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One-Unit Diameter Hydrogen Atomic Model

*Khalid A Fattah**

Merowe Institute of Technology, Merowe University of Technology Court Street, Merowe City, Sudan

Abstract

A hydrogen atomic model of one-unit diameter enclosing reduced diameter orbits was suggested. Investigations of the hydrogen line and minimum quanta of Max Planck were carried. A formula relating the proposed model and Bohr model was derived. A corresponding diameter correlating the lower and upper energy states was determined and used to compute the spectral lines of hydrogen spectrum series. All the series are found to be confined between orbit 1 and orbit 12 of the proposed model.

Keywords

Bohr theory, Vacuum wavelength, Inner orbits, Energy quanta, Atomic unit length

Introduction

Hydrogen spectrum series represents broad spectral lines which have been investigated widely in literature McMahon [1]. Models formulated to study and investigate hydrogen spectrum are mainly based on Bohr theory. The change in energy between orbits constitutes the basis of the models mentioned in the literature. The process photon emission and absorption takes place, when electromagnetic radiative waves interact systems of quantum nature.

One unit diameter hydrogen atomic model [2] has been proposed and computation of the spectral lines from ultraviolet to infrared validated the model. A comparison of hydrogen spectrum series computation with other models in the literature was carried out. Moreover, 21.1 cm hydrogen line was investigated through the model in addition to, Planck's constant.

Materials and Methods

Hydrogen spectrum series

Atomic spectrum has been classified to a number of spectral series and described in Bohr theory of hydrogen atom and other models based on it. The observed spectral lines are caused by the electron transitions between energy levels.

Wavelength, *L*, is given by the Rydberg's formula, equation (1), when electron transits between energy level, ni and the energy level, n_f

$$1/L = R_H (1/n_i^2 - 1/n_f^2) \quad (1)$$

where R_H is Rydberg's constant = 1.09677 × 107 m^{-1}, The six well known spectrum series as usually mentioned in literature are shown in Table 1.

Hydrogen line 21.1 cm wavelength

This is the vacuum wavelength of 21.1 cm which has frequency of 1420.4 MHz. It is an electromagnetic radiation occurs due to change in energy state of hydrogen atom. It is well known in radio astronomy because it can penetrates dust clouds.

Planck's constant planck's

Constant (h = 6.626E-34 J. sec.) is an essential characteristic that formulates the mathematical quantum mechanics and describes the particles behaviour and waves in atomic radiation and light spectra. Radiated waves emitted or absorbed in discrete energy quanta, gives the significance of this constant.

One-Unit Diameter Model

The proposed model of hydrogen atom is based on:

I/ The outermost orbit of hydrogen atom has a diameter of one atomic unit length, (orbit 1 dia. = 1 a.u.l.)

II/ Inner orbits have diameters in terms of the reciprocal of the orbit number.

This means all inner orbits diameters are enclosed inside

***Corresponding author:** Khalid A Fattah, Merowe Institute of Technology, Merowe University of Technology Court Street, Merowe City, Sudan

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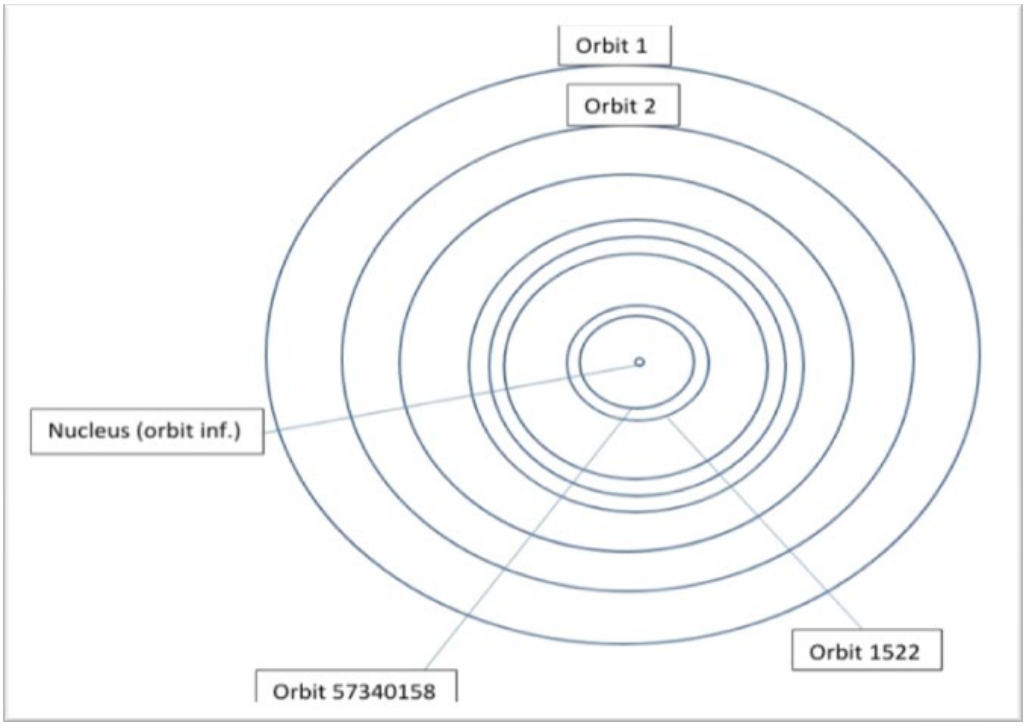

Figure 1: Hydrogen atomic model.

Table 1: Hydrogen spectrum series.

n_i	n_f	Series Name	Wavelengths (nm)	Frequency (1/ sec)
1	2 - ∞	Lyman	91.16-121.54	3.29E+15-2.47E+15
2	3 - ∞	Balmer	364.63-656.34	8.22E+14-4.57E+14
3	4 - ∞	Paschen	820.42-1875.24	3.65E+14-1.60E+14
4	5 - ∞	Brakkett	1458.52-4051.45	2.06E+14-7.40E+13
5	6 - ∞	Pfund	2278.94-7458.36	1.32E+14-4.02E+13
6	7 - ∞	Humphreys	3281.68-12369.40	9.14E+13-2.42E+13

Table 2: Geometric properties of proposed model.

Orbit №	Diameter (a.u.l.)	Orbit Area (sq. a.u.)	Spherical Surface Area (sq. a.u.)
1	1	0.785714	3.142857
2	1/2	0.196429	0.785714
3	1/3	0.087302	0.349206
4	1/4	0.049107	0.196429
5	1/5	0.031429	0.125714
6	1/6	0.021825	0.087302
7	1/7	0.016035	0.064140
10	1/10	0.007857	0.031429
20	1/20	0.001964	0.007857

a ½ atomic unit length diameter (orbit 2). Figure 1 represents the model showing important orbits.

Table 2 represents the geometric properties of orbits. In addition to the circular areas of orbits presented in the table, the spherical surface areas of orbits are also given in order to visualize 3D of the atom and to account for the energy of the radiated electromagnetic waves as mentioned in [2].

It worth mentioning that, the last inner orbit has a diameter equals to the reciprocal of infinity just adjacent to the nucleus, which means its diameter tends to zero. On

Table 3: Corresponding diameters to energy states differences.

n_i, n_f	2	3	4	5	6	7	∞
1	0.8660	0.9428	0.9682	0.9798	0.9860	0.9897	1.0000
2		0.3727	0.4330	0.4583	0.4714	0.4792	0.5000
3			0.2205	0.2667	0.2887	0.3012	0.3333
4				0.1500	0.1863	0.2052	0.2500
5					0.1106	0.1400	0.2000
6						0.0858	0.1667

Table 4: Computed hydrogen spectral lines.

Series Name	Wavelengths (nm)	Frequency (1/ sec)	Confined between orbits
Lyman	91.15-121.54	3.29E+15-2.47E+15	1-2
Balmer	364.61-656.29	8.22E+14-4.57E+14	2-3
Paschen	820.36-1875.12	3.65E+14-1.60E+14	3-5
Brakkett	1458.42-4051.18	2.06E+14-7.40E+13	4-7
Pfund	2278.79-7457.85	1.32E+14-4.02E+13	5-10
Humphreys	3281.45-12368.55	9.14E+13-2.42E+13	6-12

the other hand, Hydrogen atomic models in literature are in opposite formulation, where the nearest orbit to nucleus is orbit 1 and other orbits spread outwards.

Results and Discussion

Computational equations of one-unit diameter are presented in [2]. Hydrogen line, 21.1 cm wavelength, 1420.4 MHz frequency, is present at orbit 1522 in the proposed model where its diameter equals 1/1522 a.u.l.

Dadarao [3] mentioned for the Dark Photon and Max plank computation of minimum quanta of electromagnetic radiated energy of 4.136E-15 eV. This is equivalent to Plank's constant 6.626E-34 J. sec. According to the proposed model, orbit 57340158, Figure 1, satisfies this value as its frequency equal one Hz, one over one second, and wavelength 3.00E+8 m (speed of light).

The relationship between the parameters in the two approaches, Fattah [2] and equation (1), was investigated and a formula relates them was derived. In particular, a corresponding diameter was determined for each change in energy states between ni and nf. Equating wavelengths of both models, the corresponding diameter D_j is determined from the following equation;

$$D_j^2 = (1/n_i^2 - 1/n_f^2) \quad (2)$$

Table 3 represents the results of equation (2), indicating that all orbits in the hydrogen atom are enclosed in a 1-atomic unit diameter.

The wavelengths of the six series mentioned earlier were computed through the proposed model using D_j. Results are shown in Table 4.

In this model, it is clearly noticed that, all the six series are confined between orbit 1 and orbit 12 unlike to those mentioned in Table 1. Spectral lines have shown interference in infrared range. It is to be noticed also, the model computes continuous spectrum since radiation properties for any diameter between orbits can be calculated, as it is not based on energy differences as in Bohr model. More searches and investigations are needed to correlate the images of computations in both models, particularly, the large difference in ranges of the series.

Conclusion

A new approach was followed to study the spectrum of hydrogen atom. A model of one-unit diameter enclosing reduced diameter orbits was conducted to investigate the hydrogen line and minimum quanta of Max Planck. A formula relating the proposed model and Bohr model was derived. A diameter correlating the lower and upper energy states was determined and used to compute the spectral lines of hydrogen spectrum series. All the six series are found to be confined between orbit 1 and orbit 12. More investigations required to correlate the electron revolution frequency to the hydrogen spectrum frequencies.

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