The Atomic and Quantum Mechanics Achievements of the Theory of Solar System Wave Packet

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Abstract

In the previous article we discussed about Solar System Wave Packet (SSWP). It makes sense if we want to generalize our theory to the subatomic world. So, based on the theory of SSWP, we will enter into the atomic physics and arrive to a new atomic model with considerable results.

Keywords: Atomic model, Quantum mechanics, Schrodinger equation, Quantum Jumps, Wave-Particle Duality, Spreading of Wave Packet

1. Associated Wave Packet of Sun

The equation of SSWP is (Soltani 2023):

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

As we said in our previous article (Soltani 2023) it is unacceptable to imagine that the wave packet of solar system is not related with an object. In this section we will show that the equation of SSWP is exactly in the form of real part of the solution of Schrodinger equation and therefore, based on what we have learned from Quantum mechanics, we can attribute it to an object like the sun. In fact, in this section we prove that equation 1 is the result of superposition of a set of infinite number of flat matter waves which each of them is a solution of Schrodinger equation; And so we can consider equation 1 as a solution of Schrodinger equation. Base of calculations in this section is superposition principle.

Consider a set of infinite number of flat matter waves $\boldsymbol{Ae^{i(kx-wt+\emptyset_0)}}$, $\boldsymbol{Ae^{i(kx+wt+\emptyset_0)}}$, $\boldsymbol{Ae^{i(kx-wt-\emptyset_0)}}$ and $\boldsymbol{Ae^{i(kx+wt-\emptyset_0)}}$ which move in the positive and negative directions of the x-axis (These four groups of waves are all of possible form of flat matter waves); and assume that all of these waves are under the effect of potential $V(x)$. In such a case the angular frequency (w) of each of these matter waves is equal:

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

Because, based on De Broglie theory, the energy of a matter wave is equal to the energy of associated particle of the wave namely E= $\frac{P^2}{2m} + V(x)$ (e.g., Fleisch & Kinnaman 2015).

As you know these four groups of waves with general equation $Ae^{i(kx \pm wt \pm \emptyset_0)}$ are the solution of the Schrodinger equation namely

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

These waves interact together in space based on superposition principle. From these infinite number of waves we will show that the superposition of *a part of* these waves, which **1)-** their wave number is around the median of k_0 and between $k_0 + {}^{\Delta k}/_2$ and $k_0 - {}^{\Delta k}/_2$ and **2)** - their angular frequency equals w_0 and **3)-** the amplitude of these waves is on the bell shaped function $A(k) = (\frac{2\alpha}{\pi})^{1/4}e^{-\alpha(k-k_0)^2}$(which is a Gaussian function), *is in the form of equation 1*[1].

First consider a set of infinite number of these waves with equation: $\boldsymbol{Ae^{i(kx-w_0t+\emptyset_0)}}$ which move in the *positive direction of x-axis*. In such a case, the resultant of these waves, using the superposition principle, is a wave packet with equation 2 (Branson 2003, Gasiorowicz 1974, Cohen 1977).

$$\psi_{total}(x,t) = \frac{1}{\sqrt{2\pi}}\int_{k_0-{}^{\Delta k}/_2}^{k_0+{}^{\Delta k}/_2} A(k)e^{i(kx-w_0t+\emptyset_0)}dk \tag{2}$$

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 and shows the width of the bell-shaped function $A(k)$. Coefficient $(\frac{2\alpha}{\pi})^{1/4}$ is a normalization coefficient which is obtained by normalize of $A(k)$. Since equation 2 is derived from the superposition principle, it is the solution of the Schrodinger equation.

To solve the integral of equation 2, we calculate the superposition of all of the waves in one moment, which we consider to be the origin of time ($t = 0$), and then we can obtain the net wave at any other time. We have:

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

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

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

Considering $k' = k - k_0$, we have:

$$\psi(x,0) = (\frac{\alpha}{2\pi^3})^{1/4}e^{i(k_0x+\emptyset_0)}\int e^{-\,\alpha k'^2}e^{ik'x}dk' \tag{5}$$

[1] 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, under the effect of a potential, we have $w = \hbar k^2/2m + V/\hbar$ (Cohen 1977). 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. For free matter waves we have: $w = \hbar k^2/2m$.

Using the variable transformation $\acute{k} - \frac{ix}{2\alpha} = q$ (Branson 2003 & Gasiorowicz 1974) we can change this integral to the familiar Gaussian integral $\int_{-\infty}^{\infty} dq\, e^{-\alpha q^2} = \sqrt{\frac{\pi}{\alpha}}$ and solution it. After replacement and simplification, we reach the following final solution (Branson 2003 & Gasiorowicz 1974):

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

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

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

Substituting $e^{ik_0 x - ik_0 x}$; we will have:

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

This integral is similar to integral 5. So, we can solution it with the similar way. Therefore, we have:

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

We call ψ here ψ_1.

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

Due to the presence of the factor $k_0 x - w_0 t$, equations 7 and 8 represent a traveling wave packet that propagates in the positive direction of the x-axis (Walker & Halliday 2007). This means that the location of the nodes 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 equations does not spread.

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

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

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

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

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

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

Thus:

$$Re\,\psi_{total}(x,t) = (\frac{1}{2\pi\alpha})^{1/4}\, e^{-\frac{x^2}{4\alpha}}[cos(k_0x - w_0t + \emptyset_0) + cos(k_0x + w_0t + \emptyset_0)] \tag{11}$$

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 equation of a standing wave packet.

$$\begin{cases}\alpha = k_0x - w_0t + \emptyset_0 \\ \beta = k_0x + w_0t + \emptyset_0\end{cases} \Rightarrow Re\,\psi_{total}(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\cos(k_0x + \emptyset_0)cos(w_0t)e^{-\frac{x^2}{4\alpha}} \tag{12}$$

There is not the structure of $kx \pm wt$ in equation 14 so the ψ_{total} is a standing wave. As you observe, equation 12, which is the real part of a solution of the Schrodinger equation, is exactly the same as equation 1 for $x \geq 0$. Is this similarity coincidental? No. *Therefore, equation 1 is the real part of a solution of the Schrodinger equation. It means that the Schrodinger equation and quantum mechanics are valid for astronomical objects.* Comparing equation 12 and equation 1, we have

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

If we put these values in equation 1, then we get the final equation of SSWP for $x \geq 0$:

$$Re\,\psi_t(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\,cos(w_0t)\,cos(\frac{10\pi}{3}x + \frac{\pi}{6})\, e^{-\frac{x^2}{4\alpha}} \qquad x \geq 0 \tag{13}$$

Equation 13 is obtained by calculating the superposition of a set of infinite number of waves $Ae^{i(kx - w_0t + \emptyset_0)}$ and $Ae^{i(kx + w_0t + \emptyset_0)}$ that move in opposite directions to each other (pay attention to the sign + behind $\emptyset_0$). Now if we sum a set of infinite number of flat wave functions with the equations $Ae^{i(kx - w_0t - \emptyset_0)}$ and $Ae^{i(kx + w_0t - \emptyset_0)}$ (pay attention to the sign − behind $\emptyset_0$) together, by following the path we have taken from equation 2 to equation 13, we reach the following relation;

$$Re\,\psi_t(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\,cos(w_0t)\,cos(\frac{10\pi}{3}x - \frac{\pi}{6})\, e^{-\frac{x^2}{4\alpha}}$$

Which is the same as equation 1 for $x \leq 0$. Therefore, the final form of SSWP (equation 1) is as follows:

$$\begin{cases} Re\,\psi(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\,cos(w_0t)\,cos(\frac{10\pi}{3}x + \frac{\pi}{6})\, e^{-\frac{x^2}{4\alpha}} & x \geq 0 \\ Re\,\psi(x,t) = 2(\frac{1}{2\pi\alpha})^{1/4}\,cos(w_0t)\,cos(\frac{10\pi}{3}x - \frac{\pi}{6})\, e^{-\frac{x^2}{4\alpha}} & x \leq 0 \end{cases} \tag{14}$$

In this equation, the larger the α is, the more the width of wave packet, along the x-axis. We drew Fig. 2 and Fig. 3 in our previous article by $\alpha = 10$ (Soltani 2023).

Here we demonstrated that equation of SSWP (equation 1) is the real part of a solution of the Schrodinger equation. So, based on what we have learned from Quantum mechanics, we can attribute it to an object in Solar system. The closest star to solar system is at a distance of 4.8 light-years, which is so far. And the biggest and heavyset object in solar system is sun. Therefore, the wave packet of solar system can only belong to the sun. De Broglie considered the wave nature for subatomic particles, and here we attributed the wave nature to celestial objects. Neither of these two actions is strange. Rather, they are truths that we must become accustomed to.

In this article, we proved that the Schrodinger equation is valid for astronomical objects; on the other hand, as you know, the Schrodinger relation is based on de Broglie equation ($\lambda = \frac{h}{mv}$). Therefore, the de Broglie equation is valid in astronomical scale[2]. But, according to the very large mass of sun, using the de Broglie relation the wavelength 0.6 AU will not obtain. So, instead of Planck constant we must choose another value for celestial objects, which is larger than h. We call this new value the Planck constant in Astronomy ($h_{Astronomy}$) abbreviated as h_A and we have: $\lambda_A = \frac{h_A}{P}$. In such a case, the Schrodinger equation in the astronomical scale can be written as follows:

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

If we follow the path of proving the Schrodinger equation (Eisberg 1974) and put the value $\hbar_A$ instead of $\hbar$, we reach equation 15.

2. How Was the SSWP Formed?

In section 1 we did not do anything strange. Rather, we have used only the superposition principle. There have been numerous number of flat matter waves in the early solar system which the superposition of a specific set of them made the wave packet in Fig. 3 in our previous article (Soltani 2023). Our calculations showed that only the interference of this special group of waves is constructive. In the protoplanetary disk and *before the formation of the sun*, there were countless flat matter waves with the general equation $e^{i(kx \pm wt \pm \emptyset_0)}$. *After the formation of sun* because of gravitational collapse, a special group of these waves interfered constructively with each other and created the SSWP.

Point: Since the protoplanetary disk of solar system was under effect of gravity of new born sun; In section 1 we investigated the superposition of matter waves which they were under the effect of a potential $V(x)$.

3. Atomic Physics

3.1. New Atomic Model

It makes sense if we want to generalize our theory, which was about solar system, to the subatomic world. As Niels Bohr used the planetary model to describe the atom in 1913. In this section, we present a new atomic model based on the model of the SSWP. *Our atomic model*

[2] The Davisson–Germer experiment (Davisson & Germer 1927) is the confirmation of the existence of the de Broglie's waves in subatomic scale and the regularity of the distances of the planets from sun (Titius-Bode law) is the confirmation of the existence of the de Broglie's waves in astronomical scale. Of course, as mentioned earlier, for confirmation of the existence of the de Broglie's waves in astronomical scale there are other stronger evidences such as the cleanliness of interplanetary space.

explains why the Bohr atomic orbits are quantized. Niels Bohr could not explain this issue. Here, based on this model we will explain the main and secondary spectrum of the hydrogen atom.

Some of the atomic models are shown in Fig. 1.

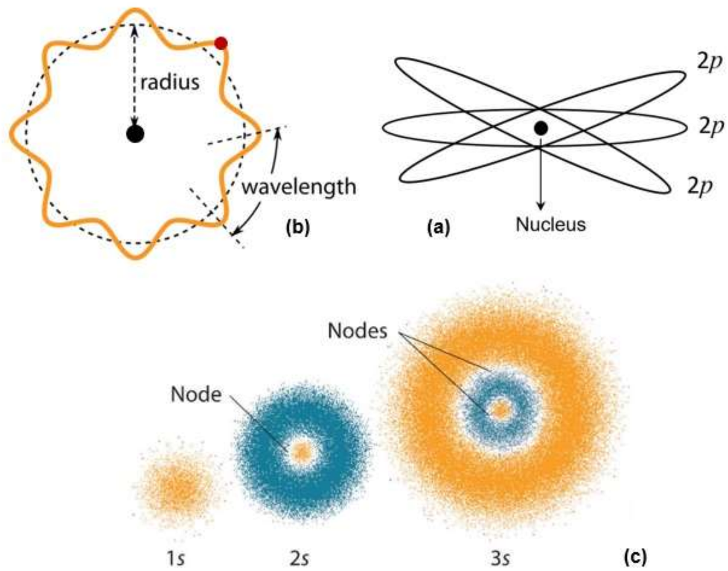

Fig. 1. Some of the atomic models. This figure shows three atomic models: **a). Bohr-Sommerfeld atomic model**: In this model, as you can see, subshells have space orientation. In this model, the horizontal $2P$ subshell is in the same plane as the $1S$ and $2S$ subshells. $1S$ and $2S$ subshells are not shown in this figure. **b). De Broglie atomic model.** De Broglie believed in standing waves around the nucleus. **c). The Max Born-Schrodinger atomic model.** In this figure S orbitals are shown. According to Max Born probability theory, the electron can be found in the distance between the nodes in the Fig. 1c. Other atomic models, such as the Rutherford or Thomson atomic models, are not shown in this figure. Fig. 1c is plotted using equation $P(r) = r^2(R_{nl})^2$, where R is the solution of Radial Schrodinger Equation (Gasiorowicz 1974).

Fig. 2 shows our atomic model, which we call the "New Atomic Model". To arrive to Fig. 2, 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 $x_1 = 0.53$Å, $x_2 = 4x_1$, $x_3 = 9x_1$, etc. In order to be able to attribute a standing wave to Bohr model, our wavelength should 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 1, the final form of "hydrogen atom wave packet" 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:

$$x = r\cos\theta \Rightarrow\ Re\,\psi(r,\theta,t) = 2(\frac{1}{2\pi\alpha})^{1/4} cos(w_0' t)\, cos(5.92r\cos\theta - \frac{\pi}{2})\ e^{-\frac{(r\cos\theta)^2}{4\alpha}} \quad (17)$$

In equations 16 and 17, we consider the angular frequency equal to w_0' that not to be confused with w_0 in equation 14. Fig. 2 is drawn in cylindrical coordinate. In the same way as described in section 1, we can show that the equation 16 is the real part of the solution of the Schrodinger equation.

The first node of the associated wave packet of the hydrogen nucleus is at r_1 = 0.53Å and the second node is at $r_2 = 2r_1$, and third at $r_3 = 3r_1$, etc. In the new atomic model, we have: $r_n = nr_1$, and in the Bohr model we have $r_n = n^2 r_1$. This means that the orbit number n in the Bohr model is the orbit number n^2 in the new atomic model. For example, the second orbit in the Bohr model is the fourth orbit in the new atomic model (Fig. 3). In Fig. 2 the electron rotates on the first node of the associated wave packet of the nucleus (just like rotation of planets in Fig. 3 in our previous article (Soltani 2023). This orbit is completely circular due to the presence of wave packet of nucleus. This orbit never turns into an ellipse under the effect of the inverse_square force of the nucleus; Because unlike SSWP, the nucleus's wave packet is never lost.

As mentioned in the previous article (Soltani 2023), the role of the oscillation of the wave packet is to prevent matters from being placed between the nodes. In the new atomic model, the formation of an atom (for example, a hydrogen atom) is such that the electron approaches the proton and is placed in the first node of the proton associated wave packet. The proton associated wave packet prevents the electron from being placed in the distance between the nodes. In this atomic model we use Bohr's assumptions and assume that the electron does not radiate while it orbits about the nucleus (Bohr 1913). In this model, like the Bohr model, the spectral lines of the elements are caused by the jump of electrons from the higher orbits to the lower orbits (Bohr 1913), which we will discuss in the next section about it. In fact, the Bohr atomic model is a subset of the new atomic model.

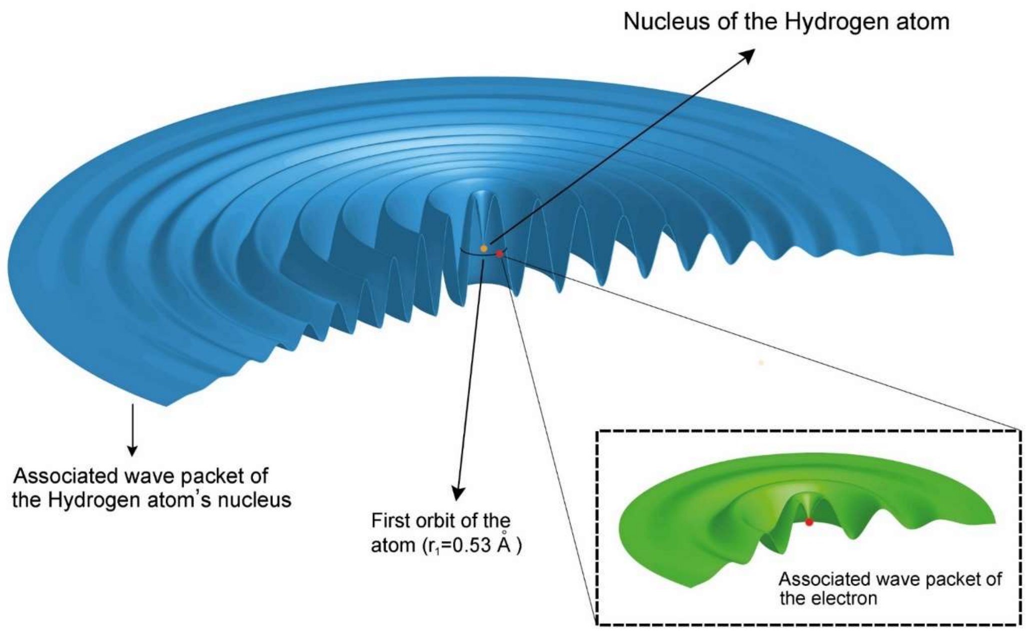

Fig. 2. The New atomic model. Blue wave packet is the diagram of $\psi(x,t)$ at the moment t = 0 based on equation 17. In this figure, associated wave packet of nucleus and associated wave packet of the electron are shown at t = 0. In this figure, the electron and its associated wave rotate about the nucleus of hydrogen atom in first orbit. The second and the other orbits are not shown in this figure. The wavelength of the blue wave packet is $2r_1$ ($r_1 =$ 0.53Å). If we 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 associated wave packet of electron in the first orbit of hydrogen atom, based on de Broglie equation ($\lambda = \frac{h}{mv}$), is 3.3 Å (Although, no one has ever measured the velocity of the electron in the first orbit of the hydrogen atom with a laboratory device; But $v_1 = \frac{1}{137}c$ is an empirical value. If v_1 does not have this value, the Rydberg constant obtained from the Bohr atomic model was not equal to its experimental value). There is no matter if the wavelength of associated wave of electron in this case is larger than the wavelength of the associated wave of the nucleus.

In Fig. 2, the nucleus's wave packet is plotted using equation 17 with α = 7 and λ = $2r_1 = 1.06$ Å or k = 5.92. And the electron wave packet with λ = 3.3 Å or k = 1.9 and α = 7. The new atomic model includes both the wave mechanics and the Bohr atomic model inside. Fig. 2 is probably the final atomic model.

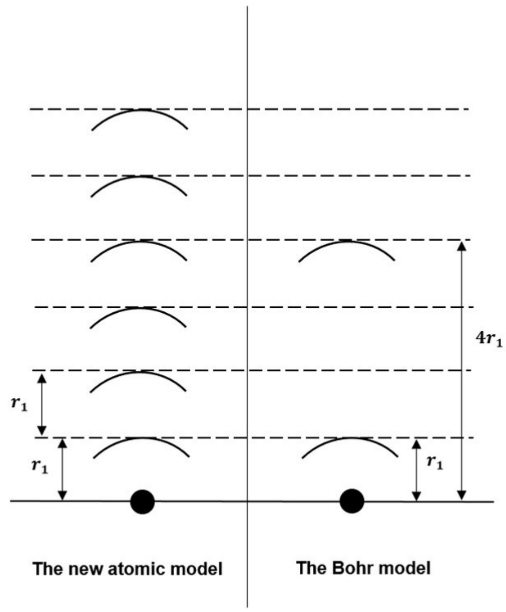

Fig. 3. The new atomic model compared to the Bohr model. For example, the second orbit in the Bohr model is the fourth orbit in the new atomic model.

3.2. Quantum jumps and Spectral Lines of the Atomic Hydrogen

When an electric spark is passed through gaseous hydrogen, the H_2 molecules are dissociated and the energetically excited H atoms are produced. These atoms emit light with discrete frequencies (namely Ballmer, Lyman, …. series) (e.g., Atkins & Paula 2018). In the hydrogen spectrum, there are other lines besides the *main spectrum lines* (namely Ballmer, Lyman, …. series.) (Merton & Barratt 1922, Allan 1924, Nicholson 1920, Richardson 1926), 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 (Allan 1924) (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 (Merton & Barratt 1922), and some have attributed them to hydrogen molecules in the lamp (Merton & Barratt 1922). But all these 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*, which this is based on Merton's article (Merton & Barratt 1922). Merton in his article and in the section "Experimental Results" proved in a very vague way that two groups of the secondary spectrum lines are related to hydrogen molecules and finally concluded that: "it is *probable* that the whole of the secondary spectrum is due to the hydrogen molecule". But we show that this is wrong, and *only a part of* these lines are related to hydrogen molecules.

In the Bohr atomic model, the lines of the emission and absorption spectrum of hydrogen atom are the result of *quantum jumps*. We use the same assumption in the new atomic theory. Consider Fig. 3. As we said, if the Bohr model has n orbits, the new atomic model has n^2orbits. For example, the second Bohr orbit is the fourth orbit in the new atomic model (Fig. 3). Based on this, for example, the spectrum line Ly_α in the Lyman series, which equals ν_{21} in the Bohr model, is equal to ν_{41} in the new atomic model. Since the number of orbits in the new atomic model is more, we should expect more quantum jumps and consequently *more emission lines* in the hydrogen spectrum. For example, according to Fig. 3, in the new atomic model, we should be able to observe ν_{21},ν_{32}, ν_{31}, ν_{51}, ... and many other frequencies, in addition to the lines predicted by the Bohr atomic model. For example, ν_{31} in the new atomic model equals

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

$$\therefore \Rightarrow \nu_{31} = 2.23 \times 10^{15}\ Hz \implies \lambda_{31} = 1340\ \text{Å}$$

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 $E_\infty = \frac{-k_e e^2}{2r}$ (Ohanian 1987, Eisberg 1974). The equation $E_\infty = \frac{-k_e e^2}{2r}$ is the equation of energy of electron when the mass of nucleus is infinite. In the above equation, μ is reduced mass. The Bohr atomic model does not predict the wavelength $\lambda_{31} = 1340$ Å. The observation of this wavelength in the hydrogen spectrum is a strong confirmation for the new atomic theory. As another example, based on the new atomic model, we have:

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

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

$$h\nu_{104} = E_{10} - E_4 \Rightarrow \lambda_{104} = 4925\ \text{Å} \qquad and \qquad \lambda_{84} = 5980\ \text{Å}$$

These two wavelengths along with the previous wavelength can be seen in Fig. 4. This diagram shows the spectrum of a deuterium arc lamp, instead of a hydrogen lamp. The Deuterium lamp mostly used in spectroscopy, because it provides more intensity at shorter wavelengths and in the ultraviolet region. The wavelengths displayed in the deuterium spectrum are exactly the same as the wavelengths of the hydrogen spectrum with a very slightly shift toward shorter wavelengths (Ohanian 1987, Eisberg 1974) (this is due to the very small difference between Rydberg constant for deuterium and hydrogen (Ohanian 1987, Eisberg 1974) and the difference between these two wavelengths is not appearing until three digits after the decimal point). In Fig. 4, D_α and D_β are consecutive wavelengths of the Ballmer series. The number of the secondary lines is very large both at short wavelengths and at long wavelengths.

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

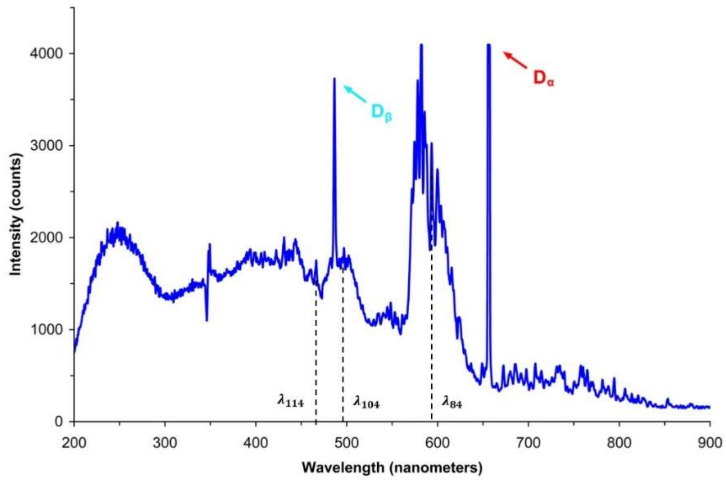

Fig. 4. The spectrum of the deuterium lamp. In this diagram, the position of the wavelengths is shown slightly approximately.

4. Quantum Achievements

It seems that in this paper we have been able to put wave mechanics in the right path and achieve the correct atomic model. This article puts an end to many confusions and mistakes.

The quantum achievements of the article are as follows:

1- Non-spreading of wave packet: In this article, in section 1, we showed that the superposition of a particular group of matter waves leads to a wave packet (equation 14) which does not spread over time. This achievement saves Schrodinger's wave mechanics from a major problem. I think no one is as pleased with this achievement as Schrodinger. Schrodinger was always annoyed by the spread of the wave packet.

Since Schrodinger believed to the wave packet without associated particle (Fig. 5) (McEvoy & Oscar 2013), he tried to justify nature phenomena on this basis. But the Schrödinger's wave packets had an important problem: Lorentz warned Schrodinger that his wave packet would spread over time (McEvoy & Oscar 2013). This point of Lorentz showed that the Schrödinger's wave packet should be destroyed after a while. In my theory, the quantum wave packet does not spread over time. And this is an important finding for wave mechanics.

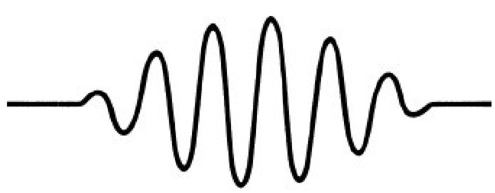

Fig. 5. Free electron from Schrodinger point of view

2- Rejection of the use of Max Born's probability concept: Our article means getting rid of Max Born's probability concept and his atomic model in Fig. 1c. In Fig. 2, electron and proton are at the center of their associated wave packets, and so the issue of probability is meaningless. Prior to my article, $\psi(x,t)$ was a meaningless mathematical thing and only $|\psi(x,t)|^2$ meant something to us (e.g., Gasiorowicz 1974). But this article gave meaning to $\psi(x,t)$ and from now on $|\psi(x,t)|^2$ can only be considered as the intensity of the wave packet at x and t, not probability.

3- The end of the wave-particle duality controversy for matter: Our atomic model for fundamental particles ends the particle-wave duality for matter. After our article, every fundamental matter particle is a wave packet with a particle at its center. For example, in diffraction experiments of electron, what appears on the screen is the effects of interference of the green wave packet of electron in Fig. 2 with the wave packet of another electron. And in the face-to-face collision of, for example, electron and proton with each other, the main role is for the center particles of wave packets in Fig. 2, not the wave packet. Before our article, the reason for the dual behavior of fundamental particles in different phenomena was unknown to us. From today, the nature of a matter particle is clear for us and so we know the reason for its dual behavior.

4- The reason for the existence of Bohr's atomic orbits: After the presentation of Bohr's theory, the question that was raised for scientists was that in an excited atom, what is the reason of quantization of Bohr's orbits? Or how does an electron that goes to a higher orbit know where the higher orbit is? "It's as if the electrons in your model know where to stop", Ernest Rutherford told Bohr. Our theory answers this problem. This is the wave packet of the atom's nucleus (namely blue wave packet in Fig. 2) that determines the stopping place of the electrons (location of the Bohr's orbits). The wave packet of nucleus does not allow the electron to stop in the space between the nodes.

Conclusion

De Broglie considered the wave nature for subatomic particles, and here we attributed the wave nature to celestial objects. Neither of these two actions is strange. Rather, they are truths that we must become accustomed to.

The new atomic model is a unifying model that includes both the wave packet of Schrodinger's wave mechanics and the Bohr atomic model inside. 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 Fig. 2.

In addition to predicting the main lines of the hydrogen spectrum (that is, the Ballmer, Lyman series, etc.), the new atomic model also gives us the secondary lines of the spectrum. I think, prediction of the secondary lines of the hydrogen spectrum is an important success for the new atomic model.

We know very little about the truth or spirit of quantum physics. Richard Feynman and Brian Greene better explain this. In 1965, Richard Feynman wrote: ‘’ There was a time when the newspapers said that only twelve men understood the theory of relativity. I do not believe there ever was such a time. There might have been a time when only one man did because he was the only guy who caught on, before he wrote his paper. But after people read the paper a lot of people understood the theory of relativity in one way or other, certainly more than twelve. On the other hand I think I can safely say that nobody understands quantum mechanics’’(Greene 2000). Or Brian Greene writes in his book (Greene 2000): " . . . By 1928 or so, many of the mathematical formulas and rules of quantum mechanics had been put in place . . .. But in a real sense those who use quantum mechanics find themselves following rules and formulas laid down by the "founding fathers" of the theory calculational procedures that are straightforward to carry out **without really understanding why the procedures work or what they really mean**. **Unlike relativity, few if any people ever grasp quantum mechanics at a "soulful" level**. . . . . Does it mean that on a microscopic level the universe operates in ways so obscure and unfamiliar that the human mind, evolved over eons to cope with phenomena on familiar everyday scales, is unable to fully grasp "what really goes on"? Or, might it be that through historical accident physicists have constructed an extremely awkward formulation of quantum mechanics that, although quantitatively successful, obfuscates the true nature of reality? No one knows. Maybe some time in the future some person will see clear to a new formulation that will fully reveal the "whys" and the "whats" of quantum mechanics" (Greene 2000). Based on these sentences, I think this article has been able to reveal the spirit and truth of Quantum mechanics to a great extent, and it seems that a big step has been taken.

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