Looking for alternatives to Bode's Law

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This article is a rewriting of the one published in the 18th release of the students magazine of the Faculty of Physics of the University of Barcelona called "Plant 8" published in May 1983.

(Mistakes have been corrected and the reading of the tables has been detailed)

Key word: quantization of planetary orbits

Introduction

Bode's law is an empirical rule formulated for the first time by the German astronomer Wolf (1741), copied by Titius (1772) and disclosed by Bode (1778), that offers the values of the average distances of the planets to the Sun.

A way to obtain it is by assigning natural numbers to planets 0,1,2,...., etc., and replacing them in the expression

d= 0.4 + 0.3 * 2^(n-1)

and imposing in n=0, "d" to be 2/5 ("d" is the distance expressed in astronomical units).

The obtained series fits well for Mercury, Venus, the Earth, Mars, the average of the asteroid belt, Jupiter, Saturn and Uranus. For Neptune and Pluto there is no such a match. (see table (1))

Remembering that Bode's law was disclosed in 1778, it is necessary to say that Uranus was discovered as a planet in 1781 by F.W. Herschel and whose distance to the Sun matches the value which Bode's law proposed for n=7. Only three years after its spreading, Bode's law achieved its first success.

In 1801 and 1802 the asteroids Juno and Vesta were discovered, and Ceres and Palas were discovered in 1847 (to name the four more shining asteroids). This supposed a new success because the asteroids filled up the emptiness that existed in the value of the law for n=4.

But Neptune, discovered in 1846, and soon Pluto, in 1930, has deferred more and more from the values assigned by the law for n=8 and n=9.

Let us remember the history of the planets that refuse to obey the law. Neptune was discovered on the 13th of September of 1846 by Galle in the observatory of Berlin, when he was studying an area in the sky where Leverrier had anticipated the existence of an unknown body that justified the disturbances observed in the Uranus movement.

Pluto was discovered in 1930 by Clyde Tombaugh of the Lowell observatory. The same Lowell, in 1915 had predicted the existence of a new outer planet to Neptune that satisfactorily explained the disturbances that the orbit of Uranus kept suffering. But the discovery obtained in the observatory was accidental, because Pluto does not have sufficient mass to disturb the Uranus movement. The Uranus disturbances have not been justified yet.

Exposition

Being empirical laws, I raise the alternative that not all the planets have to obey a same law. Some can fulfill one, and others can obey a different law, and even not all the levels of a given law have necessarily to be complete.

According to this, that is without imposing that the law is unique and without gaps, I have obtained two different alternatives. One of them is a minimum modification to the Bode's law, and the other is completely different, and where it can be seen that the disposition of the planetary orbits is very similar to the disposition of the electronic levels in the Bohr atom.

Table 1:

Planet	**Distance**	**Formula**	**Number**	**Difference**	**Discrepancy**
Mercury	0.39	0.40	0	- 0.01	- 2,5 %
Venus	0.72	0.70	1	+ 0.02	+ 2,8 %
The Earth	1.00	1.00	2	+ 0.00	+ 0.0 %
Mars	1.52	1.60	3	- 0,08	- 5.0 %
Ceres-Palas	2.77	2.80	4	- 0.03	- 1.0 %
Asteroids	2.90	2.80	4	+ 0.10	+ 3.5 %
Silvia-Camila	3.48	------	------	------	-----
Jupiter	5.20	5.20	5	+ 0.00	+ 0.0 %
Saturn	9.54	10.00	6	- 0.46	- 4.6 %
Uranus	19.20	19.60	7	- 0.40	- 2.0 %
Neptune	30.09	38.80	8	- 8.69	- 22,5 %
Pluto	39.52	77.20	9	- 37.70	- 48,8 %

The previous table (1) could express Bode's law as it is understood at the present time.

Reading from right to left, the first column (under the heading "Planet") expresses the name of the star to whom the data in the row refer.

The second column (under the heading "Distance") expresses the average distance to the Sun expressed in astronomical units.

The third column (under the heading "Formula") expresses result of applying the formula of the distance of Bode's law for each planet.

The fourth column (under the heading "Number") expresses the assigned natural number to the star in the formula of Bode's law.

The fifth column (under the heading "Difference") is the difference between the second and third columns.

The sixth column (under the heading "Discrepancy") expresses the relative inaccuracy calculated as the quotient between the fifth and third columns.

Table 2:

Planet	**Distance**	**Formula**	**Number**	**Difference**	**Discrepancy**
Mercury	0.39	0.40	0	- 0.01	- 2,5 %
Venus	0.72	0.70	1	+ 0.02	+ 2,8 %
The Earth	1.00	1.00	2	+ 0.00	+ 0.0 %
Mars	1.52	1.60	3	- 0,08	- 5.0 %
Ceres-Palas	2.77	2.80	4	- 0.03	- 1.0 %
Asteroids	2.90	2.80	4	+ 0.10	+ 3.5 %
Silvia-Camila	3.48	------	------	------	-----
Jupiter	5.20	5.20	5	+ 0.00	+ 0.0 %
Saturn	9.54	10.00	6	- 0.46	- 4.6 %
Uranus	19.20	19.60	7	- 0.40	- 2.0 %
Neptune	30.09	------	------	------	------
Pluto	39.52	38.80	8	- 0.72	+ 1.8 %

The previous table (2) is organized in the same way as table (1) and it expresses the modified Bode's law.

The only modification is to consider that Bode's law does not refer to Neptune and that therefore Pluto is assigned value n=8. [1]

Once this modified Bode's law was obtained, I wondered if it would be possible to find another different law which allowed to obtain such a sufficiently exact expression.

Observing a table of average distances expressed in astronomical units (the average distance from the Earth to the Sun is taken as a unit) I could not appreciate any simple relation. It occurred to me, I do not know exactly why, to build up a table in which the unit were the value of the average distance from Mercury to the Sun, I will call that unit "Mercury".[2]

The only thing that I observed was that the value of the distance corresponding to Pluto was about 100 times greater than the value of the distance corresponding to Mercury, that is, it was about 100 times the value taken as a unit in this new table.(see table (3))

Pluto is the tenth planet to which the Bode's law without modification talks about. If I made the square root of the average distance from Pluto to the Sun expressed in mercury units, I obtained approximately value 10. Was it by chance? What would happen when making the square root of the values of the average distances of the remaining planets?

Table 3:

Planet	**Distance**	**Root**	**Number**	**Difference**	**Discrepancy**
Mercury	1.00	1.00	1	+ 0.00	+ 0.0 %
Venus	1.86	------	------	------	------
The Earth	2.58	------	------	------	------
Mars	3.93	1.98	2	- 0,02	- 1.0 %
Ceres-Palas	7.15	------	------	------	------
Asteroids	7.44	------	------	------	------
Silvia-Camila	8.99	2.99	3	- 0.01	- 0.1 %
Jupiter	13.43	3.66	4	- 0.34	- 8,5 %
Saturn	24.64	4.96	5	- 0.04	- 0.8 %
Preuranus	------	------	6	------	------
Uranus	49.12	7.01	7	+ 0.01	+ 0.1 %
Posuranus	------	------	8	------	------
Neptune	77.70	8.81	9	- 0.19	- 2.1 %
Pluto	102.03	10.10	10	+ 0.10	+ 1.0 %

The previous table (3) shows the result. The table is similar to the previous ones but the square root of the average distance expressed in mercury units is compared to a natural number.

The second column (under the heading "Distance") expresses the average distance to the sun expressed in mercury units.

The third column (under the heading "Root") expresses the square root of the values in the second column,

The fourth column (under the heading "Number") assigns a natural number to the star or planet,

The fifth column (under the heading "Difference") is the difference between second and third columns,

The sixth column (under the heading "Discrepancy") shows the relative inaccuracy as the quotient between the fifth and fourth columns.

I will call the obtained empirical law “Mercury Law" and its expression is:

$$d = n^2$$

We can say that the fact that Bode’s law without modification assigned the tenth place to Pluto as the Mercury Law does is a coincidence, since the Mercury Law does not consider two of the planets (Venus and the Earth), but in counterpart, the Mercury Law allows the possibility of the existence of two planets or asteroids unknown to me, near Uranus and corresponding to n=6 and n=8. The final result is that Pluto equally occupies the tenth place (n=10).

In addition, while Bode’s law is as acceptable for the pair of asteroids Ceres and Palas, as it is for the average of asteroids, the "Mercury Law" is only valid for the pair of asteroids Silvia and Camila.

Another difference is that Jupiter that fits very well for n=5 for Bode’s law, is the one that worse fits in the Mercury Law. The existence of two gaps in n=6 and n=8 in the Law Mercury can make us think that the disturbances that Uranus undergoes can be due to the action of one of bodies corresponding to n=6 and n=8, both unknows to me. [3]

The existence of planet wich do not follow the modified Bode's law (the case of Neptune) or that do not follow the Mercury Law makes us suppose of the existence of another or other laws that correspond to these stars.

A conclusion that I believe it's interesting is: "the amount of angular moment for mass unit of planets or asteroids that obey the mercury law approximates to a multiple whole number of a certain constant value".

The name of "Mercury Law" comes from the fact that it is average distance from this planet to the Sun the one that we take as a unit.

Explanation: The values of the tables are an approach up to hundredth.

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Interjection [1]: just a short time after the publication of the article I discovered that this modification had aready been raised by others.

Interjection [2]:the underlined text is an addition. I have recently known that J. Conklin has carried out something similar.

Interjection [3]: Chiron was discovered in 1977 by Kowal, but in 1983 I did not know about it.

- Obtained documentation of the library of the Faculty of Physics of the University of Barcelona (Spain).