

Solar System Wave Packet

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Abstract

Pluto, Ceres and all planets of solar system except Neptune, with a high approximation, follow a law called Titius-Bode law (TBL) or Bode law, which can by no means be considered as a stochastic event. This law shows that the distance of the planets from the sun in Solar system is regulated. Here, we prove that, probably, 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 $\phi_0 = \frac{\pi}{6}$, is the reason for TBL. In this article we will obtain the equation of this wave packet empirically. Finally, we will prove that without solar system wave packet, it is not possible to reach to the TBL from the protoplanetary disk of solar system. Here we prove that the nebular theory (or nebular hypothesis) without our wave theory is an incomplete theory. The distribution of Asteroids in the Asteroid belt is ring-shaped. In this Article we prove that this annular shape can be explained by our wave theory.

Keywords: Solar system formation, Titius-Bode law, Nebular theory, Asteroid belt

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 law known as Bode law or Titius-Bode law (TBL). According to this law, 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 law. If this law 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 law that Ceres was discovered in 1801 [1]. In this article, we will find the reason for the existence of the TBL. In fact, we will prove that, probably, the presence of a cosine and standing wave packet in solar system is the reason for existence of TBL. TBL 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 nebular theory, which explains the formation of the solar system, without considering the solar system wave packet (SSWP) is incomplete theory. We will prove that without SSWP, it is not possible to reach to the TBL from the protoplanetary disk. The distribution of Asteroids in the Asteroid belt is ring-shaped. In this Article we prove that this annular shape is another evidence for existence of SSWP.

Planet	T-B law 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	1.0	0.00%
Mars	1.6	1.52	-4.77%
Ceres	2.8	2.77	-1.16%
Jupiter	5.2	5.2	+0.00%
Saturn	10.0	9.58	-4.45%
Uranus	19.6	19.2	-1.95%
Pluto	38.8	38.48	+1.05%

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

2. A Cosine Standing Wave and Titius-Bode Law

Consider a standing and cosine wave 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 $0.4 AU$, $0.7 AU$, $1 AU$, $1.3 AU$, $1.6 AU$, $\dots$ $2.8 AU$, $\dots$ 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, 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 TBL 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 packet". In this article, we will obtain the equation of this wave packet.

3. Solar System Wave Packet

As mentioned, a cosine and standing wave, with the wavelength $\lambda = 0.6 AU$ ($k = \frac{2\pi}{\lambda} = \frac{10\pi}{3}$), can predict the position of the planets in solar system. First, we want to derive the phase constant (ϕ_0) of this wave. Any wave in which the variables x and t are entered as a combination of $kx \pm \omega t$ is a traveling wave [2]. For example, $\sin(kx - \omega t + \phi_0)$ is a traveling wave. Thus, a standing wave is in the form of $\cos(\omega t) \cos(kx + \phi_0)$ or $\sin(\omega t) \cos(kx + \phi_0)$ or $\sin(\omega t) \sin(kx + \phi_0)$ or $\cos(\omega t) \sin(kx + \phi_0)$. As mentioned, a cosine standing wave can predict the positions of planets. Therefore, the form of the standing wave of solar system must be either $\sin(\omega t) \cos(kx + \phi_0)$ or $\cos(\omega t) \cos(kx + \phi_0)$ (In the following, we choose one of these two forms). For the nodes of these two standing waves, we have $\cos(kx + \phi_0) = 0$. As mentioned previously, Mercury is on the second node of Solar system wave (the second node corresponds to the phase $\frac{3\pi}{2}$ because $\cos \frac{3\pi}{2} = 0$). We have:

$$x_{Mercury} = 0.4 \text{ AU} \Rightarrow \psi(x_{Mercury}) = 0 \Rightarrow \cos(kx_M + \phi_0) = 0 \Rightarrow kx_M + \phi_0 = \frac{3\pi}{2} \xrightarrow{k=\frac{10\pi}{3}} \phi_0 = \frac{\pi}{6}$$

Having k and ϕ_0 , we can easily find the position of the other planets using the equation $kx + \phi_0 = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \dots, \frac{(2m-1)\pi}{2}$ (Where m is the node number). For example

$$kx_{Venus} + \phi_0 = \frac{5\pi}{2} \Rightarrow \frac{10\pi}{3}x_{Venus} + \frac{\pi}{6} = \frac{5\pi}{2} \Rightarrow x_{Venus} = 0.7 \text{ AU}$$

or

$$kx_{Earth} + \phi_0 = \frac{7\pi}{2} \Rightarrow \frac{10\pi}{3}x_{Earth} + \frac{\pi}{6} = \frac{7\pi}{2} \Rightarrow x_{Earth} = 1 \text{ AU}$$

$$kx_{Mars} + \phi_0 = \frac{11\pi}{2} \Rightarrow \frac{10\pi}{3}x_{Mars} + \frac{\pi}{6} = \frac{11\pi}{2} \Rightarrow x_{Mars} = 1.6$$

The distances of the other planets can also be calculated in the same way, which is quite consistent with experience. According to the above equation (namely $kx + \phi_0 = \frac{(2m-1)\pi}{2}$), Neptune is on the ninety-eighth node, which corresponds to the phase $\frac{195\pi}{2}$. Contrary to the TBL, which is not able to predict the distance of Neptune, our wave theory predicts the position of Neptune. Therefore, a cosine and standing wave with $\phi_0 = \frac{\pi}{6}$ and $k = \frac{10\pi}{3}$ can be attributed to solar system. But what is the general equation of this wave? As mentioned, the equation of solar system wave must contain a component with the equation $\cos(\frac{10\pi}{3}x + \frac{\pi}{6})$ and on the other hand, this wave must be a standing wave so that the position of the nodes (planets) does not change. Therefore, as mentioned, the form of solar system wave must be either $\cos(\delta wt) \cos(\frac{10\pi}{3}x + \frac{\pi}{6})$ or $\sin(\delta wt) \cos(\frac{10\pi}{3}x + \frac{\pi}{6})$. There is no difference between $\cos(\delta wt)$ and $\sin(\delta wt)$ Because we know from trigonometric identities that: $\cos(\delta wt) = \sin(\delta wt + \frac{\pi}{2})$. Therefore, we choose the function $\cos(\delta wt) \cos(\frac{10\pi}{3}x + \frac{\pi}{6})$. δ is a constant number. Since solar system has a certain size and is not infinitely wide, its wave must be localized (a wave packet). If we consider an expression in the form $e^{-\gamma x^2}$ (which is a Gaussian function and plays the role of the wave envelope) in the final equation of solar system wave packet, in such a case, the final equation is a localized wave or a wave packet¹. Thus, the primary form of the equation of SSWP is as follows (equation 1) and the planets are on the nodes of this wave packet (Fig. 1):

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

In equation 1, γ , C and δ are constant values and this is an empirical equation.

¹ Although a Gaussian wave packet is also infinitely wide, but it is very localized.

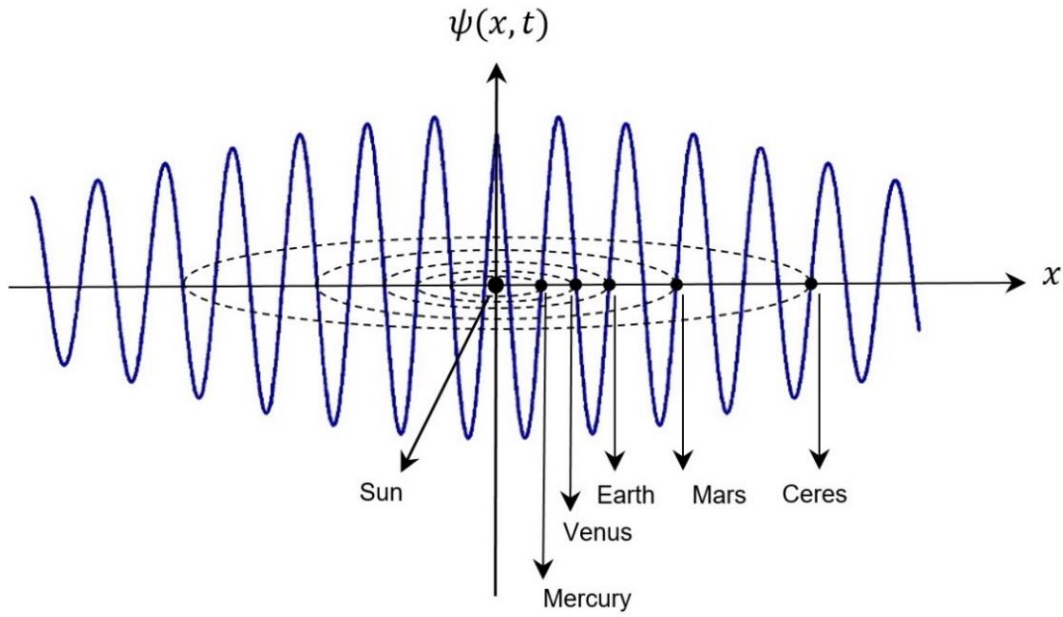


Fig. 1. Solar system standing wave packet with $\lambda = 0.6 \text{ AU}$ and $\phi_0 = \frac{\pi}{6}$. Diagram of $\psi(x, t)$ at the moment $t = 0$. The value of $\psi(0,0)$ equals $\sqrt{3}C/2$. This diagram is drawn by certain values C , and γ in equation 1 ($C = 0.75$ and $\gamma = 0.03$). As you can see, the planets are on the nodes of the wave packet. 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 be explained in the section 4: "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. Solar system wave packet (Fig. 1) is a standing wave that rotates, along with solar system, around the center of the Milky Way galaxy.

According to equation 1, the wave packet of solar system appears to be infinitely wide. But at long distances, the amplitude decreases drastically.

4. Elliptical Orbits

In this section we will show that the nebular theory without our wave packet theory is an incomplete theory and our wave packet model must be attached to the nebular theory in order to explain the formation of solar system.

The equation 1 in cylindrical coordinate (in cylindrical coordinate we have $x = r \cos \theta$) is:

$$x = r \cos \theta \Rightarrow \psi(r, \theta, t) = C \cos(\delta \omega t) \cos\left(\frac{10\pi}{3} r \cos \theta + \frac{\pi}{6}\right) e^{-\gamma(r \cos \theta)^2} \quad (2)$$

Figure 2 is the shape of figure 1 in three dimensions based on equation 2 ($C = 0.75$ and $\gamma = 0.03$):

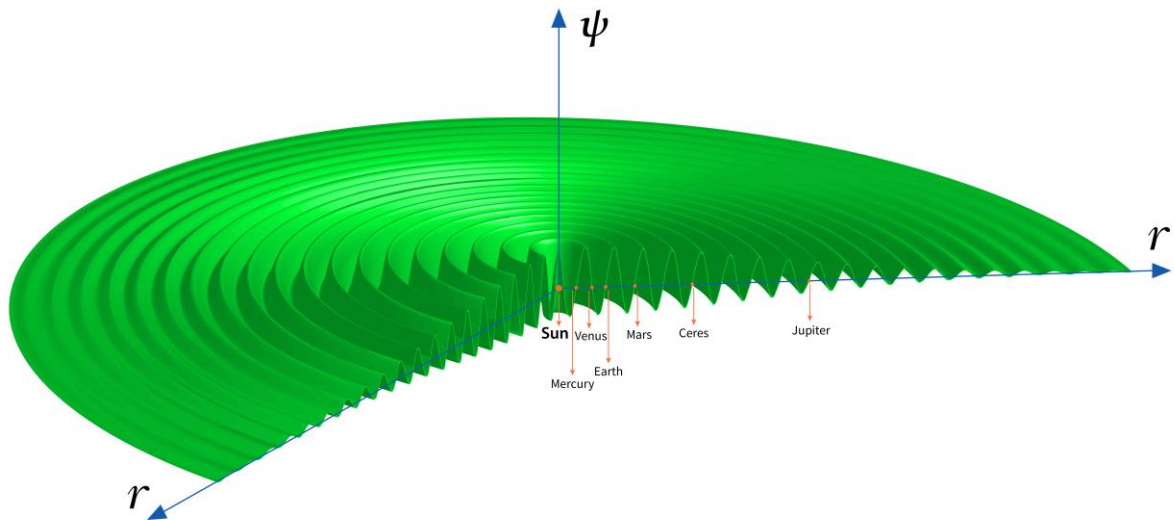


Fig. 2. The oscillation of solar system wave packet in three dimensions. Diagram $\psi(r, \theta, t)$ at the moment $t = 0$. Here the wave packet in Figure 1 is shown in three dimensions. Fig 2 is drawn in cylindrical coordinates using equation 2. Obviously, this wave packet continues indefinitely, based on equation 1 (or equation 2). Because of existence the exponential factor in equation 2, the amplitude of the wave gradually decreases while we move away from the ψ -axis.

As you can see in Fig. 1 and Fig. 2, because of symmetry of equations 1 and 2, the orbits, created by the SSWP, are circle. **But the real orbits of the planets are elliptic.** The reason of elliptic orbits is the existence of the inverse_square gravitational force of the sun². As you know, the sun formed earlier than the planets [3][4][5]. Simultaneously with the formation of the sun, about 4.6 billion years ago [4], its wave packet was also formed³, and the oscillation of this wave packet arranged and collected the gas-dust particles of Protoplanetary disk in regular orbits (Titius-Bode orbits). Just like the standing wave patterns on the kettledrum head in 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 circular nodes [6]. Similarly, because of oscillation of SSWP, in some nodes of the wave packet the gas-dust particles of protoplanetary disk agglomerated (like figure 3) and then compressed due to collisions with each other⁴ and then formed large grains, asteroids or planetesimals (which we call them **primary asteroids**), Protoplanets and finally planets, respectively⁵. **Simultaneously**, the inverse_square force of the sun was at work, and changed the circular orbits to elliptical orbits.

² 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.

³ The wave packet of the solar system probably was formed either when the sun was a protostar or when the newborn sun was entered to the Main-sequence. The distance between these two phases is very short (less than 50 million years) [3] and both phases occurred before the formation of the planets. In both states, we have no idea how and why this wave packet formed.

⁴ "Collisions" were more like gentle touches. The particles were far too small to attract each other gravitationally at this point, they were able to stick together through electrostatic forces—the same "static electricity" that makes hair stick to a comb [7].

⁵ 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 packet, 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 and the location of node is empty.

As you know, the mass distribution in the asteroid belt is ring-shaped, just like the powder ring in Figure 3, and this is another confirmation for our wave theory. Can a theory other than our wave theory explain the annular shape of the Asteroid belt? In asteroid belt, the process of planet formation has stopped at the Asteroids stage; Because of orbital resonances with Jupiter, Protoplanet and planet was not formed [8]. Orbital resonances with Jupiter disrupted the orbits of asteroids in the asteroid belt, preventing them from accreting into a planet. Many were ejected, but some remained and make up the asteroid belt today [8][9]. As we have said, based on our wave model and nebular theory, the formation of a planet is due to the cooperation of Solar System Wave Packet, electrostatic and gravitational forces. But in the asteroid belt, Jupiter has prevented this cooperation.

Although the largest mass of the asteroid belt, which has almost 30 % of the total mass of the belt (namely Ceres), is at distance 2.8 AU; But as the observations show, the asteroid belt is wide between 2.2 AU and 3.2 AU. In my opinion, at the beginning of the formation of the solar system, because of oscillation of SSWP, first, the asteroid belt formed at distance 2.8 AU (As we explained in the previous paragraph). In this distance and in the early years, some of the **primary asteroids** collided with each other and formed Ceres, due to the gravitational and electrostatic forces. But some of these primary asteroids were not absorbed by Ceres. In later years due to the collision of these remaining asteroids with each other, the Asteroid belt widened and the fragmented asteroids (**secondary asteroids**) were distributed at a distance 2.2 AU to 3.2 AU; with various Orbital eccentricities (from zero to above 0.3) and Orbital inclinations (from zero to $>20^\circ$). It is obvious that the strength of the collisions of primary asteroids with each other have been effective in the variety of eccentricities and orbital inclination of secondary asteroids.

In addition to the collision of primary asteroids with each other, the collision of a foreign object could also cause the belt to widen. Imagine that a set of primitive asteroids formed at a distance of 2.8 due to the oscillation of the wave packet. And all of them orbit around the sun with a same angular velocity. A collision of a celestial body with some of these early asteroids could disrupt all or part of the belt order and cause various collisions. Like a train hitting an obstacle that causes the wagons to crash. These collisions have led to the formation of secondary asteroids and the widening of the asteroid belt.

If SSWP did not exist; the planets might have been formed around the sun but the distance of planets from the sun was random and irregular. Without SSWP, it is not possible to reach to the TBL from the protoplanetary disk. Thus, it seems that the existence of a standing wave in the solar system is undeniable. Therefore, the nebular theory becomes more complete by our wave packet theory.

The reason why there is no planet in some nodes in figure 1 and 2 is due to the unbalanced mass distribution in the protoplanetary disk of solar system. Since the mass distribution in the Protoplanetary disk had not been uniform. During formation of the planets, in some nodes of the SSWP, 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 and the location of node is empty.



Fig. 3. Standing wave pattern on a kettledrum head. One of many possible standing wave patterns on a kettledrum head, made visible by dark powder sprinkled on the drumhead. As the head is set into oscillation at a single frequency by a mechanical oscillator at the upper left of the photograph, the powder collects at the nodes. Similarly, due to the oscillation of the SSWP the dust grains and gas of the solar system protoplanetary disk were collected in certain orbits.

5. What is Waving?

What is the nature of SSWP? In this section we will show that the oscillation of SSWP **probably** is the oscillation of Dark matter.

In this article, we showed that oscillation of a standing wave had been effective in the formation of orbits of solar system planets and created the Bode rule. On the other hand, we know that Dark matter interacts with baryonic matters (baryonic in astronomical terms) and affects them⁶. Therefore, it can be concluded that the oscillation of SSWP in Fig. 2 probably is the oscillation of Dark matter (or dark matter is one of the candidates for the nature of SSWP). Of course, the Spacetime also interacts with baryonic matter and affects it. But we cannot consider the oscillation of Spacetime as the wave of the solar system. Because in such a case the curvature of Spacetime lines in figure 3 causes the planets to move along the r-axis. We think this article could give scholars new ideas about dark matter. Of course, there is another possibility. This wave may not be dark matter. It might be something we are not familiar with.

Conclusion

In this article we proved that almost there is no doubt about the existence of a wave packet in the solar system. In this article we proved that the nebular theory without our wave packet theory is an incomplete theory and our wave packet model must be attached to the nebular theory in order to explain the formation of the solar system. Without the solar system wave packet, it is not possible to reach to the TBL from the protoplanetary disk. Is the description of TBL by a wave a coincidence? **This is very improbable.** The ring-shaped of Asteroid belt is

⁶ In addition to gravitational interactions, dark matter may also have elastic collision (like collision between drumhead and dark powder particles in Fig 3) with baryonic matter (namely objects made with protons, neutrons, and electrons like gas-dust particles in protoplanetary disk)

206 another confirmation for our wave theory. Can a theory other than wave theory explain the
207 annular shape of Asteroid belt? The annular shape of Asteroid belt and Titius-Bode Law are
208 two evidences for existence of SSWP.

209 Does SSWP still exist today? Or was it only present in the early days of the solar system
210 formation? I do not know and I have no idea about it.

211 Based on the discussions of section 5 we think this article could give scholars new ideas about
212 the nature of dark matter.

213 **References:**

- 214 [1]. Carrol, B. Ostlie, D. *An Introduction to Modern Astrophysics* (Cambridge University Press, Cambridge, ed.
215 2, 2017), pp. 716-717
216 [2]. Walker, J. Halliday, D. *Fundamentals of Physics*. (Wiley Ltd, ed. 10, 2007), pp. 449-450
217 [3]. Zeilik, M. *Astronomy. Ch. 14* (Cambridge University Press, ed. 9, 2002).
218 [4]. Bonanno, A. Schlattl, H. Paternò, L. The age of the Sun and the relativistic corrections in the EOS. *Astronomy*
219 *and Astrophysics*. **390** (3). 1115–1118 (2002)
220 [5]. Williams, J. Cieza, L. Protoplanetary Disks and Their Evolution. *Annual Review of Astronomy and*
221 *Astrophysics*. **49**: 67–117 (2011)
222 [6]. Rossing, T. The Physics of Kettledrums. *Scientific American*, **247**, No. 5, 172-179 (1982)
223 [7]. Bennett, J & et al. *The Essential Cosmic Perspective* (Addison-Wesley, ed. 6, 2012), page 165
224 [8]. Bennett, J & et al. *The Essential Cosmic Perspective* (Addison-Wesley, ed. 6, 2012), page 263-265
225 [9]. Bennett, J & et al. *The Essential Cosmic Perspective* (Addison-Wesley, ed. 6, 2012), page 280