

Resonance Formula of the Hydrogen Spectrum

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We introduce for the purpose of discussion and experimental testing a new so-called resonance formula for the spectrum of hydrogen. It is more general than the Balmer-Rydberg formula. It should be noted that this new formula is derived in accordance with the laws of classical mechanics. It contains a larger number of series, and also many more spectral lines in each series. The starting point is a planetary model of the atom and the concept that electrons move in classical elliptical orbits, and that all parameters of its motion (coordinates, momentum, energy, speed, etc.) appear as continuous functions of time. The distinct lines in the spectrum are explained by the condition of resonance between the speed with which the electron moves in its orbit and the speed of precession.

1. Introduction

Historically, a considerable problem in science has been the explanation of the discrete atomic emission spectra. Attempts to solve this particular problem from a classical mechanics point of view have been largely unsuccessful until now. It was in this context that quantum mechanics emerged as a means of explaining these results. It is from quantum mechanics that the ideas of photons of energy, the dualism between waves and particles, and other concepts arose which violate some of the most important laws of classical physics.

In our view, the solution to the problem of the discrete nature of atomic emission spectra can be found in a more fundamental consideration of the interaction between the atomic nucleus and the electrons in the shell. In our first work on the subject [1], we solved the problem of atoms' size and stability, based on that concept. Let us remind the reader that this problem has been subject to heated discussions in the past; although that article was submitted to several reputable physics journals, it was rejected. This serves as a demonstration of how deeply rooted into modern physics is the illusion that all difficulties from the past had been definitely overcome and can be solved by questionable innovations.

We here propose a more general formula for the calculation of the hydrogen emission spectrum than the Balmer-Rydberg formula. This new formula also has a larger number of series and many more spectral lines in each series. It contains the spectral lines of molecular hydrogen as well. This results from an atomic model that uses precessing, elliptical orbits, as discussed below.

2. Resonance Formula

Using normal classical mechanics to solve the hydrogen problem [2-5], we arrived at the following resonance formula for the spectral lines of atomic and molecular hydrogen, which we advanced for discussion and experimental verification:

$$\lambda = \lambda_0 \frac{n(m+n)}{m} \quad (1)$$

where the minimum wavelength of λ is $\lambda_0 = 1/R$ $n=1,2,3,\dots$ and $m=2,3,4,\dots$ are the quantum numbers such that $m_1=n+1$, and R is the Rydberg constant.

Eq. (1) is based on the planetary model of the atom and the concept of the electron circling around the atom along a classic elliptical orbit whereby all motion parameters (coordinates, momentum, energy, speed, etc.) are represented as continuous functions of time. According to our theory [4, 5], when an atom emits light, the electron orbits along a precessing elliptical trajectory with an angular speed

$$\Omega = 8b^3 \omega_0 \quad (2)$$

It is in turn the sum of two components $\Omega = \omega_{or} + \omega_{pr}$

$$\begin{aligned} \omega_{or} &= 8b^3 \omega_0 \sqrt{1-b^2} && \text{orbiting angular speed} \\ \omega_{pr} &= 8b^3 \omega_0 (1 - \sqrt{1-b^2}) && \text{precession angular speed } \omega \end{aligned}$$

The condition of emission of certain spectral line occurs when there is a resonance between the speed of the electron traveling along the orbit, and the precession speed. For this to happen, the ratio ω_{or}/ω_{pr} must be a ratio of integers. And this is so when the radical equals

$$\sqrt{1-b^2} = m/(m+n) \quad (3)$$

The principal quantum number n defines the number of the series. At the same time, it has physical significance because it gives the number of revolutions needed for the perihelion to reach a resonance. For instance, at $n=1$ the resonance will be achieved after one full revolution of the perihelion to 360° . At $n=5$, the resonance will be achieved after five full revolutions of the perihelion, or to an angle of 1800° , etc.

The azimuthal quantum number m is related to the polarization. It defines the directions of propagation for certain spectral lines. In [4, 5] we derived the angle $\Delta\varphi$ of the perihelion shift during one full revolution of the electron along the orbit,

$$\Delta\varphi = 2\pi \left(\frac{1}{\sqrt{1-b^2}} - 1 \right) \quad (4)$$

and therefore, taking into account Eq. (3), it yields

$$\Delta\varphi = \frac{2\pi n}{m} \quad (5)$$

where m defines the directions of propagation for the spectral line in question, emitted while the perihelion revolves to an angle of $2\pi n$.

3. Spectral Series' Limits

The theoretical limits of the separate series of spectral lines are listed in Table 1. As regards the lower limit of each series, it should be kept in mind that this limit will be approached when $m \rightarrow \infty$. Hence, it will be always narrower than the predominant lines. In addition, when approaching the lower limit, the electron will need to make more revolutions until a resonance is reached. That is why the intensity of these spectral lines will decrease and they will be difficult to discern.

It must be remembered also, that when m increases, the shift angle $\Delta\varphi$ in Eq. (4) decreases, and consequently the lines will converge and the line spectrum will be transformed (degenerate) into a spectral band. In order for these spectral lines to appear, a greater energy is necessary; i.e. the hydrogen gas should have a higher temperature.

n	λ - upper limit	λ - lower limit
1	1367	911
2	3039	1822
3	4786	2736
4	6563	3647
5	8357	4561
6	10159	5437
7	13777	7299

Table 1. Wavelength λ in \AA

4. Is It Really Necessary to Separate the Atomic and Molecular Spectra?

When considering the hydrogen spectrum, the Balmer- Rydberg formula comes first. For this reason, in our previous works [2-5], our goal was to demonstrate that, after the substitution $\sqrt{1-b^2} = 1-n^2/m^2$, our theory complied with that formula.

It turned out however, that our theory is capable of predicting many more resonances and a greater number of series and spectral lines than the Balmer-Rydberg formula can. This triggered our interest to examine the spectrum of molecular hydrogen. We have been fortunate enough to stumble upon some older spectral tables [6, 7] featuring the atomic and molecular hydrogen spectral lines simultaneously. It is quite interesting that newer tables [8, 9] do not feature any spectral lines of molecular hydrogen – does this mean that they are trying to conceal something?

After establishing that our theory is capable of predicting most of the spectral lines of molecular hydrogen as well as atomic hydrogen, we asked ourselves: What is the possible reason to put forward separate theories and separate spectral tables for atomic and molecular hydrogen? And why this is done only for hydrogen? Considering that the hydrogen spectrum is observed in gas discharge tubes (Geisslers), doesn't it become difficult to discern which spectral lines come from atomic and which one from molecular hydrogen?

Our opinion is that both spectra – the atomic one and the so-called molecular one – are electronic in nature, and depend on the electron's motion. Therefore they should be explained by one theory and all data be given in a single table. Thus we suggest that the reader observe Fig. 1. It shows a photograph of hydrogen spectrum taken at low resolution of the spectrometer. The brighter spectral lines from Balmer series (H_α and H_β) are seen on a colored background - red and blue, respectively. However, if the observation is made in a spectrometer with higher resolution, the reader will notice that the background in fact consists of closely located spectral lines. There are two theories explaining the situation shown on the photograph. First, the distinctive spectral lines (H_α and H_β) are explained by the Balmer-Rydberg's formula and interpreted as atomic hydrogen spectrum. Second, the spectral lines from the background are explained by a completely different theory and interpreted as molecular hydrogen spectrum.

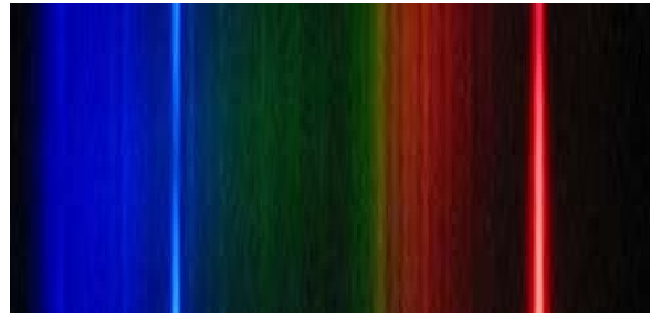


Fig. 1. Observed emission spectrum of hydrogen

From the point of view of our theory, this distinction is not necessary: the spectral lines in the separate series overlap (see Table 1). The exact succession of spectral lines belonging to different series can be established if they are presented in one table. Selected parts of such table, created in Excel, for the sectors surrounding spectral lines $H_\alpha, H_\beta, H_\delta$ of the Balmer's series, are shown in Table 2. They have different colors in order to make a distinction between the overlapping series. It is seen, that H_α line is being emitted in three series simultaneously and lines H_β and H_δ - in two series. This explains why these specific spectral lines have greater intensity and are clearly discernible on the background of densely packed spectral lines of lesser intensity formed by the carrier series.

$H_\alpha = 6562.8$			$H_\beta = 4861.33$			$H_\delta = 4101.75$		
λ	N	m	λ	n	m	λ	n	m
6565.06	7	242	4873.99	5	72	4148.89	4	29
6564.3	7	243	4869.65	5	73	4132.13	4	30
6563.54	7	244	4865.43	5	74	4116.45	4	31
6562.8	4	5	4861.33	4	12	4101.75	3	6
6562.8	6	30	4861.33	5	75	4101.75	4	32
6562.8	7	245	4857.33	5	76	4087.93	4	33
6562.06	7	246	4853.44	5	77	4074.94	4	34
6561.32	7	247	4849.64	5	78	4062.68	4	35

Table 2. Wavelength λ in \AA

Table 2 was created with the following assumptions in mind:

- minimum wavelength is $\lambda_0 = 1/R = 911.5$
- module of 400. This means that each one of the series has $n \times 400$ spectral lines; i.e. the azimuthal quantum number m has values in the range $n + 1 \leq m \leq n \times 400$.

Presumably, the Balmer-Rydberg formula accounts only for lines with greater intensity and these prominent lines are interpreted as the atomic spectrum. Later on, when the lesser intensity lines were observed, it became difficult to explain them by the already created theory and therefore they were attributed to the so-called molecular spectrum.

5. Mechanics of the Hydrogen Atom and the Discrete Emission Spectrum

The currently prevailing theory explains the discrete nature of the atomic emission spectrum via the so-called "electronic transitions". However, with regard to the exact mechanism governing these transitions, everything is uncertain and covered by the haze of quantum mechanics. The atoms are regarded as kind of "black boxes", which in some incredible way emit and absorb some even more incredible particles - photons.

In contrast, the theory presented here makes everything clear - from the beginning to the end. The reference point is the planetary model of the atom and the assumption that the electron is moving along a classical elliptical orbit with all parameters of motion (coordinates, angular momentum, energy, speeds, etc.) being continuous functions of time. The discontinuous, discrete emission spectrum of the atom is explained with the event of a resonance between the electron orbiting speed and the precession speed of the orbit.

As mentioned already, the key to solving the problem of two separate spectra is to adopt a more fundamental approach regarding the precise interaction between the atomic nucleus and the electrons in the shell. In other words, the key is contained in the force function (potential) of the nucleus, which in the case of hydrogen is [1]:

$$U = \frac{e^2}{r} \left(1 + \frac{\dot{r}}{\alpha c} \right) \quad (6)$$

where e is the electric charge, r the current orbit radius, \dot{r} the radial speed, c the speed of light and α the fine structure constant.

We have shown [2-5] that based on this potential, a differential equation of the electron trajectory can be derived as follows:

$$\frac{d^2 \rho}{d\varphi^2} + \frac{e^2}{\alpha c M} \frac{d\rho}{d\varphi} + \rho = \frac{m_e e^2}{M^2} \quad (7)$$

having the solution

$$r = \frac{p}{1 + \exp(-b\varphi) \varepsilon \cos(\sqrt{1-b^2} \varphi + \gamma)} \quad (8)$$

where $\rho = 1/r$, p is the focal parameter of the orbit, m_e is the electron mass, M is the angular momentum, ε is orbit's eccentricity and γ is the angle of phase shift.

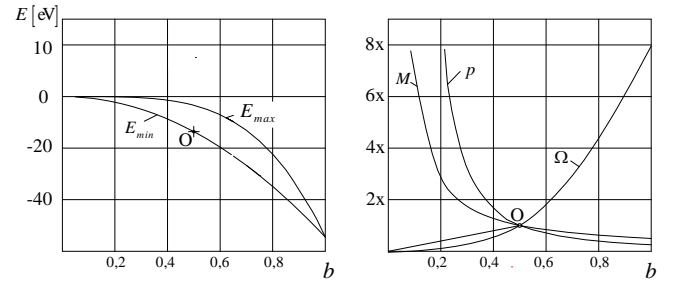


Fig. 2. Changes in the mechanical parameters of the movement of electrons as a function of the parameter b . Point O corresponds to the ground state of the atom. a) energy E b) momentum M , angular velocity Ω and focal parameter p . The symbols $2x, 4x, 6x, \dots$ mean $M = 2\hbar$, $\Omega = 2\omega_0$, $p = 2r_0$, where ω_0 and r_0 are respectively angular velocity and orbital radius of a ground state of the atom.

There is no need to repeat all the calculations from my previous work now. Fig. 2 shows how the electron parameters will change as a function of the parameter b during orbiting, where

$$\begin{aligned} M &= \frac{\hbar}{2b} && \text{angular momentum} \\ p &= \frac{r_0}{4b^2} && \text{focal parameter of the orbit} \\ E_{\min} &= -4b^2 E_0 && \text{energy minimum} \\ E_{\max} &= -4b^4 E_0 && \text{energy maximum} \end{aligned} \quad (9)$$

E_{\min} and E_{\max} are the limits in order to observe an emission of the spectral line. Here \hbar is Planck's constant, and r_0 and E_0 are the radius and energy of the atom in the base state respectively. These limits are in line with two conditions:

1. orbit eccentricity ε satisfies $0 \leq \varepsilon < 1$, where

$$\varepsilon = \frac{1}{\sqrt{1-b^2}} \sqrt{1 + \frac{2EM^2}{m_e e^4}} \quad (10)$$

2. the orbit is preserved as a whole.

It can be seen from the graphs that all these parameters are continuous functions of the parameter b and, consequently continuous functions of time. Neither energy quanta nor angular momentum quanta are needed at all. Consequently, there are no photons!

Here, the most important mechanical parameter is the angular momentum M . It defines the absolute angular speed in Eq. (2) and the ratio between the angular speed of the orbiting electron and the angular speed of precession. That ratio is crucial for occurrence of the resonance when light is emitted. Therefore, a spectral line will be emitted only when the angular momentum is

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

Our theory then concludes that the discrete event is occurring continuously!

6. Conclusion

We have here presented evidence which better explains the discrete nature of atomic emission spectra from a classical mechanics point of view. A new resonance formula has been derived. As a consequence, and in line with our open letter [10], there exists a strong challenge to Einstein's relativism as well as quantum mechanics. Both have been challenged for some time, and this adds one more challenge to the list.

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