Solar System Wave Function and its Achievements

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Abstract

Pluto, Ceres and all planets of solar system except Neptune, with a high approximation, follow a rule called Titius-Bode rule or Bode rule, which can by no means be considered as a stochastic event. This rule shows that the distance of the planets from the sun in Solar system is regulated. Here, we prove that the existence of a standing and cosine wave packet in solar system, with the wavelength $\lambda = 0.6\ AU$ (AU represents the distance of earth from the sun) and the phase constant $\emptyset_0 = \frac{\pi}{6}$, is the reason for Bode rule. Moreover, we prove that this huge wave packet belongs to the sun. In the following of the article, based on the solar system wave function, we will enter into the atomic field and arrive to a new atomic model that helps us to describe many phenomena such as the normal Zeeman effect.

Keywords: Solar system, Titius-Bode rule, Quantum mechanics, Atomic model, Schrodinger equation, Thought experiment, Normal Zeeman effect

1. Introduction

The planets of solar system move around the sun in elliptical orbits such that the sun is in one of the focal points of these ellipses. These ellipses are very close to the circle, and in fact the orbits of the planets of solar system are concentric circles. Pluto, Ceres and all planets of Solar system except Neptune, with a high approximation follow a rule known as Bode rule or Titius-Bode rule. According to this rule, the distance of each planet from the sun is equal to $a = 0.4\ AU + 0.3\ AU \times 2^n$, where $0.4\ AU$ is the distance of Mercury from the sun (or more precisely the length of the semi-major axis of Mercury's orbit) and $n = 0,1,2,3, \dots$ [1]. Table. 1 shows the high accuracy of the Bode rule. If this rule was only true for three or four planets, then we could call it a coincidence, but when it is true for seven planets, plus Ceres and Pluto, there is definitely a reason for it. It was historically based on this rule that Ceres was discovered in 1801 [1]. In this article, we will find the reason for the existence of the Bode rule. In fact, we will prove that the presence of a cosine and standing wave packet in solar system is the reason for existence of Bode rule; and moreover, we will prove that this wave packet belongs to the sun. In this article we prove that the Schrodinger equation is valid at the scale of the solar system and is not limited to subatomic particles. Bode rule does not predict the distance of Neptune from the sun but, this article is able to give us the distance of Neptune. In this paper and in the section "Elliptical orbits", we prove that each model for explain the formation of solar system without considering the solar system wave function is incomplete and wrong.

Next, using the model of solar system standing wave, we enter into the fundamental topics of quantum mechanics and arrive at an atomic model that has both the Schrodinger wave function and the Bohr atomic model inside. Our atomic model explains why the Bohr atomic orbits are

quantized (or In other words why the orbital angular momentum is quantized: $L = n\hbar$). Niels Bohr, neither in her famous article [2] nor in the years that followed, could not explain the reason for this event. The new atomic model predicts the existence of secondary lines in the hydrogen spectrum[1]. These are lines that neither the Bohr atomic model nor any other model has been able to explain [3][4][5][6]. Moreover, based on our new atomic model, we explain the reason of the normal Zeeman effect, etc.

Planet	T–B rule distance (AU)	Semi-major axis (AU)	Deviation from prediction
Mercury	0.4	0.39	−2.5%
Venus	0.7	0.72	+2.8%
Earth	1.0	1.00	0.00%
Mars	1.6	1.52	−4.77%
Ceres	2.8	2.77	−1.16%
Jupiter	5.2	5.20	+0.00%
Saturn	10.0	9.58	−4.45%
Uranus	19.6	19.20	−1.95%
Pluto	38.8	39.48	+1.05%

Table. 1. Planets distances from the sun and the prediction of Bode rule. Bode rule cannot predict the distance of Neptune from the sun.

2. Wave Function and Bode Rule

Consider a standing and cosine wave function with a wavelength $\lambda = 0.6\ AU$ in solar system; if we assume that the first node of this wave is at a distance of $0.1\ AU$ from the sun the next nodes are at the distances of $0.4\ AU$, $0.7\ AU$, $1\ AU$, $1.3\ AU$, $1.6\ AU$, ... $2.8\ AU$, … from the sun. Each node is $0.3\ AU$ ahead of the previous node. If we consider the planets of solar system in the position of the nodes of this wave, in such a case, there is no planet on the first node ($0.1\ AU$) and Mercury is on the second node, Venus is on the third node, earth is on the fourth node, Mars is on the sixth node, and the position of fifth node ($1.3\ AU$) is empty. The seventh, eighth, and ninth nodes are empty, and Ceres is on the tenth node. Jupiter is placed on the eighteenth node and Saturn is on the thirty-third node, and Uranus, Neptune, and Pluto are on the nodes farther from the sun. As you can see, a wave function, with the wavelength $\lambda = 0.6\ AU$, easily predicts the position of the planets and it seems that a huge and standing wave plays a role in determining the position of the planets in solar system. Therefore, we can consider the reason for the Bode rule to be the existence of a large cosine wave in solar system that oscillates along the axis perpendicular to the plane of solar system. we call this wave "Solar system wave function". In this article, we will obtain the equation of this wave function. But what does this wave belong to? we answer this question in this article. The presence of a huge cosine wave in solar system seems strange at first sight, but

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[1] Two series of lines appear in the spectrum of the hydrogen lamps. One series are the Ballmer, Lyman, Paschen, ... series. And the other lines called the secondary spectrum, which their number is very numerous and does not follow Rydberg equation: $\frac{1}{\lambda} = R\left(\frac{1}{n_{low}^2} - \frac{1}{n_{up}^2}\right)$. Of course, this secondary spectrum is now known as the molecular spectrum, which this issue is based on Merton's article [3]. In this article, we show that this is wrong and only a part of the secondary spectrum lines is relevant to the hydrogen molecule.

64 quantum mechanics eradicates our surprise. Based on quantum mechanics, a wave packet can be
65 assigned to each object which called the "associated wave" of that object, and this associated wave
66 is the solution of the Schrodinger equation. In this article, we prove that the above standing and
67 cosine wave function (Solar system wave function) is in the form of a solution of the Schrodinger
68 equation and therefore, based on quantum mechanics, this wave must belong to an object in Solar
69 system; we demonstrate that this object is the sun (We are aware that today Quantum mechanics,
70 the Schrodinger equation, and the de Broglie wavelength relation only use for subatomic scale and
71 subatomic objects. But, in this article, we prove that quantum mechanics is also valid in
72 astronomical scale and we will obtain the shape of Schrodinger equation and de Broglie
73 wavelength relation in astronomical scale).

74 ## 3. Wave Function of Solar System

75 As mentioned, a cosine and standing wave function, with the wavelength $\lambda = 0.6\ AU$ ($k = \frac{2\pi}{\lambda} =$
76 $\frac{10\pi}{3}$), can predict the position of the planets in solar system. First we want to derive the phase
77 constant ($\emptyset_0$) of this wave function. Any wave in which the variables x and t are entered as a
78 combination of $kx \pm wt$ is a traveling wave [7]. For example, $sin(kx - wt + \emptyset_0)$ is a traveling
79 wave. Thus, a standing wave is in the form of $cos(wt)\,cos(kx + \emptyset_0)$ or $sin(wt)\,cos(kx + \emptyset_0)$
80 or $sin(wt)\,sin(kx + \emptyset_0)$ or $cos(wt)\,sin(kx + \emptyset_0)$. As mentioned, a cosine standing wave can
81 predict the positions of planets. Therefore, the form of the standing wave of solar system must be
82 either $sin(wt)\,cos(kx + \emptyset_0)$ or $cos(wt)\,cos(kx + \emptyset_0)$ (In the following, we choose one of these
83 two forms). For the nodes of these two standing waves we have $cos(kx + \emptyset_0) = 0$. As mentioned
84 previously, Mercury is on the second node of Solar system wave function (the second node
85 corresponds to the phase $\frac{3\pi}{2}$ because $Cos\ \frac{3\pi}{2} = 0$). We have:

86 $$x_{Mercury} = 0.4\ AU \Rightarrow \psi(x_{Mercury}) = 0 \Rightarrow Cos(kx_M + \emptyset_0) = 0 \Rightarrow kx_M + \emptyset_0 = \frac{3\pi}{2} \xRightarrow{k = \frac{10\pi}{3}} \emptyset_0 = \frac{\pi}{6}$$

87 Having k and $\emptyset_0$, we can easily find the position of the other planets using the equation
88 $kx + \emptyset_0 = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \dots, \frac{(2m-1)\pi}{2}$ (Where m is the node number). For example

90 $$kx_{Venus} + \emptyset_0 = \frac{5\pi}{2} \Longrightarrow \frac{10\pi}{3}x_{Venus} + \frac{\pi}{6} = \frac{5\pi}{2} \Longrightarrow x_{Venus} = 0.7\ AU$$

89 or

91 $$kx_{Earth} + \emptyset_0 = \frac{7\pi}{2} \Longrightarrow \frac{10\pi}{3}x_{Earth} + \frac{\pi}{6} = \frac{7\pi}{2} \Longrightarrow x_{Earth} = 1\ AU$$

92 $$kx_{Mars} + \emptyset_0 = \frac{11\pi}{2} \Longrightarrow \frac{10\pi}{3}x_{Mars} + \frac{\pi}{6} = \frac{11\pi}{2} \Longrightarrow x_{Mars} = 1.6$$

93 The distances of the other planets can also be calculated in the same way, which is quite consistent
94 with experience. According to the above equation ($kx + \emptyset_0 = \frac{(2m-1)\pi}{2}$), Neptune is on the ninety-
95 eighth node, which corresponds to the phase $\frac{195\pi}{2}$. Contrary to the Bode rule, which is not able to

3

96   predict the distance of Neptune, our wave theory predicts the position of Neptune. Therefore, a

97   cosine and standing wave function with $\emptyset_0 = \frac{\pi}{6}$ and $k = \frac{10\pi}{3}$ can be attributed to solar system. But

98   what is the general equation of this wave function? As mentioned, the function of solar system

99   must contain a component with the equation $cos(\frac{10\pi}{3}x + \frac{\pi}{6})$ and on the other hand, this wave must

100   be standing so that the position of the nodes (planets) does not change. Therefore, as mentioned,

101   the form of solar system wave function must be either $cos(\delta wt)\,cos(\frac{10\pi}{3}x + \frac{\pi}{6})$ or

102    $sin(\delta wt)\,cos(\frac{10\pi}{3}x + \frac{\pi}{6})$. There is no difference between $cos(\delta wt)$ and $sin(\delta wt)$ Because we

103   know from trigonometric identities that: $cos(\delta wt) = sin\left(\delta wt + \frac{\pi}{2}\right)$. Therefore, we choose the

104   function $cos(\delta wt)\,cos(\frac{10\pi}{3}x + \frac{\pi}{6})$ and then we will show that our choice is correct (δ is a constant

105   number that we will derive its value). Since solar system has a certain size and is not infinitely

106   wide, its wave function must be localized (a wave packet). If we consider an expression in the

107   form $e^{-\gamma x^2}$ (which is a Gaussian function and plays the role of a wave envelope) in the final

108   function of solar system, in such a case, the final equation is a localized wave or a wave packet[2].

109   The value of γ, which is a positive number, will be obtained in the following. Thus, the primary

110   form of the wave function of solar system is as follows (equation 1) and the planets are on the

111   nodes of this wave function (Fig. 1):

112
$$
\begin{cases}
\psi(x,t) = C\,cos(\delta wt)\,cos(\dfrac{10\pi}{3}x + \dfrac{\pi}{6})\ e^{-\gamma x^2} & x \geq 0 \\[2mm]
\psi(x,t) = C\,cos(\delta wt)\,cos(\dfrac{10\pi}{3}x - \dfrac{\pi}{6})\ e^{-\gamma x^2} & x \leq 0
\end{cases}
\tag{1}
$$

113   In equation 1, γ, C and δ are constant values and we obtain their values in this article. This is an

114   empirical equation which we will obtain it from mathematic methods in the next section.

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[2] Although a Gaussian wave packet is also infinitely wide, but it is very localized.
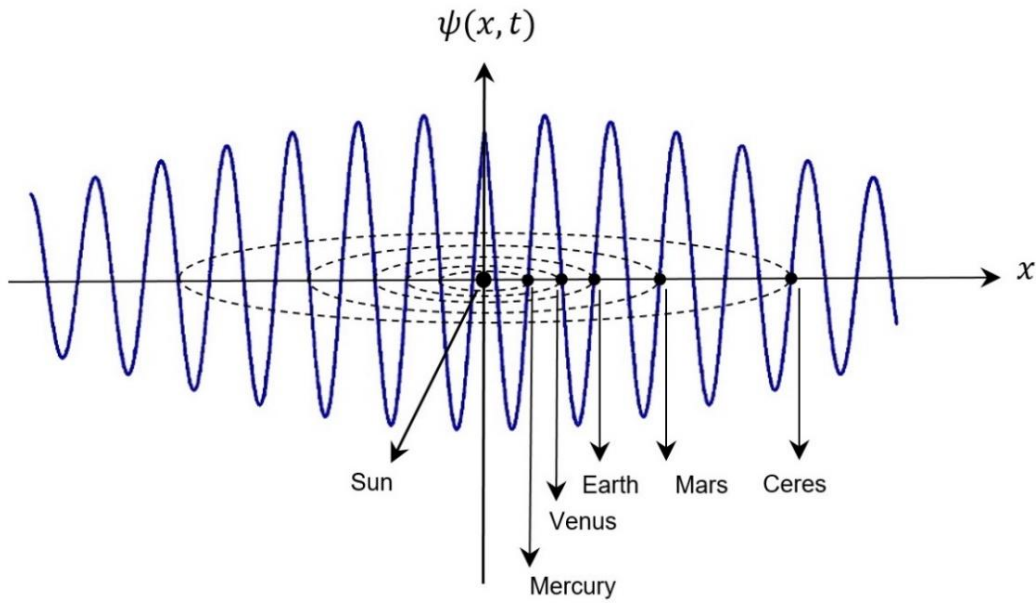
Fig. 1. Solar system standing wave packet with λ = 0.6 *AU* and $\emptyset_0 = \frac{\pi}{6}$. Diagram of $\psi(x,t)$ at the moment t = 0. The value of $\psi(0,0)$ equals $\sqrt{3}C/2$. This diagram is drawn by a certain value of C, δ and γ in equation 1, which we will obtain their value in this article. As you can see, the planets are on the nodes of the wave function. Jupiter, Saturn, Uranus, Neptune, and Pluto are on the nodes farther from the sun. The reason why there is no planet in some nodes will explained in the section 7: "elliptical orbits". This is due to the unbalanced mass distribution in the protoplanetary disk of solar system.

In figure 1, the wave oscillates along the ψ axis over time. But the nodes and the anti-nodes do not move relative to each other along the x-axis. This does not mean that the wave packet is stationary in the space; it is just like passengers sitting on a train who do not move relative to each other but the train is moving relative to the rails. In the same way, solar system wave packet (equation 1) is a standing wave that rotates, along with solar system, around the center of the galaxy.

As you observed, function 1 could easily predicts the position of planets. In the continuation of the article, we will prove that this function is in the form of the real part of a solution of the Schrodinger equation (As you know, the solutions of the Schrodinger equation have two parts: Real and Imaginary) and that's why we can assign it to an object like the sun.

There can be no doubt about the existence of a standing wave in the solar system. Is it possible to matching of Titius-Bode rule and the wave in figure 1, be accidentally? In the section "elliptical orbits" we will show that how we can arrive to the Bode rule from the protoplanetary disk, by oscillation of solar system wave function.

4. Single-Frequency Wave Packet

We obtained the equation of a single-frequency wave packet in the previous section, empirically (equation 1). But, a thought experiment [20] arrives us to this conclusion that a single-frequency

138 wave packet cannot be existed. This thought experiment investigates the beat between two single-
139 frequency waves. In this thought experiment, it is proved that only a wave with infinite spreading
140 can be single-frequency. This means that a wave packet, which is localized, cannot be single
141 frequency. This experiment apparently has a logical and unambiguous face. but there is a very
142 important problem about thought experiments. A thought experiment, even if based on a logical
143 process, may lead to wrong results. We prove this with an example. A well-known example is the
144 famous experiment of Michelson and Morley about the velocity of light [21]. If you do the
145 Michelson and Morley experiment in your mind[3], you will conclude that the velocity of light
146 depends on the velocity of observer and source. This was something that Michelson and Morley
147 also expected. But when their experiments were performed in the real world, they concluded that
148 the velocity of light is independent of the velocity of observer and source. This example shows
149 that we cannot comment on the results of an experiment until it is not performed in the real world.
150 This example fully proves that a thought experiment is meaningless because you cannot rely on its
151 results and its results may be wrong. Obviously, this rule (Unreliability of the results of a thought
152 experiment) also is true for the mentioned beat thought experiment. And therefore we cannot
153 comment on the results of the beat experiment until it is performed. Which it means that we cannot
154 comment on the existence or nonexistence of single-frequency wave packet. In addition, attention
155 to the empirical equation 1 we have a single-frequency wave packet and therefore the beat thought
156 experiment is contrary to observation and so is wrong.

157 In the next section, we will obtain equation 1 mathematically and we will show that the equation
158 1 is the real part of the solution of the Schrodinger equation.

5. Associated Wave Packet of Sun

160 In this section we will show that the equation 1 is the real part of the solution of the Schrodinger
161 equation. Base of calculations in this section is superposition principle. Consider a set of infinite
162 number of flat matter waves $Ae^{i(kx-wt+\emptyset_0)}$, $Ae^{i(kx+wt+\emptyset_0)}$, $Ae^{i(kx-wt-\emptyset_0)}$ and
163 $Ae^{i(kx+wt-\emptyset_0)}$ which move in the positive and negative directions of the x-axis; and assume that
164 all of these waves are under the effect of potential $V(x)$. These four groups of waves are all of
165 possible form of flat matter waves. In such a case the angular frequency (w) of each of these matter
166 waves is equal:

$$w = \frac{E}{\hbar} = \frac{1}{\hbar}(\frac{P^2}{2m} + V(x))$$

168 Because, based on De Broglie theory, the energy of a matter wave is equal to the energy of
169 associated particle of the wave i.e. E$=\frac{P^2}{2m} + V(x)$. As you know these four groups of waves with
170 general equation $Ae^{i(kx\pm wt\pm\emptyset_0)}$ are the solution of the Schrodinger equation namely

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[3] In fact, all experiments are initially a thought experiment. Some of them remain a thought experiment due to the human inability to perform the experiment in the real world, and some become real physical experiment.

$$171 \qquad i\hbar\frac{\partial}{\partial t}\psi(x,t) = -\frac{\hbar^2}{2m}\frac{\partial^2\psi(x,t)}{\partial x^2} + V(x)\psi(x,t)$$

172   These waves sum together in space based on superposition principle. From these infinite
173   number of waves we will show that the superposition of a part of these waves, which their
174   angular frequency equals w_0 and their wave number is around the median of k_0 and
175   between $k_0 + \frac{\Delta k}{2}$ and $k_0 - \frac{\Delta k}{2}$ and the amplitude changes of these waves is equal to
176    $A(k) = (\frac{2\alpha}{\pi})^{1/4}e^{-\alpha(k-k_0)^2}$ (which is a Gaussian function[4]), is in the form of equation 1.

177   Consider a set of infinite number of matter waves $Ae^{i(kx-wt+\emptyset_0)}$ which move in the positive
178   direction of x-axis and their angular frequency equals w_0 and their wave number is around the
179   median of k_0 and between $k_0 + \frac{\Delta k}{2}$ and $k_0 - \frac{\Delta k}{2}$ and the amplitude changes of these waves
180   is equal to $A(k) = (\frac{2\alpha}{\pi})^{1/4}e^{-\alpha(k-k_0)^2}$. In such a case, the resultant of these waves, using the
181   superposition principle, is a wave packet with equation 2 [8][9][10].

$$182 \qquad \psi_{total}(x,t) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} A(k)e^{i(kx-w_0t+\emptyset_0)}dk \qquad (2)$$

183   Where k means k_x. In equation $A(k) = (\frac{2\alpha}{\pi})^{1/4}e^{-\alpha(k-k_0)^2}$, α is a constant with a positive value
184   and shows the width of the bell-shaped function $A(k)$. $(\frac{2\alpha}{\pi})^{1/4}$ is a normalization coefficient which
185   is obtained by normalize of $A(k)$. Since equation 2 is derived from the superposition principle, it
186   is the solution of the Schrodinger equation [10].

187   To obtain $\psi_{total}(x,t)$ from equation 2, we calculate the superposition of all of the waves in one
188   moment, which we consider to be the origin of time ($t = 0$), and then we can obtain the net wave
189   at any other time. We have:

$$190 \qquad \psi(x,0) = \frac{1}{\sqrt{2\pi}}\int A(k)e^{i(kx+\emptyset_0)}dk \qquad (3)$$

191   The above equation is the momentary image of the net wave. Multiply equation 3 by $e^{ik_0x-ik_0x}$.
192   We have:

$$193 \qquad \psi(x,0) = \frac{1}{\sqrt{2\pi}}e^{i(k_0x+\emptyset_0)}\int A(k)e^{i(k-k_0)x}dk \qquad (4)$$

194   Considering $\acute{k} = k - k_0$, we have:

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[4] In the Electromagnetic (EM) waves we cannot consider one w_0 for two or many waves in which their k is different
from each other, because for all of the EM waves we have: $w = ck$ where c is the velocity of light. But for matter
waves the issue is different. In the matter waves we have $w = \frac{\hbar k^2}{2m}$ [10]. As you can see w is the function of k and m.
Therefore, it is possible to choose one value of w_0 for the waves in which their k is different from each other.

$$195 \qquad \psi(x, 0) = (\frac{\alpha}{2\pi^3})^{1/4} e^{i(k_0 x + \emptyset_0)} \int e^{-\alpha \acute{k}^2} e^{i\acute{k}x} d\acute{k} \qquad (5)$$

196 Using the variable transformation $\acute{k} - \frac{ix}{2\alpha} = q$ [8][9] and the Gaussian integral

197 $\int_{-\infty}^{\infty} dq\, e^{-\alpha q^2} = \sqrt{\frac{\pi}{\alpha}}$, equation 5 can be calculated. After replacement and simplification, we reach

198 the following final solution [8][9]:

$$199 \qquad \psi(x, 0) = (\frac{\alpha}{2\pi^3})^{1/4} \sqrt{\frac{\pi}{\alpha}}\, e^{i(k_0 x + \emptyset_0)}\, e^{-\frac{x^2}{4\alpha}} = (\frac{1}{2\pi\alpha})^{1/4} e^{i(k_0 x + \emptyset_0)}\, e^{-\frac{x^2}{4\alpha}} \qquad (6)$$

200 Lets check the normalization

$$201 \qquad \int_{-\infty}^{\infty} |\psi(x)|^2\, dx = \sqrt{\frac{1}{2\pi\alpha}} \int_{-\infty}^{\infty} e^{-\frac{x^2}{2\alpha}}\, dx = \sqrt{\frac{1}{2\pi\alpha}} \sqrt{2\alpha\pi} = 1$$

202 Given a normalized $A(k)$, we get the normalized $\psi(x)$.

203 Now, how is the time variation of equation 6? Let's go back to equation 2:

$$204 \qquad \psi(x, t) = \frac{1}{\sqrt{2\pi}} \int A(k) e^{i(kx - w_0 t + \emptyset_0)} dk = (\frac{\alpha}{2\pi^3})^{1/4} \int e^{-\alpha(k - k_0)^2} e^{i(kx - w_0 t + \emptyset_0)} dk$$

205 Substituting $e^{ik_0 x - ik_0 x}$ in the equation:

$$206 \qquad \psi(x, t) = (\frac{\alpha}{2\pi^3})^{1/4} e^{i(k_0 x + \emptyset_0) - iw_0 t} \int e^{-\alpha \acute{k}^2} e^{i\acute{k}x} d\acute{k}$$

207 This integral is similar to integral 5, which led to $\psi(x, 0)$ (Equation 6). Therefore, we have:

$$208 \qquad \psi(x, t) = \psi_1(x, t) = (\frac{1}{2\pi\alpha})^{1/4}\, e^{i(k_0 x - w_0 t + \emptyset_0)}\, e^{-\frac{x^2}{4\alpha}} \qquad (7)$$

$$209 \qquad e^{i\theta} = cos\theta + isin\theta \implies Re\, \psi_1(x, t) = (\frac{1}{2\pi\alpha})^{1/4} cos(k_0 x - w_0 t + \emptyset_0)\, e^{-\frac{x^2}{4\alpha}} \qquad (8)$$

210 Due to the presence of the factor $k_0 x - w_0 t$, equations 7 and 8 represent a traveling wave packet
211 that propagates in the positive direction of the x-axis [7]. This means that the location of the nodes
212 is not known. Due to the absence of t in $e^{-\frac{x^2}{4\alpha}}$ in equations 7 and 8, the wave packets in these
213 equations does not spread.

214 Previous calculations was about superposition of the waves $e^{i(kx - w_0 t + \emptyset_0)}$. Similarly, we use the
215 recent trend to obtain the superposition of flat waves traveling in the negative direction of
216 the x-axis, i.e. $Ae^{i(kx + w_0 t + \emptyset_0)}$. If we do this, we get to equation 9:

$$217 \qquad \psi_2(x, t) = (\frac{1}{2\pi\alpha})^{1/4}\, e^{i(k_0 x + w_0 t + \emptyset_0)}\, e^{-\frac{x^2}{4\alpha}} \qquad (9)$$

8

218
$$Re\,\psi_2(x,t) = (\frac{1}{2\pi\alpha})^{1/4}\cos(k_0 x + w_0 t + \emptyset_0)\,e^{-\frac{x^2}{4\alpha}} \tag{10}$$

219 This equation shows a traveling wave packet that propagates in the negative direction of
220 the x-axis.

221 Now we sum up the two equations 10 and 8 together to get the final wave.

222
$$Re\,\psi_{total}(x,t) = Re\,\psi_1 + Re\,\psi_2$$

223 Thus:

224
$$Re\,\psi_{total}(x,t) = (\frac{1}{2\pi\alpha})^{1/4}\,e^{-\frac{x^2}{4\alpha}}[\cos(k_0 x - w_0 t + \emptyset_0) + \cos(k_0 x + w_0 t + \emptyset_0)] \tag{11}$$

225 Using $cos\alpha + cos\beta = 2cos\frac{1}{2}(\alpha + \beta)cos\frac{1}{2}(\alpha - \beta)$ and $\cos(\theta) = \cos(-\theta)$ we obtain the
226 equation of a standing wave packet.

227
$$\begin{cases}\alpha = k_0 x - w_0 t + \emptyset_0 \\ \beta = k_0 x + w_0 t + \emptyset_0\end{cases} \Rightarrow Re\,\psi_{total}(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\cos(k_0 x + \emptyset_0)\cos(w_0 t)e^{-\frac{x^2}{4\alpha}} \tag{12}$$

228 There is not the structure of $kx \pm wt$ in equation 12 so the ψ_{total} is a standing wave. As you
229 observe, equation 12, which is the real part of a solution of the Schrodinger equation, is exactly
230 the same as equation 1 for $x \geq 0$, which is solar system wave function. It means that equation 1 is
231 the real part of a solution of the Schrodinger equation. It means that the Schrodinger equation and
232 quantum mechanics are valid in astronomical scale. By comparing equation 12 and equation 1, we
233 have

234
$$\delta = 1 \;,\; \gamma = \frac{1}{4\alpha} \quad and \quad C = 2(\frac{1}{2\pi\alpha})^{1/4}$$

235 If we put these values in equation 1, then we get the final equation of solar system wave function
236 for $x \geq 0$:

237
$$Re\,\psi_t(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\cos(w_0 t)\cos(\frac{10\pi}{3}x + \frac{\pi}{6})\,e^{-\frac{x^2}{4\alpha}} \qquad x \geq 0 \tag{13}$$

238 Equation 13 is obtained by calculating the superposition of a set of infinite number of waves
239 $Ae^{i(kx-w_0 t+\emptyset_0)}$ and $Ae^{i(kx+w_0 t+\emptyset_0)}$ that move in opposite directions to each other (pay attention
240 to the + sign behind $\emptyset_0$). Now if we sum a set of infinite number of flat wave functions with the
241 equations $Ae^{i(kx-w_0 t-\emptyset_0)}$ and $Ae^{i(kx+w_0 t-\emptyset_0)}$ (pay attention to the $-$ sign behind $\emptyset_0$) together, by
242 following the path we have taken from equation 2 to equation 13, we reach the following relation;

243
$$Re\,\psi_t(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\cos(w_0 t)\cos(\frac{10\pi}{3}x - \frac{\pi}{6})\,e^{-\frac{x^2}{4\alpha}}$$

244 Which is the same as equation 1 for $x \leq 0$. Therefore, the final form of solar system wave function
245 (equation 1) is as follows:

$$\begin{cases} Re\ \psi(x,t) = 2(\dfrac{1}{2\pi\alpha})^{1/4} cos(w_0 t)\, cos(\dfrac{10\pi}{3}x + \dfrac{\pi}{6})\ e^{-\frac{x^2}{4\alpha}} & x \geq 0 \\[2ex] Re\ \psi(x,t) = 2(\dfrac{1}{2\pi\alpha})^{1/4} cos(w_0 t)\, cos(\dfrac{10\pi}{3}x - \dfrac{\pi}{6})\ e^{-\frac{x^2}{4\alpha}} & x \leq 0 \end{cases} \tag{14}$$

246

247 In this equation, the larger the α is, the more the width of wave packet, along the x-axis. We drew
248 Fig. 1 by $\alpha = 10$. In this section we did not do anything strange. Rather, we have used only the
249 superposition principle. We calculated the superposition of infinite number of flat matter waves
250 with general equation $e^{i(kx \pm wt \pm \phi_0)}$ which their angular frequency equals w_0 and the wave number
251 of these waves is around the median of k_0 and between $k_0 + \Delta k/2$ and $k_0 - \Delta k/2$ and the
252 amplitude changes of these waves is equal to $A(k) = (\frac{2\alpha}{\pi})^{1/4}e^{-\alpha(k-k_0)^2}$ and they are under the
253 effect of potential $V(x)$[5]. There have been infinite number of flat matter waves in newborn solar
254 system which the superposition of a set of them made the wave function in figure 1. We will talk
255 more about this in the section "Elliptical Orbits".

256 Here we demonstrated that solar system wave function (equation 1) is the real part of a solution of
257 the Schrodinger equation. So, based on quantum mechanics, we can assign it to an object in Solar
258 system. The closest star to solar system is at a distance of 4.8 light-years, which is so far. And the
259 biggest and heavyset object in solar system is sun. Therefore, the wave function of solar system
260 can only belong to the sun. In the section " Elliptical orbits ", we will discuss more about the
261 formation of the solar system wave packet. De Broglie considered the wave nature for subatomic
262 particles, and here we attributed the wave nature to celestial objects. Neither of these two actions
263 is strange. Rather, they are truths that we must become accustomed to.

264 In this article, we proved that the Schrodinger equation is valid in astronomical scale; on the other
265 hand, as you know, the Schrodinger relation is based on de Broglie equation ($\lambda = \frac{h}{mv}$). Therefore,
266 the de Broglie equation is valid in astronomical scale[6]. But, according to the very large mass of
267 sun, using the de Broglie relation the wavelength 0.6 AU will not obtain. So, instead of Planck
268 constant we must choose another value for celestial objects, which is larger than h. We call
269 this new value the Planck constant in Astronomy ($h_{Astronomy}$) abbreviated as h_A and we
270 have: $\lambda_A = \frac{h_A}{P}$. In such a case, the Schrodinger equation in the astronomical scale can be written
271 as follows:

$$i\hbar_A \frac{\partial}{\partial t}\psi(x,t) = -\frac{\hbar_A^2}{2m}\frac{\partial^2 \psi(x,t)}{\partial x^2} + V(x)\psi(x,t) \tag{15}$$

272

273 If we follow the path of proving the Schrodinger equation [11] and put the value $\hbar_A$ instead of $\hbar$,
274 we reach equation 15. The Davisson–Germer experiment [12] is considered as the confirmation of

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[5] Since the solar system is under effect of gravity of Milky Way galaxy center; therefore here we investigated the superposition of matter waves which they are under the effect of potential.

[6] The Davisson–Germer experiment [12] is the confirmation of the existence of the de Broglie wave in subatomic scale and the regularity of the distances of the planets from sun (Titius-Bode rule) is the confirmation of the existence of the de Broglie wave in astronomical scale

275 existence of the de Broglie wave at the atomic scale, and the regularity of the distances of the
276 planets from sun (Titius-Bode rule) is the confirmation of the existence of the de Broglie wave in
277 astronomical scale. Moreover, for the celestial wave packet we will have $w = \frac{\hbar_A k^2}{2m}$.

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290 ## 6. What is Waving?

291 As you know, since the solution of the Schrodinger equation is a complex function; It is
292 meaningless to talk about what is waving [13][14]. But in this section we will show that the real
293 part of the solution of the Schrodinger equation is the oscillation of Dark matter.

294 In this article, we showed that a standing wave oscillation had been effective in the formation of
295 orbits of solar system planets and created the Bode rule. On the other hand, we know that the Dark
296 matter interacts with the matters and affects them. Therefore, it can be concluded that the standing
297 wave oscillation in Fig. 1, with the equation 1, is the oscillation of Dark matter (Fig. 2). On the
298 other hand, the equation 1 is the real part of a solution of the Schrodinger equation. Therefore, the
299 real part of the solution of the Schrodinger equation is the oscillation of Dark matter. Of course,
300 the Spacetime also interacts with matter and affects it. But we cannot consider the oscillation of
301 Spacetime as the wave of the solar system. Because in such a case the curvature of Spacetime lines
302 in figure 2 causes the planets to move along the r-axis. On the other hand, there is another
303 possibility. This wave may not be dark matter. Rather, it might be something we are not familiar
304 with.

305 As you will see in the next section, the oscillation of dark matter collected the gas and dust particles
306 of Protoplanetary disk, in certain orbits around the newborn sun and then gradually due to collision
307 and gravitational attraction between the dusts and gas particles, the Planetesimals, Protoplanets
308 and finally the planets in the orbits were formed.

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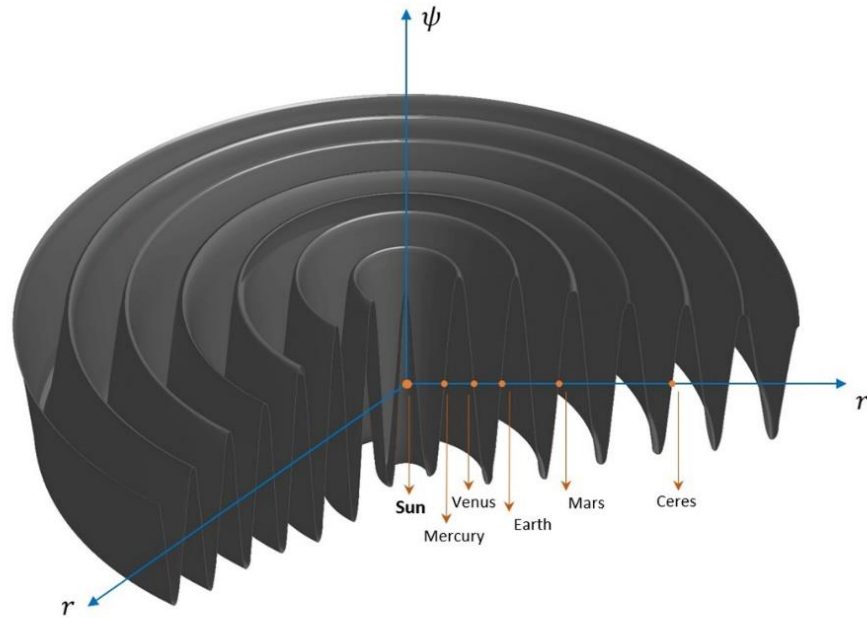
Fig. 2. The oscillation of Dark matter in the solar system. Here The wave function in Figure 1 is shown in three dimensions. Obviously, this wave function continues indefinitely, based on equation 1 (or equation 14). Because of existence the exponential factor in equation 1, the amplitude of the wave gradually decreases while we move away from the ψ-axis. Fig 2 is drawn in cylindrical coordinates using equation 14.

The equation 14 in cylindrical coordinate:

$$x = r\cos\theta \Rightarrow Re\,\psi(r,\theta,t) = 2(\frac{1}{2\pi\alpha})^{1/4} cos(w_0 t)\, cos(\frac{10\pi}{3}r\cos\theta + \frac{\pi}{6})\, e^{-\frac{(r\cos\theta)^2}{4\alpha}} \qquad (14-a)$$

7. Elliptical orbits

As you can see in Fig. 1 and Fig. 2, because of symmetry of equation 1, the orbits, created by the solar system wave function, are circle. But the real orbits of the planets are elliptic. The reason for this is the existence of the inverse_square gravitational force of the sun[7]. As you know, the sun formed earlier than the planets [15][16][17]. Simultaneously with the formation of the sun, about 4.6 billion years ago [16], its wave function was also formed[8], and the oscillation of this wave function arranged and collected the gas and dust particles of the Protoplanetary disk in regular orbits (Titius-Bode orbit). Just like the standing wave patterns on the kettledrum head (Fig. 3) As you can observe in Fig.3, by a mechanical oscillator at the upper left of the photograph, the powder collects at the nodes [18]. Over time, and because of oscillation of dark matter, in some nodes of the Solar system wave function the dust grains agglomerated and then compressed due to collisions

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[7] We know from classical mechanics that the elliptic orbits of the planets (Kepler's first law) are the result of Newton's law of gravitation, which is an inverse_square relation

[8] The wave function of the solar system probably was formed either when the sun was a protostar or when the newborn sun was on the Main-sequence. The distance between these two phases is very short (less than 50 million years) [15] and both phases occurred before the formation of the planets. In both states, we have no idea how or why this wave function formed.

327 with each other and formed larger grains, Planetesimals, Protoplanets and finally planets[9]. At the
328 same time, the inverse_square force of the sun was at work, and changed the circular orbits to
329 elliptical orbits.

330 If solar system wave function did not exist; The planets had been orbited around the sun in elliptical
331 orbits but the distance of planets from the sun was random and irregular. Without solar system
332 wave packet, it is not possible to reach to the Titius-Bode law from the molecular nebula and the
333 protoplanetary disk. Thus, the existence of a standing wave in the solar system is undeniable.


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335
336 **Fig. 3. Standing wave pattern on a kettledrum head.** One of many possible standing wave patterns on a kettledrum
337 head, made visible by dark powder sprinkled on the drumhead. As the head is set into oscillation at a single frequency
338 by a mechanical oscillator at the upper left of the photograph, the powder collects at the nodes. By the same way, due
339 to the oscillation of the solar system wave function the dust grains and gas of the solar system protoplanetary disk
340 were grouped in certain orbits.

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343

8-1. The new Atomic model

345 In this section, we present a new atomic model based on the model of the solar system wave
346 function namely Fig. 2. Our atomic model explains why the Bohr atomic orbits are quantized.
347 Niels Bohr could not explain this issue. Based on this model, the main spectrum of the hydrogen
348 atom, the secondary spectrum, the normal Zeeman effect, and the other phenomena will be
349 explained in a completely understandable way. Some of the atomic models are shown in Fig. 4.

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[9] Since the mass distribution in the Protoplanetary disk had not been uniform. During formation of the planets, in
some nodes of the solar system wave function, less dusts were collected and in some nodes, more dusts were placed
next to each other. Therefore, in some nodes a planet had been formed and in others it had not been formed.

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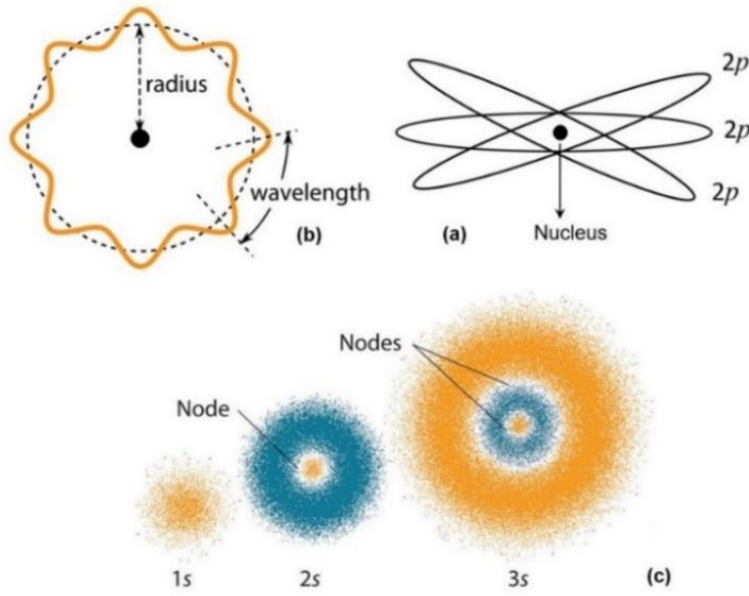
Fig. 4. Some of the atomic model. This figure shows three atomic models: **a).** Bohr-Sommerfeld atomic model: In this model, as you can see, subshells have space orientation. In this model, the horizontal $2P$ subshell is in the same plane as the $1S$ and $2S$ subshells. $1S$ and $2S$ subshells are not shown in this figure. **b).** De Broglie atomic model and **c).** the Schrodinger atomic model. In this figure Schrodinger's S orbitals are shown. According to Max Born probability theory, the electron can be found in the distance between the nodes in the Fig. 4c. Other atomic models, such as the Rutherford or Thomson atomic models, are not shown in this figure.

Figure. 5 shows our atomic model, which we call the "New Atomic Model". To arrive to figure. 5, we used the same method as at the beginning of this article. The Bohr atomic model is a successful model which its orbits are at $x_1 = 0.53\text{Å}$, $x_2 = 4x_1$, $x_3 = 9x_1$, etc. In order to be able to assign a standing wave to Bohr model, our wavelength must be equal to $2x_1 = 1.06$ Å. Suppose the first orbit of the new atomic model is the first orbit in the Bohr atomic model, namely $x_1 = 0.53$ Å. The first orbit in our model is equivalent to the first node and the first node means $\emptyset = \frac{\pi}{2}$ because $Cos\ \frac{\pi}{2} = 0$. In such a case we have:

$$x_1 = 0.53 \text{ Å} \Rightarrow \psi(x_1) = 0 \Rightarrow cos(kx_1 + \emptyset_0) = 0 \Rightarrow kx_1 + \emptyset_0 = \frac{\pi}{2} \xRightarrow{k=\frac{2\pi}{1.06}} \emptyset_0 = -\frac{\pi}{2}$$

In the same way as the reasonings at the section 3, the final form of "hydrogen atom wave function" is equal to:
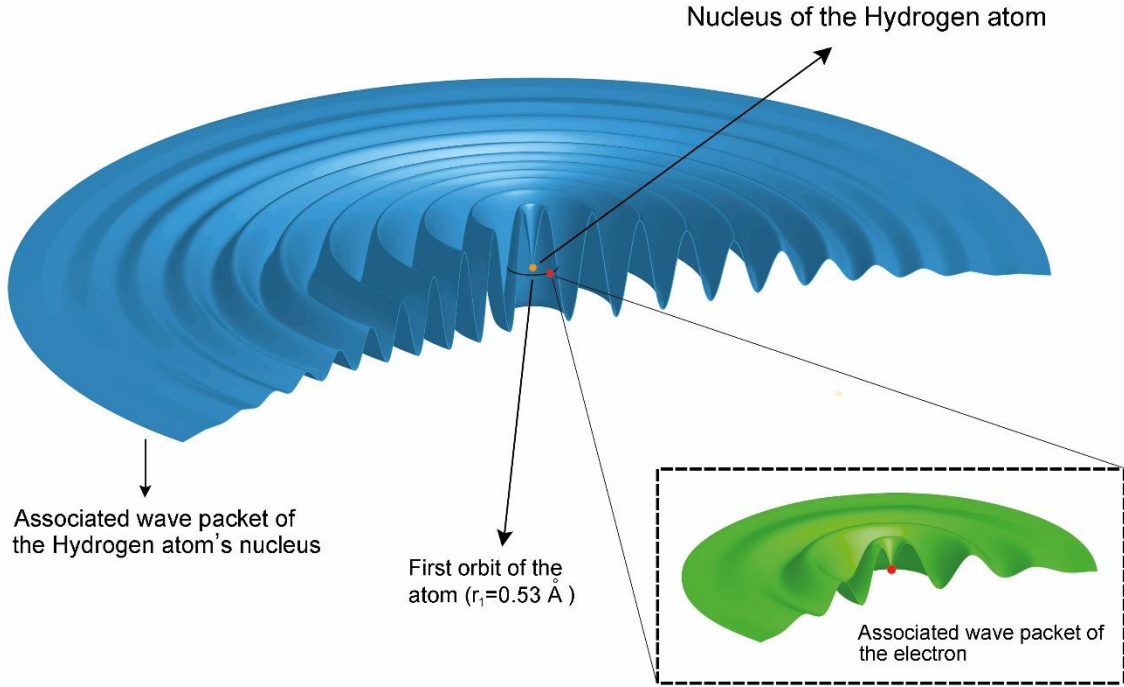
$$\begin{cases} Re\ \psi(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4} cos(w_0't) cos(5.92x - \frac{\pi}{2})\ e^{-\frac{x^2}{4\alpha}} & x \geq 0 \\ Re\ \psi(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4} cos(w_0't) cos(5.92x + \frac{\pi}{2})\ e^{-\frac{x^2}{4\alpha}} & x \leq 0 \end{cases} \quad (16)$$

The equation 16 in cylindrical coordinate:

369 $$x = r\cos\theta \Rightarrow Re\,\psi(r,\theta,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\cos(w_0' t)\cos(5.92r\cos\theta - \frac{\pi}{2})\,e^{-\frac{(r\cos\theta)^2}{4\alpha}} \qquad (16-a)$$

370 In equation 16, we consider the angular frequency equal to w_0' that not to be confused with w_0 in
371 equation 14. Figure 5 is drawn in cylindrical coordinate. In the same way in Section 5, we can
372 show that the equation 16 is the real part of the solution of the Schrodinger equation.

373 The first node of the associated wave packet of the hydrogen nucleus is at $r_1 = 0.53\text{Å}$ and the
374 second node is at $r_2 = 2r_1$, and Third at $r_3 = 3r_1$, etc. In the new atomic model we have: $r_n = nr_1$,
375 and in the Bohr model we have $r_n = n^2 r_1$. This means that the orbit number n in the Bohr model
376 is the orbit number n^2 in the new atomic model. For example, the second orbit in the Bohr model
377 is the fourth orbit in the new atomic model (Fig. 6). In figure 5 the electron rotates on the first node
378 of the associated wave packet of the nucleus (just like rotation of planets in Fig. 2). This orbit, like
379 the orbits of the planets in the solar system, is slightly elliptical due to the inverse-square coulomb
380 force of the nucleus. The protuberances in the nucleus wave function are the oscillation of dark
381 matter. As mentioned in the section "Elliptical orbits", the role of the oscillation of the wave
382 function is to prevent an electron from being placed between the nodes. In the new atomic model,
383 the formation of an atom (for example, a hydrogen atom) is such that the electron approaches the
384 proton and is placed in the first node of the proton associated wave packet. The proton associated
385 wave packet prevents the electron from being placed in the distance between the nodes. Due to the
386 Coulomb force, the electron begins to rotate around the nucleus on an elliptical orbit. In this atomic
387 model we use Bohr's assumptions and assume that the electron does not radiate while it orbits
388 about the nucleus [2]. In this model, like the Bohr model, the spectral lines of the elements are
389 caused by the jump of electrons from the higher orbits to the lower orbits [2], which we will discuss
390 in the next section about it. In fact, the Bohr atomic model is a subset of the new atomic model.

Nucleus of the Hydrogen atom

Associated wave packet of
the Hydrogen atom's nucleus

First orbit of the
atom (r_1=0.53 Å)

Associated wave packet of
the electron

392   **Fig. 5. The New atomic model.** Diagram of $\psi(x,t)$ at the moment t = 0 based on equation (16-a) (blue wave packet).
393   In this figure, associated wave packet of nucleus and associated wave packet of the electron are shown at t = 0. In this
394   figure, the electron and its associated wave rotate about the nucleus of hydrogen atom. The second and the other orbits
395   are not shown in this figure. We consider the wavelength of the nucleus wave packet to be $2r_1$ ($r_1 = 0.53$Å). If we
396   consider the first orbital velocity of electron based on the Bohr model $v_1 = \frac{1}{137}c$, in such a case the wavelength of
397   associated wave packet of electron in the first orbit of hydrogen, based on de Broglie equation ($\lambda = \frac{h}{mv}$), is 3.3 Å
398   (Although, no one has ever measured the velocity of the electron in the first orbit of the hydrogen atom with a
399   laboratory device or method; But $v_1 = \frac{1}{137}c$ is an empirical value. If v_1 does not have this value, then the precise
400   value of Rydberg constant is not obtained from the Bohr model). There is no matter if the wavelength of associated
401   wave of electron is larger than or less than the wavelength of the associated wave of the nucleus.

402   In figure 5, The nucleus wave function is plotted using equation 16 with α = 7 and λ = $2r_1$ = 1.06
403   Å or k = 5.92. And the electron wave function with λ = 3.3 Å or k = 1.9 and α = 7. The new atomic
404   model includes both the Schrodinger wave function and the Bohr atomic model inside. In fact,
405   Niels Bohr and Schrodinger each were achieved to a piece of reality, and Figure 5 is probably total
406   of reality and the final atomic model.

The new atomic model | The Bohr model

407
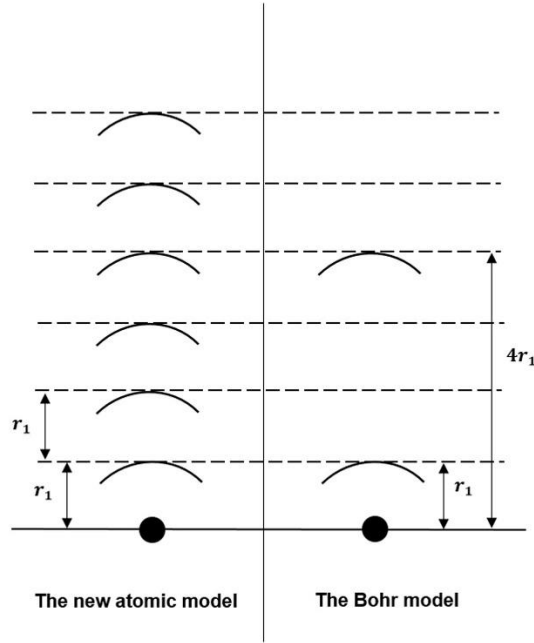
408 **Fig. 6. The new atomic model compared to the Bohr model.** For example, the second orbit in the Bohr model is the
409 fourth orbit in the new atomic model.

410 Regarding Figure 5, we said that the associated wave packet of a particle is dark matter. Dark matter has
411 mass. The mass we measure for elementary particles, such as electron and proton, with different ways is
412 actually the mass of the particle itself and its associated wave packet. Therefore, because the proton is
413 heavier than the electron, its wave packet probably is denser and heavier than the electron wave packet.

414 In the next section, first we will investigate the motion of electron around the nucleus in a hydrogen atom
415 (^1_1H) and then, based on the diagram of the first ionization energy of the elements, present our general
416 atomic model and we achieve interesting results.

8-2. The Atomic Hydrogen Model

418 We know from mechanics that a mass or an electric charge that is affected by a central force moves
419 on an ellipse which its orbital eccentricity is

420
$$e = \sqrt{1 + \frac{2EL^2}{mK^2}} \qquad (17)$$

421 Where E is the mechanical energy of the mass m, L is the orbital angular momentum and
422 $K = k_e q_1 q_2$ or $K = GMm$ [22]. Semi-major axis of this ellipse is

423
$$a = -\frac{K}{2E} \qquad (18)$$

424 And semi-minor axis is $b = a\sqrt{1 - e^2}$. The area of this ellipse is $A = \pi ab$ [22].

17

425 In the motion under the effect of central force L is a constant. And in our new atomic model because
426 of existence of associated wave packet of nucleus, L is also quantized. The amount of L for the
427 first orbit of hydrogen atom is $L_{1H} = Constant$. We have:

428
$$L_{1H} = Constant \ , \ K = k_e e^2 \implies e_{1H} = \sqrt{1 + \frac{2E_{1H}L_{1H}^2}{m_e(k_e e^2)^2}} \tag{19}$$

429 E_{1H} is 13.6 eV, based on diagram of first ionization energy. Therefore all of the values in equation
430 19 are certain values and thus e_{1H} (namely the orbital eccentricity of first orbit of hydrogen atom)
431 has a certain value. The semi-major axis equals

432
$$a_{1H} = -\frac{K}{2E_{1H}} \implies a_{1H} = -\frac{k_e e^2}{2E_{1H}} = 0.528 \text{ Å} \tag{20}$$

433 This number is the same radius of the first orbit of the Bohr atom. The semi-minor axis is equal
434 to:

435
$$b_{1H} = a_{1H}\sqrt{1 - e_{1H}^2} \tag{21}$$

436 In such a case, the area of orbit equals : $A_{1H} = \pi b_{1H} a_{1H}$. The orbit of electron is a current loop
437 and therefore the orbital magnetic dipole moment for hydrogen atom is equal to:

438
$$\boldsymbol{m}_{1H} = I\boldsymbol{A}_{1H} \tag{22}$$

439 Where I is electric current [23]. In the new atomic model, the direction of the orbital magnetic
440 dipole moment is perpendicular to the plane of the orbit. The dependence of the orbital magnetic
441 dipole moment to the area of the orbit of electron is a very important issue that helps us to justify
442 the normal Zeeman effect. In the following sections, we consider a few subshells for each main
443 orbit, which the areas of these subshells are different from each other. This difference is the cause
444 of difference in the value of $\boldsymbol{m}$, which helps us to justify the normal Zeeman effect. This method
445 is different from Bohr-Somerfield method [24] in old quantum theory. In their model, the normal
446 Zeeman effect is justified by difference in the space orientation of the subshells (Fig. 4a). But in
447 our model, all of the subshells are in the same plane and the difference is in the areas.

8-3. Many-Electron Atoms

449 The diagram of the first ionization energy is a very valuable diagram that arrived scientists to many
450 results (Fig. 7). It was by investigation of this diagram that they realized the existence of subshells,
451 the order of subshells filling, and many other results. For example, this diagram shows that in the
452 first shell is not P subshell, or d subshell does not exist in the first and second shells, or in another
453 example, this diagram shows that $4S$ subshell fills earlier than $3d$.
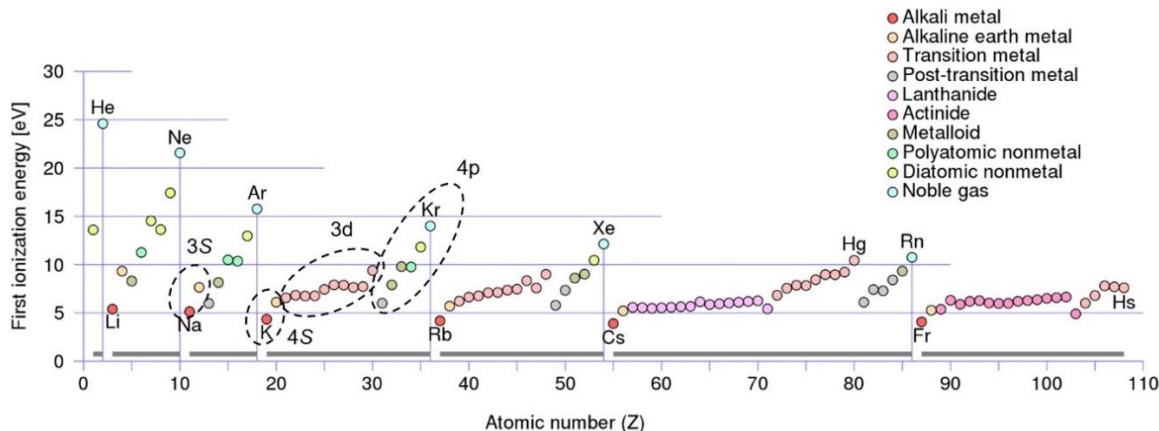
Fig. 7. The diagram of the first ionization energy.

In the new atomic model, according to the diagram of the first ionization energy and similar to the Bohr-Somerfield model, for each n layer, located at the distance $r_n = nr_1$; we consider the S, P, d, f and g subshells. These are circular and elliptical orbits that have not orientation, unlike the Somerfield model; and all of them are in the same plane and the difference is in their area (the reason for the formation of these subshells can be attributed to the quantized nucleus electric charge and electron charge). The orbital eccentricity and area of these subshells cannot be calculated (except for the hydrogen atom), but we assume that the area of the subshells is not equal. The difference in the area of the subshells cause a difference in the value of the **m** vector, which causes the occurrence of normal Zeeman effect. For example, the Neon atom has five subshells in the new atomic model. One subshell is $1S$, another $2S$ and three $2P$. All of these subshells are in the same plane, and in each of these subshells, based on the Pauli Exclusion Principle, only two electrons rotate. Here we consider a numeric index for each of the similar subshells. For example consider $2P$ subshells. we will have $2P_1, 2P_2$ and $2P_3$.

8-4. Quantum jumps and Spectral Lines of the Atomic Hydrogen

Before the Bohr atomic model, scientists did not know whether the particles in a hydrogen lamp were molecules or atoms. Because of justification of spectral series such as the Ballmer, Lyman, and Paschen series, by the Bohr atomic model, they understood that most of the particles inside the hydrogen lamp are atoms. But in the hydrogen spectrum, there are other lines besides the main spectrum lines (namely Ballmer, Lyman, …. series.) [3][4][5][6], which are called secondary spectral lines. These lines are not predicted by the Bohr atomic model. By 1922, 750 number of these lines were discovered between H_α and H_β [4] (H_α and H_β are the first and second frequencies of the Ballmer series). Some physicists have linked secondary lines to impurities in the hydrogen lamp [3], and some have attributed them to hydrogen molecules in the lamp [3]. But all this was just speculation. Our theory considers a large part of these lines to be related to hydrogen atoms and theoretically predicts their existence and gives us their wavelengths. Today, these lines are known as the molecular spectrum of hydrogen [25][26], which this is based on Merton's article [3]. Merton in his article and in the section "Experimental Results" proved in a very vague way

483   that two groups of the secondary spectrum lines are related to hydrogen molecules and finally
484   concluded that: "it is probable that the whole of the secondary spectrum is due to the hydrogen
485   molecule". But we show that this is wrong, and only a part of these lines are related to hydrogen
486   molecules.

487   In the Bohr atomic model, the lines of the emission and absorption spectrum of hydrogen atom are
488   the result of quantum jumps. We use the same assumption in the new atomic theory. Consider
489   Figure 6. As we said, if the Bohr model has n orbits, the new atomic model has n^2 orbits. For
490   example, the second Bohr orbit is the fourth orbit in the new atomic model (Fig. 6). Based on this,
491   for example, Ly_α in the Lyman series, which equals ν_{21} in the Bohr model, is equal to ν_{41} in the
492   new atomic model. Since the number of orbits in the new atomic model is more, we should expect
493   more quantum jumps and consequently more emission lines in the hydrogen spectrum. For
494   example, according to Fig. 6, in the new atomic model, we should be able to observe
495     $\nu_{21}, \nu_{32}, \nu_{31}, \nu_{51}$, ... and many other frequencies, in addition to the lines predicted by the Bohr
496   atomic model. For example, ν_{31} in the new atomic model equals

497
$$h\nu_{31} = E_3 - E_1 \xrightarrow{E_H = \frac{-\mu k_e e^2}{2m_e r}} \nu_{31} = \frac{1}{1 + \frac{m_e}{M_P}} \frac{k_e e^2}{2h} \left(\frac{1}{r_1} - \frac{1}{3r_1}\right) = 3.35 \times 10^{15} \times \frac{2}{3} \Longrightarrow$$

498
$$\therefore \nu_{31} = 2.23 \times 10^{15} \ Hz \Longrightarrow \lambda_{31} = 1340 \ Å$$

499   In the above calculations we used from equation $E_H = \frac{\mu}{m_e} E_\infty = \frac{-\mu k_e e^2}{2m_e r} = \frac{1}{1 + \frac{m_e}{M_P}} \frac{k_e e^2}{2r}$ instead of

500     $E_\infty = \frac{-k_e e^2}{2r}$ [27][28]. The equation $E_\infty = \frac{-k_e e^2}{2r}$ is the equation of energy of electron when the mass
501   of nucleus is infinite. In the above equation μ is reduced mass. The Bohr atomic model do not

502   predict the wavelength $\lambda_{31} = 1340 \ Å$. The observation of this wavelength in the hydrogen
503   spectrum is a strong confirmation for the new atomic theory. As another example, based on the
504   new atomic model, we have:

505
$$h\nu_{114} = E_{11} - E_4 = \frac{1}{1 + \frac{m_e}{M_P}} \frac{k_e e^2}{2} \left(\frac{1}{4r_1} - \frac{1}{11r_1}\right) \Longrightarrow \nu_{114} = 0.53 \times 10^{15} \ Hz \Longrightarrow \lambda_{114} = 4640 \ Å$$

506   This ray is in the visible spectrum region and we should be able to observe it. Another examples
507   are:

508
$$h\nu_{104} = E_{10} - E_4 \Longrightarrow \lambda_{104} = 4925 \ Å \quad and \quad \lambda_{84} = 5980 \ Å$$

509   These two wavelengths along with the previous wavelength can be easily seen in Fig. 8. This
510   diagram shows the spectrum of a deuterium arc lamp, instead of a hydrogen lamp. The Deuterium
511   lamp mostly used in spectroscopy, because it provides more intensity at shorter wavelengths and
512   in the ultraviolet region. The wavelengths displayed in the deuterium spectrum are exactly the
513   same as the wavelengths of the hydrogen spectrum with a very slightly shift toward shorter

514 wavelengths[10] [28] (this is due to the very small difference between Rydberg constant for
515 deuterium and hydrogen [28]). In Fig. 8, D_α and D_β are consecutive wavelengths of the Ballmer
516 series. The number of the secondary lines is very large both at short wavelengths and at long
517 wavelengths.

518 As mentioned, our atomic model (Fig. 5) is based on equation 16. In this equation, the exponential
519 factor is never zero, and therefore the infinite number of orbits can be considered around the
520 nucleus of each atom. By moving away from the nucleus according to equation 16, the effects of
521 the Coulomb force of the nucleus decreases; Therefore, in distant orbits, the electron is practically
522 not bound to the nucleus.

523 In addition to the new atomic model, some secondary lines are definitely related to hydrogen
524 molecules or impurities inside the lamp.

525
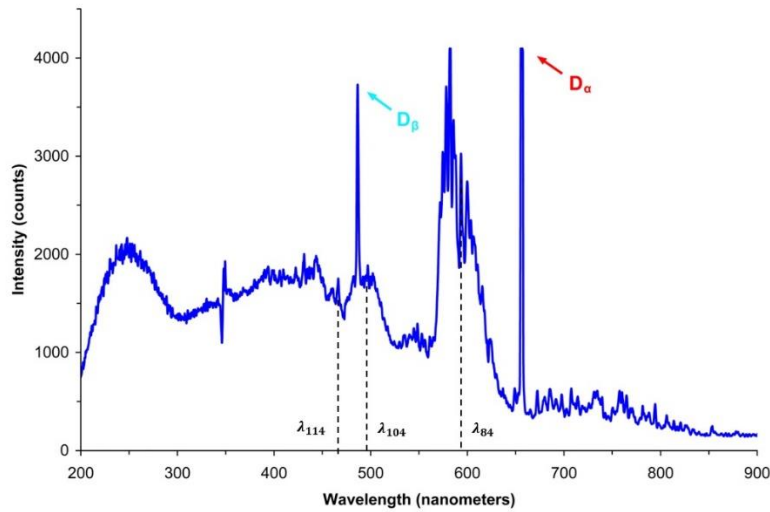
526 **Fig. 8. The spectrum of the deuterium lamp**. In this diagram, the position of the wavelengths is shown slightly
527 approximately.

8-5. The Normal Zeeman Effect

529 The splitting of spectrum lines in the presence of an external magnetic field, or the normal Zeeman
530 effect (NZE), was discovered by Zeeman in 1896. In the years that followed, Sommerfeld, who
531 justified the fine structure by considering elliptical subshells for each orbit [29], assumed that each
532 of these subshells has a different space orientation and all are not in the one plane [30]. For
533 example, the three P subshells in the second orbit have three orientations (Fig. 4a). As mentioned,
534 in the new atomic model we considered all of the subshells in one plane and assume that these
535 subshells have different areas. Because of difference between these areas the orbital magnetic
536 dipole moments of subshells ($\boldsymbol{m}$) will be different from each other, based on equation 22.

---

[10] This difference is not appearing until three digits after the decimal point

In the following, based on this point, we will explain NZE, in the usual way of proving the NZE in the old quantum mechanics [24]. The difference is that now the cause of the difference in the amount of $\boldsymbol{m}$ is the area of the subshells, not their space orientation.

Consider the third orbit of an atom and its nine subshells and assume that the area of these subshells are as shown in table 2.

Subshell of the third orbit	$3S$	$3P_1$	$3P_2$	$3P_3$	$3d_1$	$3d_2$	$3d_3$	$3d_4$	$3d_5$
Area of subshell($A_{subshell}$)	$20A_0$	$18A_0$	$20A_0$	$22A_0$	$16A_0$	$18A_0$	$20A_0$	$22A_0$	$24A_0$

Table. 2. The areas of third orbit's subshells. Here A_0 is a unit value. In this table the areas of $3S$, $3P_2$ and $3P_3$ is equal. But there is no problem about this. $3S$ is a circle; $3P_2$ is an ellipse and $3P_3$ is a more elongated ellipse.

In such a case, the difference in the energy levels in the presence of the magnetic field is obtained from the following equation:

$$\Delta E_m = -\boldsymbol{m}_{subshell} \cdot \boldsymbol{B} = -I A_{subshell} \cdot \boldsymbol{B} \tag{23}$$

Where $\boldsymbol{m}_{subshell}$ is the orbital magnetic dipole moment of each subshell. If we assume that the direction of $\boldsymbol{B}$ is perpendicular to the orbital plane (or in the direction of $\boldsymbol{A}_{subshell}$), in such a case we have:

$$\Delta E_m = -I A_{subshell} B \tag{24}$$

We want to investigate the transition between d and P states in the presence of a magnetic field. When the magnetic field is zero, the energy of the d state is E_d (for all five d subshells) and the energy of the P state is E_P (for all three P subshells) and because of transition between d and P a photon will be emitted by energy: $h\nu_0 = E_d - E_p$. When the field is turned on, the d state splits into five equally spaced magnetic sublevels, and the P state splits into three equally spaced magnetic sublevels. According to the Table 2 the difference in energy between any two adjacent magnetic sublevels being $\Delta E_m = I2A_0B$. Here we should consider the selection rules. We should assume that the transitions between the subshells follow the rule $\Delta l = \pm 1$; Where the values of l are based on the table. 3:

$l = 0$	$l = 1$	$l = 2$	$l = 3$	$l = 4$
S	P	d	f	g

Table. 3. The subshells and their numbers. Here we use the l sign only because of the historical aspect of the subject, and its connection with Schrodinger mechanics and angular momentum is by no means intended in this section. We can use any other sign.

564 $\Delta l = \pm 1$ means that the transition from d to P is allowed but from d to S is forbidden. And we
565 also should consider a selection rule for changing area of the subshells. we have:

$$\Delta A_l = 0 \ \ or \ \ \pm 2A_0$$

567 That is, only those transitions are allowed in which either A_l does not change or changes by $2A_0$.
568 For changes of n (principal quantum number) any value is allowed. Authorized transitions are
569 shown in Fig. 9.

570
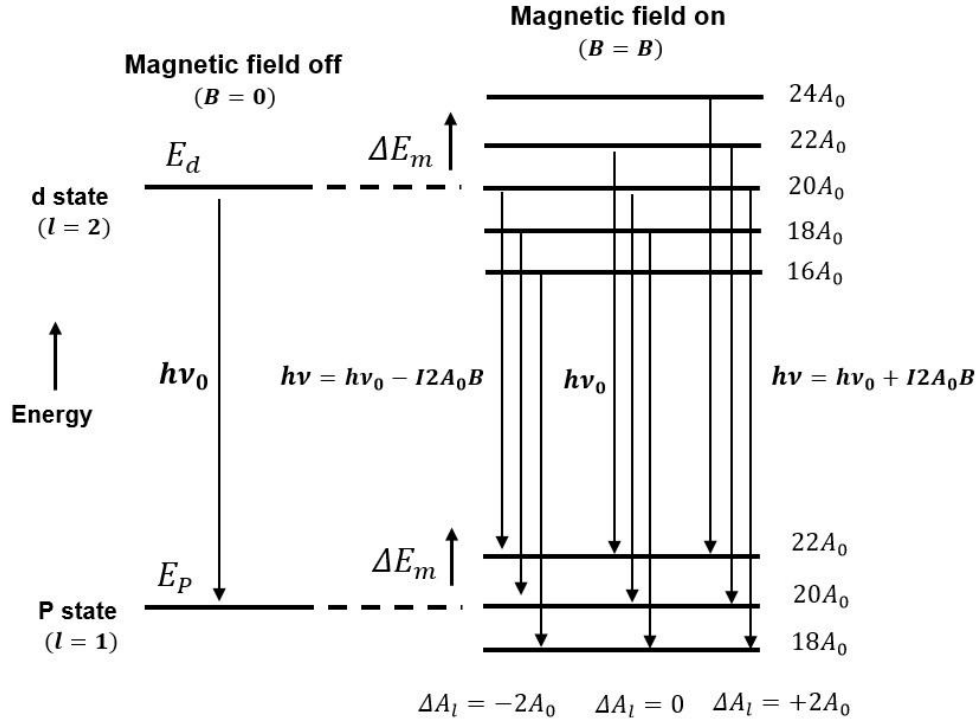
571 **Fig. 9. Schematic illustration of normal Zeeman effect.** Energy levels and spectra of $d \rightarrow P$ transition: (left)
572 zero magnetic field. (right) nonzero magnetic field.

573 We have:

574 $\quad \Delta A_l = 2A_0:$ $\quad hv = hv_0 + \Delta(\Delta E_m) \Longrightarrow hv = hv_0 + 12A_0B \Longrightarrow v = v_0 + \dfrac{12A_0B}{h}$

575 $\quad \Delta A_l = 0:$ $\quad hv = hv_0 + \Delta(\Delta E_m) \Longrightarrow hv = hv_0 \Longrightarrow v = v_0$

576 $\quad \Delta A_l = -2A_0:$ $\quad hv = hv_0 + \Delta(\Delta E_m) \Longrightarrow hv = hv_0 - 12A_0B \Longrightarrow v = v_0 - \dfrac{12A_0B}{h}$

577 Thus, each line in the emission spectrum splits into three lines by an external magnetic field. As
578 we said, we used the same common method of proving the NZE [24] here. The difference is that

579 here, instead of space orientation of the orbits, the difference in the area of the orbits causes the
580 lines to split. This description of the NZE is easier than the Sommerfeld model.

581 The above relations were obtained in the situation that **B** was in the direction of **A**. If **B** and **A** have
582 a θ angle with each other, then in the two equations of above relations we will have $Cos\theta$:

583 $$\Delta A_l = 2A_0: \qquad h\nu = h\nu_0 + I2A_0BCos\theta \Rightarrow \nu = \nu_0 + \frac{I2A_0B}{h}Cos\theta$$

584 $$\Delta A_l = 0: \qquad h\nu = h\nu_0 \Rightarrow \nu = \nu_0$$

585 $$\Delta A_l = -2A_0: \qquad h\nu = h\nu_0 - I2A_0BCos\theta \Rightarrow \nu = \nu_0 - \frac{I2A_0B}{h}Cos\theta$$

8-6. Spin as a Classical Property

587 We know that if we consider the electron as the spinning sphere of charge, in such a case, given
588 the small size of the electron ($r < 10^{-16}m$) [31] and based on the classical equation $L = I\omega$, ω
589 will have a large value. A large w means a large peripheral velocity in the equator of the spinning
590 sphere. Which in this case is higher than the velocity of light. But in our model, the electron is
591 surrounded by a wave packet of dark matter (Fig. 5). Dark matter has mass. Thus, this wave has a
592 part of the mass of the electron, and in fact the mass that humans have measured for the electron,
593 by different ways, is the mass of electron and its associated wave. The electron associated wave is
594 much larger than the electron size ($r < 10^{-16}m$). As mentioned, for example, the wavelength of
595 associated wave packet of an electron in the first orbit of a hydrogen atom is 3.3 angstroms. Thus,
596 based on the equation $I = \int r^2 dm$ the moment of inertia of the electron (namely the moment
597 of inertia of the particle along with its wave packet) increases and according to the equation
598 $L = \sqrt{s(s+1)}\hbar = \frac{\sqrt{3}}{2}\hbar = I\omega$, ω decreases (which means that the wave packet of electron, like
599 the electron, has a spinning motion). So based on our model, spin can be considered as a classic
600 motion.

601 Particle experimenters have obtained the diameter of an electron by examining face-to-face
602 collisions [31]. In these experiments, the diameter of the associated wave packet is not measured.
603 The wave packet in collisions is transparent and low effect. The diameter of the wave packet
604 usually is defined as one-half of maximum value of the function at the center.

Conclusion

606 In this article we proved that there is no doubt about the existence of a wave function in the solar
607 system. Is it possible to matching of Titius-Bode rule and the wave packet in figure 1, be
608 accidentally? Without the solar system wave packet, it is not possible to reach to the Titius-Bode
609 rule from the molecular nebula and the protoplanetary disk. De Broglie considered the wave nature
610 for subatomic particles, and here we attributed the wave nature to celestial objects. Neither of these
611 two actions is strange. Rather, they are truths that we must become accustomed to.

It seems that the new atomic model is the final model of atom. This model is a unifying model that includes both the Schrodinger wave function and the Bohr atomic model inside. In fact, Niels Bohr and Schrodinger each were achieved to a piece of reality, and Figure 5 is probably total of reality and the final atomic model. We have noticed the existence of a wave along with an object since De Broglie. But we never thought it would be in the form of Figures 5 and 2.

In our opinion, prediction of the secondary lines of the hydrogen spectrum is a complete success for the new atomic model. Based on the new atomic model, normal Zeeman effect was more easily justified. Anomalous Zeeman effect, which is caused by the spin of electron, is also easily described by the new atomic model, which we have not described due to the length of the article.

Based on this article, the associated wave packet of an object (such as electron, proton or sun) is one of the candidates for the nature of dark matter.

Anyone familiar with the history of quantum mechanics and atomic models (especially the debates and problems of the third decade of the twentieth century such as Niels Bohr and Schrodinger debates about quantum jumps) will understand that what important problems have been solved in this article. Here, we proved that the word of " thought experiment " is meaningless and an experiment must be done in the real world so that we can talk about its results. In this article, we turned quantum mechanics into a simpler and more beautiful theory.

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