/11	3/4	9/13	9/14	3/5	9/16	9/17	1/2	9/19	9/20	3/7
10	10/11	5/6	10/13	5/7	2/3	5/8	10/17	5/9	10/19	1/2	10/21	5/11
11	11/12	11/13	11/14	11/15	11/16	11/17	11/18	11/19	11/20	11/21	1/2	11/23
12	12/13	6/7	4/5	3/4	12/17	2/3	12/19	3/5	4/7	6/11	12/23	1/2
13	13/14	13/15	13/16	13/17	13/18	13/19	13/20	13/21	13/22	13/23	13/24	13/25
14	14/15	7/8	14/17	7/9	14/19	7/10	2/3	7/11	14/23	7/12	14/25	7/13
15	15/16	15/17	5/6	15/19	3/4	5/7	15/22	15/23	5/8	3/5	15/26	15/27
16	16/17	8/9	16/19	4/5	16/21	8/11	16/23	2/3	16/25	8/13	16/27	4/7
17	17/18	17/19	17/20	17/21	17/22	17/23	17/24	17/25	17/26	17/27	17/28	17/29
18	18/19	9/10	6/7	9/11	18/23	3/4	18/25	9/13	2/3	9/14	18/29	3/5
19	19/20	19/21	19/22	19/23	19/24	19/25	19/26	19/27	19/28	19/29	19/30	19/31
20	20/21	10/11	20/23	5/6	4/5	10/13	20/27	5/7	20/29	2/3	20/31	5/8
21	21/22	22/23	7/8	21/25	21/26	21/27	3/4	21/29	7/10	21/31	21/32	21/33

\* normal resonance,  $m > n$

\*\* reverse resonance  $m < n$

Let us explain how the analytical spectral line 4861.3 [Å] is emitted. Here, the resonance ratio is 3/4 ( $n = 1, m = 3$ ),  $\lambda_0 = 1215,33$  [Å] is the length of the base spectral line according to the resonance formula (27), the precession angle according to (6) is  $\Delta\varphi = 120^0$ , the radiation directions are 3, and the coefficient of beating according to (29) is  $j=4$



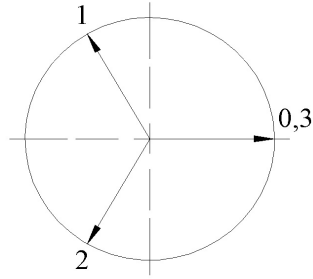


Fig.4. Emission of the spectral line 4861.3 [Å]

Let the initial position be direction 0 (Fig.4). After the perihelion is rotated by an angle  $\Delta\phi = 120^\circ$ , we have new radiation in direction 1, after another rotation of we  $120^\circ$  have radiation in direction 2 and after another rotation of  $120^\circ$  (direction 3), when the direction of the emitted spectral line coincides with the initial one

The analytical spectral line 4340.48 [Å] emits a little differently. Here, the resonance ratio is  $21/25$  ( $n = 4, m = 21$ ),  $\lambda_0 = 1085,12$  [Å] is the length of the baseline spectral line, the precession angle is  $\Delta\phi = 68,57^\circ$ , and the beat factor is  $j=4$ . Since the quantum number  $n = 4$  it means that the direction of emission of this spectral line will repeat itself after the perihelion is rotated by an angle  $\phi = 4 \times 2\pi$ , and the directions of emission will be 21 (Fig.5).

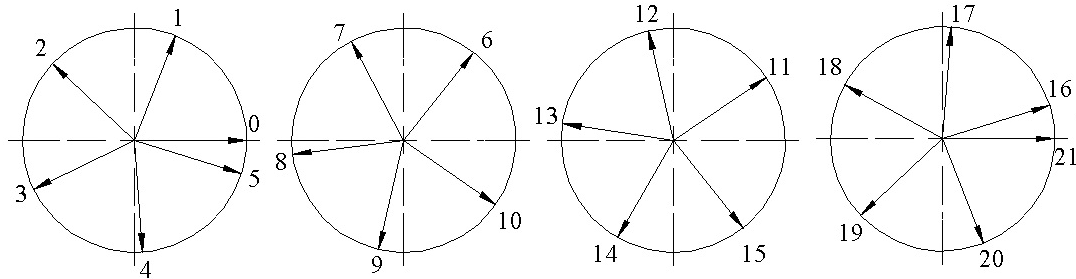


Fig.5. Emission of the spectral line 4340.48 [Å]

The initial position here is also direction 0. During the first perihelion rotation, the spectral lines in directions 1-5 will be emitted, but after there is no match, a second rotation in directions 6-10 is needed. Again there is no coincidence and in the third rotation there is radiation in the directions 11-15 and only in the fourth rotation the direction 21 coincides with the initial direction 0.

### 15. Some features of the proposed theory

This theory is based on equation (1). First of all, it should be noted that this equation is not made up. It is grounded, and as we noted above, it contains the fine structure constant, which we believe is the most important constant in quantum mechanics. It determines to what speed the electron in the hydrogen atom can be accelerated and what the radius of its orbit should be. Therefore, the fine structure constant determines the "scale" of matter in nature..

Furthermore, if the parentheses in equation (1) are revealed, we get

$$F = \frac{e^2}{r^2} + \frac{e^2}{\alpha c} \dot{r} = \frac{e^2}{r^2} + \hbar \frac{\dot{r}}{r^2} \quad (30)$$

where  $\hbar = e^2/\alpha c$  is Planck's constant, i.e. equation (1) contains the most important constants of quantum mechanics.

The proposed theory also agrees with Bohr's theory. For example, here is how the mechanical parameters of an atom are calculated depending on the fine structure constant [3].

$v_0 = \alpha c$  - Bohr's speed

$E_0 = \frac{1}{2} m_e (\alpha c)^2$  - energy of the atom in the ground state

$r_0 = \frac{e^2}{m_e (\alpha c)^2}$  - Bohr's radius

$\omega_0 = \frac{m_e (\alpha c)^2}{\hbar^2}$  - Bohr's angular velocity

$M_0 = \hbar$  -

kinetic moment

Also, the proposed theory agrees with Sommerfeld's theory. Obviously, the bottom two equations are similar

$s = C + A \cos \gamma \varphi$  - Sommerfeld equation in [7]

$\rho = \frac{1}{p} + e^{-b\varphi} \frac{\varepsilon}{p} \cos(\sqrt{1-b^2}\varphi)$  - our equation here and in [6]

As shown above, the angular velocity for perihelion closure (24) depends on the multiplier  $\omega_0/2$ , i.e. it is 2 times less of the angular velocity  $\omega_0$  of the electron in the ground state. And we were pleasantly surprised that  $\omega_0/2$  is equal to the Rydberg constant expressed in angular velocity, i.e. our theory also agrees with Rydberg's theory.

The proposed theory predicts both a linear and a banded spectrum. For example, if the resonance condition (11) is taken into account and substituted into (6), the equation for the precession angle will be

$$\Delta\varphi = 2\pi \frac{n}{m} \tag{31}$$

It is obvious that as the quantum number  $m$  increases, the precession angle decreases and the separation of individual spectral lines is more difficult, and  $m \rightarrow \infty$  the linear spectrum degenerates into a striped.

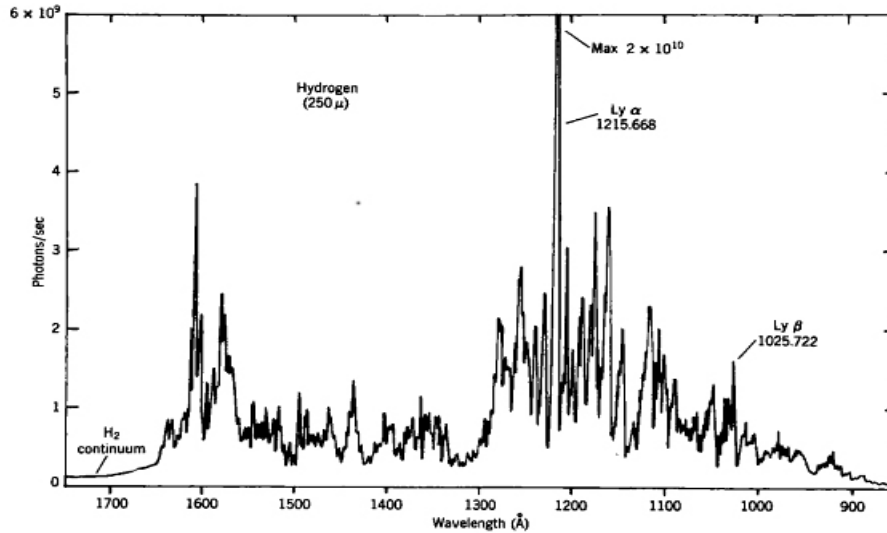


FIG. 11. A H<sub>2</sub> spectrum between 85 and 175 nm. Pressure was 0.25 Torr, and the discharge current was 400 mA [J. A. R. Samson, "Techniques of Vacuum Ultraviolet Spectroscopy." Wiley, New York, 1967].

Fig.4. Graphics by Samsom

The most solid proof of our theory is Samson's graph [13]. As can be seen, the boundaries of the spectral lines in this graph obtained experimentally, are in the range of 900 h1800 Å and coincide with the limits it predicts our theory given in Table1.

Our theory predicts a huge number of spectral lines. In this respect, it agrees Dieke's Table [14] (The Hydrogen Molecule Wavelength Table). It contains about 36000 spectral lines with lengths in the range  $2805 \div 28667 \text{ \AA}$ .

If we assume that the quantum number  $n$  is given the values  $1 \div 10$ , the quantum number  $m$  is given the values  $1 \div 100$ , and the beat factor  $j=2 \div 31$ , we will get 30000 spectral lines.

## 16. Spectral tables

The values of some of the hydrogen spectral lines predicted by the proposed theory are given in Appendix A. Three tables are shown. Series 1, 2 and 4, with quantum numbers  $n = 1, 2$  and 4. Each series has 60 rows, i.e. 60 baseline spectral lines and 420 beat wave spectral lines. The wavelengths of the baselines are calculated by the resonance formula (27), and the beat wavelengths are calculated by the formula (29). In each of the columns of the table, values of the following parameters are given:

Column:

1 - quantum number  $m$

2 - excitation energy  $\Delta E$  according to formula (23)

3 - precession angle  $\Delta\phi$  according to formula (31)

4 - the resonance ratio  $\frac{m}{m+n}$  according to Table 2

5 - length of the base spectral line  $\lambda_0$  according to (27)

6  $\div$  12 beat wavelength  $\lambda_j$  according to (29)

The most important is series 1. It is unique. The special thing here is that all the spectral lines of this series are repeated in each of the following series with a larger number. So that this table is a mirror of the proposed theory. In series 2, in addition to the repeated spectral lines of series 1, new resonance relations and new spectral lines appear, which, however, repeat after two rotations of perihelion. In series 3, new resonance relations and new spectral lines also appear, but they only recur after three rotations of perihelion, etc.

What spectral lines does table series 1 predict. Fig. 5 shows part of this table in which there are 16 basic "quantum" spectral lines and about 112 beat spectral lines. As can be seen, for the most part the spectral lines here are colored. Except for a few colored light green, all these colored lines have their analogues in Dicke's table [14], which contains spectral lines with a wavelength greater than  $2806 \text{ \AA}$ . The spectral lines with a beat factor  $j = 2$  of less than  $2806 \text{ \AA}$  remain hanging. We do not know whether spectral lines with such a wavelength, between the basic "quantum" spectral lines and the beat waves, are contained in spectral tables of other authors as well. The question is, do such waves even exist?

How are the different lines colored in Fig.5;

red - three lines from the Lyman series

pink - three of the most important analytical lines of the Balmer series, two of which are duplicated. The intensity of these spectral lines according to the Dicke table is 1.5

green - three lines from Paschen's series

gray - a large number of lines with an intensity higher than 1.5, i.e. greater than the intensity of the analytical ones. For example, spectral line 7656 is rated at intensity level 2.7.

yellow - a large number of lines with an intensity lower than 1.5.

In addition, it should be noted that our tables (Appendix A) contain all the spectral lines of the Lyman series. For example, line 949 of this series appears in series 1 at  $m = 24$ . The spectral lines and 3970 of the Balmer series appear in series 4 at  $m = 45$ .

It is also important to note that spectral lines from the Balmer series appear again and again as the quantum number increases. For example, the spectral line  $H_\beta = 4861$  repeats when the resonance ratio is  $3/4, 6/8, 9/12$ , etc. This explains why some of these spectral lines are of higher intensity and are selected for analytical ones.

m	$\Delta E$	$\Delta\varphi$	$\frac{m}{m+n}$	Basic spectral lines $\lambda_0$ [Å]	Spectral beat lines $\lambda_j = \lambda_0 \times j$							
					j=2	j=3	j=4	j=5	j=6	j=7	j=8	
					[Å]							
eV	Degree			6	7	8	9	10	11	12		
1	2	3	4	5								
1	10.2	360.00	1/2									
2	7.56	180.00	2/3	1,367.25	2,734.50	4101.75	5469	6836.25	8203.5	9570.75	10938	
3	5.95	120.00	3/4	1,215.33	2,430.67	3646	4861.33	6076.67	7292	8507.33	9722.67	
4	4.9	90.00	4/5	1,139.38	2,278.75	3418.13	4557.5	5696.88	6836.25	7975.63	9115	
5	4.16	72.00	5/6	1,093.80	2,187.60	3281.4	4375.2	5469	6562.8	7656.6	8750.4	
6	3.61	60.00	6/7	1,063.42	2,126.83	3190.25	4253.67	5317.08	6380.5	7443.92	8507.33	
7	3.19	51.43	7/8	1,041.71	2,083.43	3125.14	4166.86	5208.37	6250.29	7292	8333.71	
8	2.85	45.00	8/9	1,025.33	2,050.88	3076.31	4101.75	5127.19	6152.63	7178.06	8203.5	
9	2.58	40.00	9/10	1,012.78	2,025.56	3038.33	4051.11	5063.89	6076.67	7089.44	8102.22	
10	2.36	36.00	10/11	1,002.65	2,005.30	3007.95	4010.6	5013.25	6015.9	7018.55	8021.2	
11	2.17	32.73	11/12	994.36	1,988.73	2983.09	3977.45	4971.82	5966.18	6960.55	7954.91	
12	2.01	30.00	12/13	987.46	1,974.92	2962.38	3949.83	4937.29	5924.75	6912.21	7899.67	
13	1.87	27.69	13/14	981.62	1,963.23	2944.83	3926.46	4908.08	5889.69	6871.31	7852.92	
14	1.75	25.71	14/15	976.61	1,953.21	2929.82	3906.43	4883.04	5859.64	6836.25	7812.86	
15	1.65	24.00	15/16	972.22	1,944.53	2916.8	3889.07	4861.33	5833.6	6805.87	7778.13	
16	1.55	22.50	16/17	968.47	1,936.94	2905.41	3873.88	4842.34	5810.81	6779.28	7747.75	

Fig.5. Part of the spectral table series 1

### 16. Conclusion

A theory is proposed to explain the spectrum of hydrogen, which is largely a continuation of the classical theories of Bohr and Sommerfeld.

Formulas for calculating the length spectral lines are derived.

It can be asserted with a high degree of certainty that the theory thus proposed agrees with the accumulated experimental data.

Solving the problem for hydrogen can serve as a model for how to solve the quantum mechanics of other atoms.

### Reference

- [1] R.P. Feynmann, The Character of Physical Law, London (1965)
- [2] A. Datshev, Quantum Mechanics and Physical Reality, Sofia, ed. BAS (1969) (in French);
- [3] D.G. Stoinov, "Electricity and magnetism as an interaction between moving oscillators" Deposited manuscript. Central Technology Library. No. 466 (1993)
- [4] D.G. Stoinov, "Interaction Between Moving Oscillators", Galilean Electrodynamics, Volume 10, No. 2, pp. 37-38 (1999)
- [5] D.G. Stoinov, "What is the Electrical Charge? Coulomb's law", Galilean Electrodynamics, Volume 11, No. 5, pp. 97-99 (2000)
- [6] D. G. Stoinov, D.D. Stoinov "The constant defining the atomic scale"  
<https://drive.google.com/file/d/1ANHVBFWICrCjIAMDzvRg3FPoJhK7e8Dw/view>
- [7] D.G Stoinov, D.D. Stoinov, "Quantum mechanics: a classical mechanics , point of view", Part 1..  
[https://drive.google.com/file/d/1n0On6-sqSmY-KFnI\\_LbXDQMhY\\_WLLz1g/view?pli=1](https://drive.google.com/file/d/1n0On6-sqSmY-KFnI_LbXDQMhY_WLLz1g/view?pli=1)
- [8] D. G. Stoinov, D.D. Stoinov, "A new quantum mechanics of the hydrogen atom. Resonance formula"  
<https://www.gsjournal.net/Science-Journals/Research%20Papers-Quantum%20Theory%20%20Particle%20Physics/Download/7404>
- [9] A. Sommerfeld, Atombau und Spektrallinien, v. I, p. 226 , Mir, Moskow, (1956,) ( in Russian)
- [10] M. Born, Atomik Physics. p. 136 ( Nauka i izkustvo, Sofia, 1972, (in Bulgarian)
- [11] D. G. Stoinov, D. D. Stoinov, "On the Kinematic Interpretation of the Balmer-Rydberg Formula", *General Science Journal*;
- [12] Appendix A. Table of Spectral Lines of the Hydrogen Atom.  
[https://drive.google.com/file/d/1hrJcqeC4BYi9GP70rxOxb1cGTdwCgK5s/view?usp=drive\\_link](https://drive.google.com/file/d/1hrJcqeC4BYi9GP70rxOxb1cGTdwCgK5s/view?usp=drive_link)
- [13] J.A.R. Samson. "Techniques of Vacuum Ultraviolet Spectroscopy" Wiley, New York. (1967)
- [14] H.M. Grosswhite, "The Hydrogen Molecule Wavelength Table of G. H. Dieke", Wiley-Interscience, New York London -Toronto (1971)  
[https://drive.google.com/file/d/1-soyV3hTVdQv4GBUq\\_LODmhQWRrcCC/view?usp=sharing](https://drive.google.com/file/d/1-soyV3hTVdQv4GBUq_LODmhQWRrcCC/view?usp=sharing)