Analysis of Kepler’s law to the movement of celestial bodies

Galuh Titi Fatimah, Dian Marini, Supardi, and Akhmad Aminuddin Bama*

Dept. of Physics, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indonesia,

Email: galuhtitifatimah@gmail.com,
*Corresponding author: akhmadbama@yahoo.com

Abstract. Unity of planetary movement theory from Newton's law and Kepler's law shows the orbiting motion of the planet to the sun. Kepler’s law illustrates the movement of planets orbiting the sun, assuming the sun is silent, thereby exposing the path of the orbits of planets that are often encountered so far. In fact, the sun also moves towards a certain center, so that the form of a planetary orbital path that is so closed is not a reflection of the actual movement of the planet. When the sun moves then the movement of the planet is not an elliptical but rigid. In addition the earths movement orbiting the sun is not as simple as it is described, because it is not just the earth that orbits the sun but there are other celestial bodies that also orbits the sun. So it is necessary to show the relationship of the movement of other planets to the movement of the earth around the sun. The purpose of this study is to find out the relation between the movement of other planets to the earths motion orbiting the sun and to know the true orbit path of the planets as the sun moves too. From this study, it can be seen that the use of Kepler's law equations and Newton's laws that have existed so far is not for the actual movement of the solar system, because many factors influence. During this time, the use of Kepler's law and Newton's law for the movement of the earth and the sun always considered their physical conditions ideal, assuming the sun was silent. The actual conditions of the sun moving, the shape of the trajectory of the movement of celestial bodies is not elliptical but rigid.

1. Introduction
The theory of the planets evolve as stated that the sun is the center of the solar system, causing her circulating around the heavenly bodies. It shored up by theory put forward by Isaac Newton on the gravitational explaining the interaction of celestial bodies, and the orbit put forward by Johannes Kepler suggested that the planets around the sun with a ellipsoidal. And the planetary motion within the solar system described in the three laws of Kepler and Newton explaining the interplay of the two celestial bodies [9]. Kepler spend three laws, (1) orbit planet is an ellipse with the sun is at a single focus; (2) segments line connecting a planet and the sun sweep the same area during the interval the same time; (3) square of the period orbit of a planet comparable to cube of the axis semi-mayor orbit. While newton explain how much the force of attraction on both it [7]. Both theory that suggested Newton and Kepler both consider the sun as the center of the solar system in a state of silence.

In analyzing the circulation of the planet, Kepler explained that the orbit of each planet succeeded in forming an ellipse with the sun in a state at one of its focal points. A new phenomenon called sunrise lately where it is said that the sun also occurs in the universe. In the entire solar system it moves to orbit the Milky Way galaxy. If the sun moves with the center of the galaxy, the shape of the
planet's trajectory can no longer be done, so it will have another form that is not conic. So, how does the Kepler theory apply, which states that planetary orbits help the sun form an ellipse? By this matter, in this paper an analysis of the laws will be carried out in terms of explaining the circulation of celestial objects in the sun.

The movement of celestial bodies, for example planet earth, around the sun and the moon around the earth can be understood through the laws of gravity and the laws of motion of mechanics. According to Newton's law, if the influence of the gravitational force of other planets in the solar system on a single planet is ignored and only the influence of the gravitational force by the sun is observed, the orbit will be a perfect ellipse with the sun at one of its fire points. But if the influence of the other planet's gravitational force is taken into account, the orbit of the planet Mercury is no longer a perfect ellipse [2]. Based on this, in this paper an analysis will be carried out regarding the interaction of planets with the sun if other planetary motions are taken into account. How do the sun and earth interact when the movements of Venus and Mars are also taken into account.

2. Kepler’s Law

The night sky with myriad stars and glowing planets always fascinates people. Towards the end of the sixteenth century, astronomer Tycho Brahe studied the movements of the planets and made far more accurate observations than previously available. Using Brahe data, Johannes Kepler discovered that the planetary pathways about the Sun were ellipses.

He also pointed out that each planet moves faster when its orbit brings it closer to the Sun and slower when its orbit takes it farther. Finally, Kepler developed the exact mathematical relationship between the planet's orbital period and the average distance from the Sun. He stated these results in three laws of empirical planetary motion. In the end, these laws formed the basis of Newton's discovery of the law of gravity.

2.1. Kepler's I Law

Kepler's I Law describes the shape of a planet's orbit that reads "The trajectory of each planet around the Sun is an ellipse with the Sun located at one of its focal points."

Ellipses are flat shapes that are one of cone slices (other than circles, hyperboles, and parabola). With eccentricity (spike level) the ellipse is between 0 and 1. The trajectory of a planet around the Sun will be an ellipse, and the sun will always be in one of these two foci, as illustrated in figure 1.

![Figure 1. The path of a planet around the Sun. The Sun is at one of its focal points (F1 or F2)](image)

If the position of the planet changes then the distance \( r_1 \) (the distance of the planet from F1) and \( r_2 \) (the distance of the planet from F2) also changes. If \( a \) is called the semi-major axis, \( b \) is called the semi-minor axis, and \( c \) is from the center point to F1, then

\[
c^2 + b^2 = a^2
\]  

(1)
The shape of the elliptical orbit is determined by the eccentricity \((e)\) of the ellipse. The smaller the eccentricity, the elliptical shape will be closer to the circle shape. Conversely, if the eccentricity gets bigger, the ellipse shape will be elongated and thin. Eccentricity distance is a ratio of distance \(c\) to distance \(a\).

\[
e = \frac{c}{a}
\]

(2)

The farthest distance of the planet from the Sun is called the aphelium point. Meanwhile, the planet's closest distance from the Sun is called the perihelium point. If it is considered the Sun is in F1, the distance between the perihelium and the aphelium is

Distance Perihelion \(= (a - c) = a(1 - e)\)  
Distance Aphelion \(= (a + c) = a(1 + e)\)

(3)

(4)

Technically, the ellipse is not the same as a circle, but most planets follow a low-eccentric orbit (approaching a perfect circle). Therefore, in carrying out orbit calculations the Planet is usually considered to be a perfect circle.

The ellipse is the place of the points whose sum of distances from two fixed points, called F, is constant, as shown in Figure 1 showing the planet following an elliptical path with the Sun at one focus. The Earth's orbit is almost circular, with the distance to the Sun at the perihelion (closest point) being \(1.48 \times 10^{11}\) m and at the aphelion (farthest point) being \(1.52 \times 10^{11}\) m. The semimajor axis is equal to the mean of these two distances, that is (93 million miles) for Earth orbit. This meaningful distance defines an astronomical unit (AU): \(1AU = 1.50 \times 10^{11} m = 93 \times 10^6\) mil.

2.2. Kepler's II Law

Kepler's II Law explains the speed of the planet's orbit. The line that connects any planet with the Sun sweeps the same area at different times.

The sound of Kepler's second law is "Every planet moves so that an imaginary line drawn from the Sun to the planet covers the same area in the same time". As a simple illustration, reviewed in Figure 2. In that picture, it can be seen that in the same time frame, the area of triangle \(\triangle MAB\) is equal to the area of triangle \(\triangle MCD\). This has the effect that if the path is an ellipse, the length of the arc (trajectory) traveled by the motion of the planet from A to B is different from the path C to D.

Thus the rate of the planet orbiting is also not the same at each track point in the shape of an ellipse. In the depiction of Planet and Sun shown in Figure 2, the planet will travel faster when the planet is closer to the Sun (from A to B) and the planet will move more slowly, when the planet is far from the Sun.

![Figure 2. The planet moves to form the triangle path AMAB and ΔMCD in the same time span](image)

2.3. Kepler's III Law

Kepler's III Law describes the planetary revolution period which is associated with the path of its average orbit, namely "The planetary square squares around the sun in proportion to the three-degree
average distance of the planet from the Sun." If the major spring axis \((a)\) is expressed as a orbit orbit \((r)\) and the planetary revolution period is expressed as \(T\), then Kepler's III law can be written as

\[
\frac{T_1^2}{r_1^3} = \frac{T_2^2}{r_2^3}
\]

In accordance with this law, the speed and position of the planet's motion changes periodically so that it can be used to determine the period of travel of the planet around the sun \([1]\).

3. **Newton's Law of Gravity**

In the 17th century Sir Isaac Newton (1642-1727), revealed that gravitational forces or commonly referred to as gravity cause interactions between two objects, which are gravitational or gravity forces generated by the mass of the two objects. This force will always attract other objects that also have mass.

Newton's idea of the gravitational force inspired when he saw an apple falling from the tree. The apple that falls down the motion is accelerated due to the gravitational pull that comes from the center of the earth, so that apples and the earth experience interaction. These interactions are called gravitational interactions, namely interactions that occur between two objects in mass such that there is an attraction between the two objects Figure 3 \([11]\). According to Newton, "Gravitational force is proportional to the two interacting masses and is inversely proportional to the square of the distance between the two".

Mathematically this statement can be written as

\[
\vec{F} = G \frac{Mm}{r^2} (-\hat{r})
\]

The use of Newton's law has ignored other celestial bodies around it. If other celestial bodies are taken into account how the planet interacts? Can any other planet affect the interaction of two planets?

4. **Movement of the Earth and the Sun**

More accurate measurement results allow that the motion of the planets does not exactly follow Kepler's law. For example, a planet's motion deviation has been detected against the path of its elips. According to Newton it happened because of the planet's gravitational interaction not only with the Sun, but also with other planets. This deviation or perturbation is a clue for Newton to form his universal gravitational theory \([5]\).

Based on the theory that developed, the Sun is the center of the solar system, so that the planets around it circulate around it. In addition, the Sun also runs in the universe around the galaxy as the moon travels around the earth.

According to the calculations of astronomers, the Sun moves with a speed of approximately 720 thousand km per hour. That means the Sun moves as far as approximately 17,280,000 kilometers a day. Together with the Sun, all planets and satellites in the sun's gravitational system (solar system) also travel this distance. The solar system surrounds the center of the galaxy that is so vast and far away. Until now, it is known (from the latest data) that the diametric size of the Milky Way galaxy ranges from 150,000 light years. This galaxy, containing 200 to 400 billion stars, with an estimated 50 billion planets in existence, 500 million of which can be found at the center of the Milky Way galaxy.

The Milky Way Galaxy moves at speeds of 552-630 km per second. The sun moves 720 thousand km per hour and requires 230 million years to complete one round around the Milky Way galaxy. The day goes around the galactic center in a spiral-like shape that runs up and down, with one cycle of
rotation from the north to the south point for 30 million years. All these celestial bodies move in the circulation line for millions of years. Each moves along its path in perfect harmony and order along with others. All celestial bodies including planets, satellites that accompany planets, stars, and even galaxies, have their respective orbit or orbit [4].

Until now the theory that developed (assumed to be true) was the theory which states that planets, such as the Earth, surround the Sun. The magnitude of the average speed of the Earth around the Sun can be obtained by assuming that:

- Earth's track or orbit is a perfect circle
- The sun stays in the center of the circle
- The distance of the Earth's orbit around the Sun is known
- The Earth's Period around the Sun is known

with the distance of the Earth's orbit around the Sun (r) it is considered 1, 496 × 1011m (Grayzeck, 2016).

Next to the Earth around the Sun, it turns out that the Sun also surrounds the center of the galaxy. The average speed of the Sun around the center of the galaxy can be obtained by assuming that:

- The path or orbit of the Sun is a perfect circle
- The center of the galaxy is silent
- The distance of the Sun's orbit around the center of the galaxy is known
- The period of the Sun around the galaxy is known

with the distance of the Sun's orbit around the galaxy (r) it is considered 2,36518 × 1020m, (Coffey, 2011).

As discussed in Subsection 2.1, Kepler's law deals only with simple closed paths (especially ellipses or circles) for planets with the Sun located at one focal point. According to the law, one circulation of the planet surrounds the Sun to form an ellipse. The trajectory occurs when the beginning and end ends are at the same point. If the Sun moves then the trajectory of the planet's orbit does not form a closed path (ellipse) as assumed by Kepler, but forms a rolling path as shown in Figure 4.

![Figure 4](image.png)

**Figure 4.** The path of the planet around the sun assuming the sun moves

In searching for interactions 2 celestial bodies always ignore other celestial bodies. But actually other celestial bodies also influence their interactions. So the notion of the interaction of celestial bodies that have been there is not necessarily true.

5. Conclusion

The conclusion of this paper is to illustrate that the presumption over the use of Kepler's law could be wrong. Because the use of Kepler's law has assumed the sun is silent, so it can conclude that the trajectory of the planet's orbit is elliptical. In fact, the sun moves towards the center of the solar system. If the Sun moves around the center of the galaxy, then the orbit of the Planet to the Sun cannot form a closed path in the form of an ellipse but forms a rolling path. If the trajectory of the planet's orbit to the Sun scrolls, the speed of the Earth's orbit (when the Sun is still) is not the actual speed.

From this study, it can be seen that the use of Kepler's law equations and Newton's laws that have existed so far is not for the actual movement of the solar system, because many factors influence. During this time, the use of Kepler's law and Newton's law for the movement of the earth and the sun always considered their physical conditions ideal, assuming the sun was silent. The actual conditions of the sun moving, the shape of the trajectory of the movement of celestial bodies is not elliptical but rigid.
Describing that the assumption over the planetary interaction has been wrong. Because all this time in searching for interaction two celestial bodies always ignore other celestial bodies, whereas other celestial bodies can also influence the interaction of two celestial bodies.

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