

## 4. A NON-NUCLEAR MODEL OF THE HYDROGEN ATOM

### Abstract

A non-nuclear model of the atom of hydrogen gas is devised consisting of  $N_h$  planar orbits each with two particles of the same mass  $nm$  and opposite charges, of magnitude equal to the electronic charge  $e$ , revolving in the  $n$ th orbit round a common centre. A particle revolves through angle  $\psi$ , in an unclosed elliptic orbit, at a distance  $r$  from the centre, as:

$$\frac{1}{r} = \frac{A}{n} \exp(-b\psi) \cos(\alpha\psi + \beta) + \frac{m\kappa}{nL^2}$$

where  $A$  and  $\beta$  are determined from the initial conditions,  $b$ ,  $\alpha$ , and  $\kappa$  are constants,  $nL$  is a constant angular momentum in the  $n$ th orbit and  $m$  is the electronic mass. The number  $n$  (1, 2, 3... $N_h$ ) leads to quantisation of the orbits. The decay factor,  $\exp(-b\psi)$ , is the result of radiation as a particle revolves and settles in the  $n$ th stable orbit, a circle of radius  $r_n = nL^2/m\kappa$  with speed  $v_n = \kappa/nL$ . Interactions between revolving particles, in each of the  $N_h$  orbits, give rise to radiation of discrete frequencies in accordance with observations.

*Keywords:* Angular momentum, hydrogen atom, centre of revolution, radiation.

### 4.1 Introduction

The paper introduces a non-nuclear model of the hydrogen atom for the gas state. This model is different from the Rutherford's nuclear model [1] and also different from the nuclear model described by the author [2]. The non-nuclear model is stabilized and the Balmer-Rydberg formula [3], for discrete frequencies of emitted radiation, is derived, without recourse to Bohr's quantum mechanics [4].

The Balmer-Rydberg formula [3] gives the wave number of emitted radiation from the hydrogen atom as:

$$\frac{1}{\lambda_{nq}} = R \left( \frac{1}{n^2} - \frac{1}{q^2} \right) \text{ per metre} \quad (4.1)$$

where  $R$  is the Rydberg constant and  $n$  and  $q$  are integers greater than 0, with  $q$  greater than  $n$ . Niels Bohr [4] derived the formula as:

$$\nu_{nq} = \frac{1}{\lambda_{nq}} = \frac{me^4}{8c\epsilon_0^2 h^3} \left( \frac{1}{n^2} - \frac{1}{q^2} \right) \text{ per metre} \quad (4.2)$$

where  $m$  is the electronic mass,  $e$  the magnitude of the electronic charge,  $c$  is the speed of light in a vacuum,  $\epsilon_0$  is the permittivity of a vacuum and  $h$  the Planck constant. The Rydberg constant  $R$ , is:

$$R = \frac{me^4}{8c\epsilon_0^2 h^3} \text{ per metre} \quad (4.3)$$

#### 4.1.1 Alternative model of the hydrogen atom

An alternative model of the hydrogen atom is introduced in this paper. The non-nuclear model, called *bipolar model*, is for the gas state of the hydrogen atom. The bipolar model consists of a number  $N_h$  of circular orbits in one plane. The  $n$ th stable circular orbit consists of a particle of charge  $-e$  and mass  $nm$  at a distance  $2nr_1$  from another particle of the same mass  $nm$  but charge  $+e$  revolving with speed  $v_1/n$  and constant angular momentum  $nL$ , under mutual attraction. Here,  $n$  is an integer: 1, 2, 3... $N_h$ . The radius  $r_1$ , speed  $v_1$  and angular momentum  $L$  are for the inner orbit, the first orbit with  $n = 1$ . The pair of oppositely charged particles makes up the two poles of a bipolar orbit.

In the stable state, a particle of mass  $nm$ , in the bipolar or non-nuclear model, revolves in the  $n$ th circular orbit. If a particle is disturbed from the  $n$ th stable circular orbit, it revolves as a radiator emitting a burst of radiation of increasing frequency and decreasing intensity as it spirals out towards the stable circular orbit. The frequencies of emitted radiation are very nearly equal to that of revolution in the  $n$ th circular orbit.

In the bipolar model, an excited hydrogen atom will consist of a number of radiators with the charged particles oscillating in (unclosed) coplanar elliptic orbits. In the following section, it is shown that interaction between a particle of the bipolar orbit in the  $n$ th orbit and another in the  $q$ th orbit results in emission of radiation of discrete frequencies in accordance with the Balmer-Rydberg formula for the spectrum of the hydrogen atom in the gas state.

The derivation of Balmer-Rydberg formula, without recourse to Bohr's quantum theory, is the most remarkable result of this paper. It avoids the ad-hoc restrictions and removes the quantum jump of an electron as a necessary condition for emission of radiation from the hydrogen atom. It also relates the frequencies of radiation to the frequencies of circular revolutions of the electrons, something which the quantum theory failed to do.

## 4.2 Non-nuclear model of the hydrogen atom

The non-nuclear model of the hydrogen atom consists of a concentric arrangement of  $N_h$  coplanar orbits. The orbits are equally spaced, each with two particles of charges  $-e$  and  $+e$  and same mass  $nm$  revolving in the  $n$ th orbit round a centre of revolution, the centre of mass of the two particles.

### 4.2.1 Equation of the orbit of motion

The equation of the orbit of motion of a particle of mass  $nm$  revolving, in the  $n$ th orbit, at a point distance  $r$  from the centre, is derived (equation 2.29) in paper 2 [5], as:

$$\frac{1}{r} = \frac{A}{n} \exp(-b\psi) \cos(\alpha\psi + \beta) + \frac{m\kappa}{nL^2} \quad (4.4)$$

where the excitement amplitude  $A$  and phase angle  $\beta$  are determined from the initial conditions,  $b$ ,  $\alpha$  are constants,  $\kappa = e^2/16\pi\epsilon_0$  and  $nL$  is a constant angular momentum in the  $n$ th orbit..

The exponential decay factor  $(-b\psi)$ , in equation (4.4), is as a result of radiation of energy. The two charged particles will revolve, round their centre of mass, in an unclosed (aperiodic) elliptic orbit with many cycles of revolutions, radiating energy, before settling down into the  $n$ th stable orbit, a circle of radius  $nL^2/m\kappa$ .

### 4.2.2 Radiation from the non-nuclear model

The non-nuclear or bipolar model of the hydrogen atom consists of a concentric arrangement of  $N_h$  coplanar orbits. Each orbit has two particles revolving under mutual attraction, round a common centre of revolution. A particle revolves in a stable circular orbit of radius  $r_n = nr_1 = nL^2/m\kappa$  with velocity  $v_n = v_1/n = \kappa nL$ , where  $\kappa = e^2/16\pi\epsilon_0$  and  $n = 1$  for the innermost orbit. Such a configuration of  $N_h$  orbits is shown in Figure 4.1. The non-nuclear model of the hydrogen atom, in contrast to the nuclear

model, has no particle as the nucleus, but an empty common centre of mass as the centre of revolution for all the particles in the  $N_h$  orbits.

The frequency of revolution of a particle moving with constant speed  $v_n$  in the  $n$ th stable orbit, a circle of radius  $r_n$ , is:

$$f_n = \frac{v_n}{2\pi r_n} = \frac{me^4}{16\pi n \epsilon_o L} \frac{1}{2\pi (16\pi n \epsilon_o L^2)} = \frac{me^4}{2\pi (16\pi \epsilon_o)^2 L^3} \frac{1}{n^2} \quad (4.5)$$

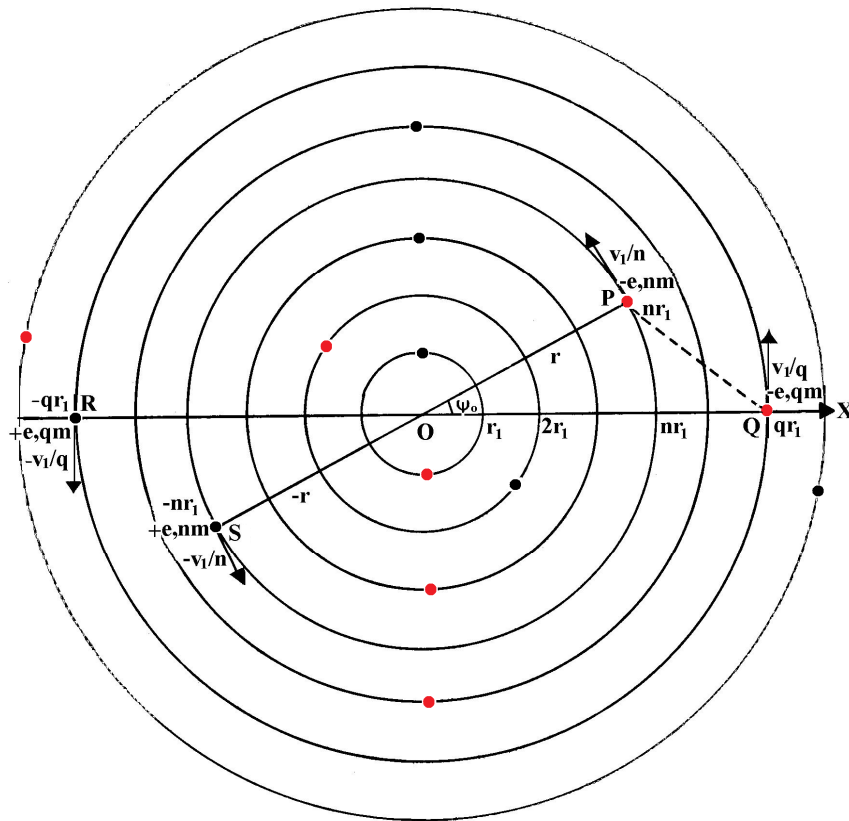


Figure 4.1. Non-nuclear model of the hydrogen atom, consisting of a number  $N_h$  of coplanar orbits each with two equal but oppositely charged particles revolving, anti clock-wise, in angle  $\psi$ , under mutual attraction. Each of the two particles in the  $n$ th orbit has mass  $nm$ , one carries charge  $-e$  and the other  $+e$ ,  $n$  being an integer from  $1 - N_h$ ,  $m$  is the electronic mass and  $-e$  the electronic charge. The  $n$ th pair of particles revolves in a circular orbit of radius  $nr_1$  with velocity  $v_1/n$  and constant angular momentum  $nmv_1r_1 = nL$

Putting  $L = h/4\pi$  gives equation (4.5) as:

$$f_n = \frac{me^4}{2\pi(16\pi\epsilon_o)^2 L^3 n^2} = \frac{me^4}{8\epsilon_o^2 h^3} \frac{1}{n^2} = \frac{cR}{n^2} \quad (4.6)$$

where the Rydberg constant  $R = me^4/8c\epsilon_o^2 h^3$ , has the value  $(1.097 \times 10^7 \text{ per metre})$  as obtained by Bohr (equation 3.2) [4] and confirmed by observation. The Planck constant  $h$  appears here in a manner reminiscent of Bohr's first postulate which makes  $nL = nh/2\pi$  as the angular momentum in the  $n$ th orbit, in contrast to the angular momentum,  $nL = nh/4\pi$ , as advanced here in order to arrive at equation (4.6).

If a particle, in the  $n$ th orbit, is dislodged from the stable circular orbit, it revolves as a radiator in an unclosed (aperiodic) elliptic orbit. It emits a burst of radiation of frequencies very nearly equal to that of revolution given by equation (4.6), before reverting back into the  $n$ th stable circular orbit.

### 4.2.3 The Balmer-Rydberg formula

We shall now follow the motion of particles in two bipolar orbits with the particles at positions  $P$  and  $Q$  of radii  $nr_i$  and  $qr_i$  respectively, revolving in anticlockwise sense round the centre  $O$  as in Figure 4.1. The frequencies of revolution at  $P$  and  $Q$  are given by equation (4.5) for the respective orbital numbers  $n$  and  $q$ .

In Figure 4.1 let the particles at positions  $P$  and  $Q$  both have negative charges at the initial stage. The relative positions of the points  $S, R, O, P$  and  $Q$  are as shown, with  $OP$  and  $OQ$  at an angular displacement  $\psi_o$  at the initial stage, time  $t = 0$ . In time  $t$  let the line  $OP$  move to  $OP_t$  through an angle  $\psi_n$ , and let the line  $OQ$  move to  $OQ_t$  through an angle  $\psi_q$ . The difference in angular displacement, the instantaneous angle  $P_tOQ_t$ , is:

$$\psi_t = \psi_o + \psi_n - \psi_q$$

The angular frequency of oscillation of the particles at  $P$  and  $Q$ , is:

$$\frac{d\psi_t}{dt} = \frac{d\psi_n}{dt} - \frac{d\psi_q}{dt} = \omega_n - \omega_q = 2\pi f_n - 2\pi f_q = 2\pi f_{nq} \quad (4.7)$$

Combining equation (4.7) above with equation (4.6) where  $f_n = cR/n^2$  and  $f_q = cR/q^2$ , gives:

$$f_{nq} = cR \left( \frac{1}{n^2} - \frac{1}{q^2} \right) \quad (4.8)$$

The four particles in two bipolar radiators, of the hydrogen atom, behave like oscillating pairs, emitting radiation in a narrow band of frequencies, with wave numbers  $\nu_{nq}$  as:

$$\nu_{nq} = \frac{f_{nq}}{c} = R \left( \frac{1}{n^2} - \frac{1}{q^2} \right) \quad (4.9)$$

The atomic particles revolve in their respective orbits as radiators. Interactions between the  $2N_h$  particles, in all the  $N_h$  number of orbits, result in the emission of radiation of discrete frequencies and wave numbers given by equations (4.8) and (4.9) respectively. Also, the atom can absorb radiation of the same frequencies as it emits. The arrangement of the particles, their revolutions and interactions between them, giving rise to emission or absorption of radiation, determines the physical and chemical properties and thermal condition of the atom,

Equation (4.9), identical to the Balmer-Rydberg formula (equation 4.1), is the result of interactions between excited charged particles as they revolve in their different unstable orbits. This is what this paper has set out to derive without recourse to quantum mechanics. In the process, the frequencies of emitted radiation are directly related to the frequencies of revolutions of the charged particles; something which quantum mechanics failed to do.

#### 4.2.4 Number of orbits in the non-nuclear model

The hydrogen atom is found to be about 1836 times the mass  $m$  of the electron. The total number  $N_h$  of orbits, each containing two particles either of mass  $nm$ , is obtained from the sum of the natural numbers:  $n = 1, 2, 3, \dots, N_h$ . Twice this sum, which carries the mass of the atom, gives  $N_h(N_h + 1)m = 1836m$ . This gives  $N_h = 42.35$ .  $N_h$  should be an integer.

### 4.3 Bipolar model versus nuclear model

The bipolar model of the hydrogen atom has no nucleus but an empty centre round which particles revolve in  $N_h$  coplanar orbits. Two positive and negative particles ( $+e$  and  $-e$ ), each bearing a multiple  $nm$  of the electronic mass  $m$ , revolve in the  $n$ th orbit,  $n$  being an integer:  $1, 2, 3, \dots, N_h$ . The total mass of particles in the  $N_h$  orbits, with two particles in each orbit, is  $N_h(N_h + 1)m$ . The positive and negative electrical charges, in an atom, cancel out exactly.

The new nuclear model has a nucleus of charge  $+N_h e$  and  $N_h$  coplanar orbits in each of which particles of charge  $-e$  and mass  $nm$  revolve. The total charge of the negative particles is  $-N_h e$ , equal and opposite of the charge on the nucleus. The total mass of the  $N_h$  revolving particles is  $\frac{1}{2}N_h(N_h + 1)m$ , same as the mass of the nucleus. Thus the bipolar model and unipolar or nuclear model of the hydrogen atom have the same number of orbits  $N_h$  and the same mass, equal to  $N_h(N_h + 1)m$ . The question now is: "What is the significance of these two different models of the hydrogen atom?"

It is suggested here that the non-nuclear (bipolar) model is what obtains with the gas phase of hydrogen while the new nuclear model exists with respect to the liquid and solid phases, depending on the ambient temperature. Let us now determine the relationship between the constant  $S$  as given by equation (3.6) [2] for the nuclear model and the Rydberg constant  $R$ , obtained from equation (4.6), for the non-nuclear model. The expression obtained, equal to the ratio of frequency  $g_n$  in the nuclear model and the frequency  $f_n$  in the non-nuclear nuclear model, is:

$$\frac{S}{R} = \frac{g_n}{f_n} = 16N_h^2 \quad (4.10)$$

The ratio  $s_n$  of radius of revolution in the  $n$ th orbit of the nuclear model and the radius  $r_n$  of the non-nuclear model, is obtained as:

$$\frac{s_n}{r_n} = \frac{1}{4N_h} \quad (4.11)$$

The ratio  $u_n$  of speed of revolution in the  $n$ th orbit of the nuclear model and the speed  $v_n$  in the non-nuclear obtained, is obtained as:

$$\frac{u_n}{v_n} = 4N_h \quad (4.12)$$

It is assumed that the constant angular momentum  $nL$ , with respect to the  $n$ th stable orbit, is the same for the nuclear and non-nuclear models of the hydrogen atom.

#### 4.4 Conclusion

Expressions for the Balmer-Rydberg formula and the Rydberg constant (equations 4.1 and 4.2), for the non-nuclear or bipolar model of the hydrogen atom, are derived without recourse to Bohr's second postulate but with a modification of the first postulate. The modification is to the

effect that *the magnitude of the angular momentum of a particle of mass  $nm$ , revolving in the  $n$ th circular orbit, is equal to  $nL = nh/4\pi$* , where  $h = 6.626 \times 10^{-34}$  J-sec. Quantisation of angular momentum ( $nL$ ) and radius of revolution ( $nL^2/m\kappa$ ) and inverse quantisation of velocity ( $\kappa/nL$ ) appear naturally as a consequence of discrete masses ( $nm$ ), being multiples of the electronic mass  $m$ , with  $n$  as the orbital number or “quantum number”, an integer greater than 0.

The angular momentum of a particle in the first orbit of the bipolar model, is  $L = h/4\pi$ . This is a fundamental quantity of value equal to  $L = 5.273 \times 10^{-35}$  J-sec. It defines the Planck constant  $h$  in terms of angular momentum rather than “unit of action”. Even though the Planck constant is featuring prominently, Bohr’s quantum mechanics is not necessary in describing the discrete frequencies of radiation from the hydrogen atom.

The radius of the first orbit ( $n = 1$ ) of the non-nuclear model of the hydrogen atom is obtained as  $r_1 = \epsilon_0 h^2 / \pi m e^2 = 5.292 \times 10^{-7}$  m. This is the same as the **first Bohr radius** [4] obtained, through quantum mechanics, for the nuclear model of the hydrogen atom. The speed of revolution in the first orbit of the non-nuclear model is obtained as  $v_1 = e^2 / 4\epsilon_0 h = 1.094 \times 10^6$  m/s. This is different from the speed of revolution in the **first Bohr orbit** of the nuclear model, which is  $u_1 = N_h e^2 / \epsilon_0 h$  m/s. A knowledge of the charge  $+N_h e$  in the nucleus, as may be obtained from experiment, is required in order to determine the radius  $s_1 = \epsilon_0 h^2 / 4N_h \pi m e^2$  and speed  $u_1$  of revolution (equations 4.11 and 4.12) in the new nuclear model.

The Rutherford-Bohr nuclear model of the hydrogen atom does not distinguish between the models in the gaseous state and in the liquid or solid state. In paper 3 [2], the new nuclear model is for the liquid or solid state and this paper gives the non-nuclear model for the gaseous state. The Balmer-Rydberg formula, which explains the frequencies of radiation in the hydrogen atom spectrum [3], should be for the gaseous state.

This paper gives two sources of radiation from the hydrogen atom. The first is from interaction between the two radiators in the  $n$ th orbit. A particle revolves in an unclosed (aperiodic) elliptic orbit emitting radiation of increasing frequencies and decreasing amplitude before settling in the  $n$ th stable circular orbit. Thus radiation from a revolving particle is a narrow band of frequencies very nearly equal to the frequency of revolution  $f_n$  given by equation (4.6). The second source of radiation is from interaction between particles revolving in the  $n$ th and  $q$ th orbits, resulting in radiation of frequency  $f_{nq}$  given by equation (4.8).

The series limit of the frequencies given by equation (4.8), with  $q \rightarrow \infty$ , is the same as the frequency given by equation (4.6). This may explain why the intensity of the series limit is not zero. For the Balmer series [5, 6, 7] the frequency limit,  $f_2 = cR/4 = 8.227 \times 10^5 \text{ GHz}$ , in the violet region (not visible), is present and measurable.

The  $n$ th orbit of the hydrogen atom, as well as the atom itself, could be considered as an “intelligent” configuration. Each orbit and the atom as a whole, if disturbed, “remembers” its previous condition or situation and returns to it, with an exhibition of energy. So, hydrogen atoms could combine and produce a manifestation of rudimentary consciousness.

## 4.5 References

- [1] E. Rutherford; “The Scattering of  $\alpha$  and  $\beta$  Particles by Matter and the Structure of the Atom”, *Phil. Mag.*, 21 (1911), 669.
- [2] M.D. Abdullahi; “A Nuclear Model of the Hydrogen Atom Outside Quantum Mechanics”, *This book* (2006), Paper 3.
- [3] Francis Bitter; *Mathematical Aspects of Physics*, Anchor Books, Doubleday & Co. Inc., New York (1963), pp. 5–23.
- [4] N. Bohr; (1913). [On the Constitution of Atoms and Molecules](#), *Phil. Mag.*, Series 6, Vol. 26 (1913), pp. 1-25..
- [5] C.R. Nave; HyperPhysics: [Hydrogen Spectrum](#). Georgia State University, (2006).
- [6] [http://en.wikipedia.org/wiki/Balmer\\_series](http://en.wikipedia.org/wiki/Balmer_series)
- [7] [http://en.wikipedia.org/wiki/Hydrogen\\_spectral\\_series](http://en.wikipedia.org/wiki/Hydrogen_spectral_series)