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RESEARCH ARTICLE

The Force of Gravity in the Solar System is in the Form of a Spring

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ABSTRACT

I mathematically proved that the laws of the spring apply to the law of gravity, and I was able to determine the speed of the planet mathematically, the period it takes to complete a complete revolution around the sun, and the force with which the planet moves through the laws of the spring. This confirms that the force of gravity between the planet and the sun is in the form of a spring, which explains the following: for example, when the Earth is at the closest possible point to the sun, the Earth moves away from the sun, even though the force of gravity is as great as possible. This behavior of maximum compression of the spring is called the maximum compression gravitational force. It also explains that when Earth is at the furthest possible point from the sun, it approaches the sun again, even though the force of gravity is as small as possible. This behavior of the maximum expansion of the spring is called the maximum expansion of the gravitational force.

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1. Introduction

The solar system is a vast and complex system held together by gravity. The Sun, which contains 99.8% of the solar system's mass, is the center of this gravitational pull. Planets, moons, asteroids, comets, and dust all orbit the sun according to gravity laws. Gravity is the force of attraction between two mass objects. The greater an object's mass, the greater its gravitational pull. The Sun has a very large mass, and thus, its gravitational pull is very strong. This is why planets orbit the sun in nearly circular paths. Planets also have their own gravitational pull. This is why the Moon orbits the planets. For example, the Moon orbits the Earth because of its gravitational pull. Solar power systems are constantly evolving. The planets slowly moved away from the sun, and the moon slowly moved away from the planets. This is because of the planets' force and the moon's gravity. Gravity is also responsible for the formation of stars and galaxies. When a large cloud of gas and dust collapses under gravity, it forms a star. The star's gravity then pulls more gas and dust, which eventually forms planets. Without gravity, the solar system cannot exist. The planets would not orbit the sun, the moons would not orbit the planets, and stars and galaxies would not form. Gravity is a fundamental force in nature that supports life. Gravity is a fascinating and mysterious phenomenon. We are still learning how it works, but we know it is essential for the solar system and the universe's existence. See the NASA data in Table I [1].

2. Methods

The Earth revolves around the sun in a complete cycle during a specific period in a fixed orbit. This cycle was repeated continuously, as shown in Fig. 1.

As we study the Earth's movement around the sun, we find that it is mathematically similar to the spring's movement. When the earth reaches its maximum distance from the sun, 152×10^6 km, it represents the spring's expansion. Then, once the earth reaches the closest distance to the sun at

TABLE I: NASA Data

	Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mass (10^{24} kg)	0.330	4.87	5.97	0.073	0.642	1898	568	86.8	102	0.0130
Distance from sun (10^6 km)	57.9	108.2	149.6	0.384	228.0	778.5	1432.0	2867.0	4515.0	5906.4
Perihelion (10^6 km)	46.0	107.5	147.1	0.363	206.7	740.6	1357.6	2732.7	4471.1	4436.8
Aphelion (10^6 km)	69.8	108.9	152.1	0.406	249.3	816.4	1506.5	3001.4	4558.9	7375.9
Orbital period (days)	88.0	224.7	365.2	27.3	687.0	4331	10,747	30,589	59,800	90,560
Orbital velocity (km/s)	47.4	35.0	29.8	1	24.1	13.1	9.7	6.8	5.4	4.7

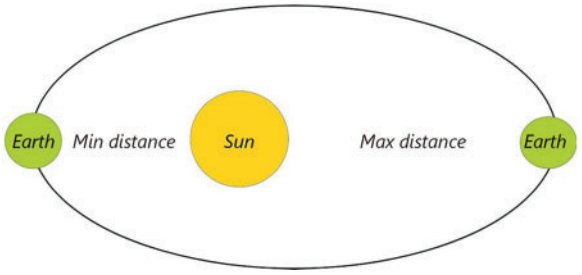

Fig. 1. Earth's orbit around the sun.

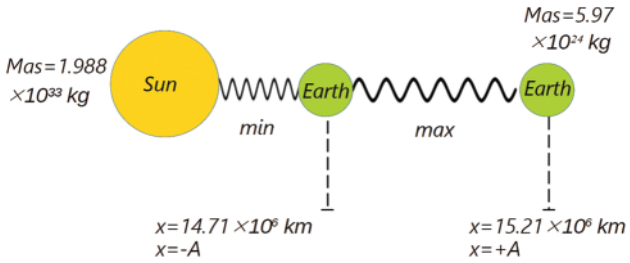

Fig. 2. The maximum and minimum distance to earth.

147.1×10^6 km, it represents the spring's contraction. This movement is repeated by the earth moving away and approaching the sun, as if the spring were expanding and contracting, as shown in Fig. 2.

Let's calculate the spring constant k using $F = -kx$, [2] but we need to find the value of F force of gravity using Newton's law $F = G\frac{m_1 m_2}{d^2}$.

$$G = 6.673 \times 10^{-11}\ \mathrm{m^3/kg\ s^2};\ \textit{Sun}\ m_1 = 1.988 \times 10^{30}\ \mathrm{kg};\ \textit{Earth}\ m_2 = 5.97 \times 10^{24}\ \mathrm{kg}$$

First, calculate F when the earth is in the closest place to the sun, which is $d = 147.1 \times 10^6$ km.

$$F = 6.673 \times 10^{-11}\frac{1.988 \times 10^{33} \times 5.97 \times 10^{24}}{(147.1 \times 10^9)^2}$$

$$F = 3.66 \times 10^{22} N$$

To calculate the spring constant k, we use the following formula $F = -kx$:

$$3.66 \times 10^{22} = k \times 147.1 \times 10^9$$

$$k = 24.88 \times 10^{10}\ \mathrm{N/m}$$

Secondly, the calculation of F when the earth is in the farthest place from the sun which is $d = 152.1 \times 10^6$ km.

$$F = 6.673 \times 10^{-11}\frac{1.988 \times 10^{33} \times 5.97 \times 10^{24}}{(152.1 \times 10^9)^2}$$

$$F = 3.423 \times 10^{22}\ \mathrm{N}$$

To calculate the spring constant k, we use the following formula $F = -kx$:

$$3.423 \times 10^{22} = k \times 152.1 \times 10^9$$

$$k = 22.51 \times 10^{10}\ \mathrm{N/m}$$

The rest of the solar system is shown in Table II. The next step is to prove the validity of the k value for the entire solar system.

TABLE II: K CONSTANT

	Mercury	Venus	Earth	Moon	Mars
Mass (10^{24} kg)	0.330	4.87	5.97	0.073	0.642
Distance from Sun (10^6 km)	57.9	108.2	149.6	0.384	228.0
Perihelion (10^6 km)	46.0	107.5	147.1	0.363	206.7
Aphelion (10^6 km)	69.8	108.9	152.1	0.406	249.3
F force of gravity Perihelion (N)	2.069×10^{22}	5.59×10^{22}	3.66×10^{22}	2.2×10^{20}	1.99×10^{21}
F force of gravity Aphelion (N)	8.98×10^{21}	5.44×10^{22}	3.424×10^{22}	1.7×10^{20}	1.37×10^{21}
k Perihelion (N/m)	44.98×10^{10}	52×10^{10}	24.88×10^{10}	60.79×10^{10}	0.9643×10^{10}
k Aphelion (N/m)	12.87×10^{10}	50×10^{10}	22.51×10^{10}	43.45×10^{10}	0.5496×10^{10}
	Jupiter	Saturn	Uranus	Neptune	Pluto
Mass (10^{24} kg)	1898	568	86.8	102	0.0130
Distance from Sun (10^6 km)	778.5	1432.0	2867.0	4515.0	5906.4
Perihelion (10^6 km)	740.6	1357.6	2732.7	4471.1	4436.8
Aphelion (10^6 km)	816.4	1506.5	3001.4	4558.9	7375.9
F force of gravity Perihelion (N)	4.59×10^{23}	4.08×10^{22}	1.54×10^{21}	6.76×10^{20}	8.76×10^{16}
F force of gravity Aphelion (N)	3.77×10^{23}	3.32×10^{22}	1.27×10^{21}	6.51×10^{20}	3.1×10^{16}
k Perihelion (N/m)	61.98×10^{10}	3.01×10^{10}	5.6×10^{8}	1.5×10^{8}	1.97×10^{4}
k Aphelion (N/m)	46.27×10^{10}	2.2×10^{10}	4.2×10^{8}	1.4×10^{8}	4.29×10^{3}

2.1. Proofing 1

The speed at which the planets of the solar system rotate around the sun is known. According to NASA data, Earth's speed around the sun is 29.8 km/s. Spring movement can be used to calculate the speed of the attached body.

The following law $v = A\sqrt{k/m}$ [2] uses the spring constant to calculate the speed. For Earth at $A = 147.1 \times 10^9$ m, $k = 24.88 \times 10^{10}$ N/m, m $= 5.97 \times 10^{24}$ kg.

$$v_{preihelion} = 147.1 \times 10^9 \sqrt{\frac{24.88 \times 10^{10}}{5.97 \times 10^{24}}}$$

$$v_{preihelion} = 30.03 \text{ km/s}$$

Earth at $A = 152.1 \times 10^9 \text{m}, k = 22.51 \times 10^{10}$ N/m, m $= 5.97 \times 10^{24}$ kg.

$$v_{aphelion} = 152.1 \times 10^9 \sqrt{\frac{22.51 \times 10^{10}}{5.97 \times 10^{24}}}$$

$$v_{aphelion} = 29.53 \text{ km/s}$$

$$v_{average} = \frac{30.03 + 29.53}{2} = 29.784 \text{ km/s}$$

Using the spring law, we calculated the spring constant, which corresponds to the observed speed of Earth. This proves our theory that a force other than gravity exists. Table III lists all members of the solar system. The spring constant in this table accurately calculates the speed of the planet's flow, which is comparable to NASA's calculations.

2.2. Proofing 2

We know that the Earth's rotation period around the sun is 365.2 days, according to NASA data. According to this law, $T = 2\pi\sqrt{m/k}$ [2] we can calculate the duration of the Earth's rotation around the sun in terms of the spring constant.

If $k = 24.88 \times 10^{10}$ N/m, $m = 5.97 \times 10^{24}$ kg,

$$T_{perihelion} = 2\pi\sqrt{\frac{5.97 \times 10^{24}}{24.88 \times 10^{10}}}$$

$$T_{perihelion} = 30778102.8\,s = 356.23\,days$$

TABLE III: Velocity

	Mercury	Venus	Earth	Moon	Mars
NASA orbital velocity (km/s)	47.4	35.0	29.8	1	24.1
k Perihelion (N/m)	44.98×10^{10}	52×10^{10}	24.88×10^{10}	60.79×10^{10}	0.9643×10^{10}
k Aphelion (N/m)	12.87×10^{10}	50×10^{10}	22.51×10^{10}	43.45×10^{10}	0.5496×10^{10}
Velocity Perihelion related to k (km/s)	53.70	35.12	30.03	1.04	25.33
Velocity Aphelion related to k (km/s)	43.60	34.90	29.53	0.99	23.06
Velocity average related to k (km/s)	48.65	35.015	29.784	1.019	24.2
	Jupiter	Saturn	Uranus	Neptune	Pluto
NASA orbital velocity (km/s)	13.1	9.7	6.8	5.4	4.7
k Perihelion (N/m)	61.98×10^{10}	3.01×10^{10}	5.6×10^{8}	1.5×10^{8}	1.97×10^{4}
k Aphelion (N/m)	46.27×10^{10}	2.2×10^{10}	4.2×10^{8}	1.4×10^{8}	4.29×10^{3}
Velocity Perihelion related to k (km/s)	11.56	9.89	6.96	5.44	5.46
Velocity Aphelion related to k (km/s)	12.74	9.38	6.64	5.39	4.24
Velocity average related to k (km/s)	12.15	9.63	6.8	5.42	4.85

TABLE IV: Period

	Mercury	Venus	Earth	Moon	Mars
NASA orbital period (days)	88.0	224.7	365.2	27.3	687.0
k Perihelion (N/m)	44.98×10^{10}	52×10^{10}	24.88×10^{10}	60.79×10^{10}	0.9643×10^{10}
k Aphelion (N/m)	12.87×10^{10}	50×10^{10}	22.51×10^{10}	43.45×10^{10}	0.5496×10^{10}
T Perihelion period (days)	62.28	222.55	356.23	25.20	593.37
T Aphelion period (days)	116.44	226.95	374.51	29.80	785.97
T average period (days)	89.36	224.75	365.37	27.50	689.67
	Jupiter	Saturn	Uranus	Neptune	Pluto
NASA orbital period (days)	4331	10,747	30,589	59,800	90,560
k Perihelion (N/m)	61.98×10^{10}	3.01×10^{10}	5.6×10^{8}	1.5×10^{8}	1.97×10^{4}
k Aphelion (N/m)	46.27×10^{10}	2.2×10^{10}	4.2×10^{8}	1.4×10^{8}	4.29×10^{3}
T Perihelion period (days)	4,024.28	9,989.80	28,630.70	59,968.14	59,075.13
T Aphelion period (days)	4,657.62	11,685.00	33,059.88	62,072.92	126,592.84
T average period (days)	4,340.95	10,837.40	30,845.29	61,020.53	92,833.99

If $k = 22.51 \times 10^{10}\,\mathrm{N/m}, m = 5.97 \times 10^{24}\,\mathrm{kg}$,

$$T_{aphelion} = 2\pi\sqrt{\frac{5.97 \times 10^{24}}{22.51 \times 10^{10}}}$$

$$T_{aphelion} = 32357822.35\,s = 374.51\,days$$

$$T_{average} = \frac{356.23 + 374.51}{2} = 365.37\,days$$

The spring constant was proven to be valid by determining how long the Earth takes to complete an entire cycle around the sun. We performed this for all solar system members in Table IV. In comparison with NASA data on planets far from the sun, there was an error rate of no more than 2.5%.

3. Energy Stored in the Spring

In springs, the equilibrium position is indicated by $x = 0.00$ m, which is the position where the energy contained in the spring is zero. In a spring, $U = 1/2kx^2$ [2] is the potential energy stored when it's stretched or compressed at a distance x. If the spring constant of the earth is $k = 24.88 \times 10^{10}$ N/m and $x = 147.1 \times 10^{9}$ m, then,

$$U_{perihelion} = \frac{1}{2}24.88 \times 10^{10} \times \left(147.1 \times 10^{9}\right)^2$$

$$U_{perihelion} = 2.69 \times 10^{33}\,J$$

TABLE V: Energy Stored Related to k Constant

	Mercury	Venus	Earth	Moon	Mars
Perihelion (10^6 km)	46.0	107.5	147.1	0.363	206.7
Aphelion (10^6 km)	69.8	108.9	152.1	0.406	249.3
k Perihelion (N/m)	44.98×10^{10}	52×10^{10}	24.88×10^{10}	60.79×10^{10}	0.9643×10^{10}
k Aphelion (N/m)	12.87×10^{10}	50×10^{10}	22.51×10^{10}	43.45×10^{10}	0.5496×10^{10}
Energy U Perihelion (J)	4.75×10^{32}	3.0×10^{33}	2.69×10^{33}	4.0×10^{28}	2.059×10^{32}
Energy U Aphelion (J)	3.13×10^{32}	2.96×10^{33}	2.6×10^{33}	3.58×10^{28}	1.07×10^{32}
Energy U average (J)	3.94×10^{32}	2.98×10^{33}	2.64×10^{33}	3.79×10^{28}	1.564×10^{32}
	Jupiter	Saturn	Uranus	Neptune	Pluto
Perihelion (10^6 km)	740.6	1357.6	2732.7	4471.1	4436.8
Aphelion (10^6 km)	816.4	1506.5	3001.4	4558.9	7375.9
k Perihelion (N/m)	61.98×10^{10}	3.01×10^{10}	5.6×10^{8}	1.5×10^{8}	1.97×10^{4}
k Aphelion (N/m)	46.27×10^{10}	2.2×10^{10}	4.2×10^{8}	1.4×10^{8}	4.29×10^{3}
Energy U Perihelion (J)	1.699×10^{35}	2.77×10^{34}	2.09×10^{33}	1.499×10^{33}	1.938×10^{29}
Energy U Aphelion (J)	1.54×10^{35}	2.49×10^{34}	1.89×10^{33}	1.45×10^{33}	1.166×10^{29}
Energy U average (J)	1.619×10^{35}	2.63×10^{34}	1.99×10^{33}	1.47×10^{33}	1.55×10^{29}

TABLE VI: Energy Related to Mass and Velocity

	Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mass (10^{24} kg)	0.330	4.87	5.97	0.073	0.642	1898	568	86.8	102	0.0130
Orbital velocity (km/s)	47.4	35.0	29.8	1	24.1	13.1	9.7	6.8	5.4	4.7
Energy KE (J)	3.7×10^{32}	2.98×10^{33}	2.65×10^{33}	3.65×10^{28}	1.86×10^{32}	1.628×10^{35}	2.67×10^{34}	2.0×10^{33}	1.487×10^{33}	1.435×10^{29}

If the spring constant of the earth is $k = 22.51 \times 10^{10}$ N/m and $x = 152.1 \times 10^{9}$ m, then,

$$U_{aphelion} = \frac{1}{2} 22.51 \times 10^{10} \times \left(152.1 \times 10^{9}\right)^2$$

$$U_{aphelion} = 2.6 \times 10^{33}\, J$$

$$U_{average} = \frac{\left(2.69 \times 10^{33}\right) + \left(2.6 \times 10^{33}\right)}{2} = 2.64 \times 10^{33}\, J$$

By using the earth's spring constant, we calculated the energy stored in the spring. Table V shows all the planets in our solar system.

3.1. Proofing Energy Stored in the Spring

Based on the planet's mass and velocity, we can calculate the kinetic energy of the planet using the law of $KE = 1/2mv^2$ [2] see Table VI. Earth example:

$$KE = \frac{1}{2} 5.97 \times 10^{24} \times (29800)^2$$

$$KE = 2.65 \times 10^{33}\, J$$

The energy oscillates between the kinetic energy of the mass and the potential energy stored in the spring. The energy oscillates back and forth between the kinetic energy and potential, changing completely from one form of energy to the other as the system oscillates. The motion starts with all energy stored in the spring as the elastic potential energy. As the planet moves, the elastic potential energy is converted into kinetic energy, which becomes entirely kinetic energy at the aphelion position. Some kinetic energy results in Table VI are quite close to those in Table V, which is the energy stored in the spring. If we apply the velocities found in Table III, we obtain results that are identical to those found in Table V (see Table VII).

This confirms the connection between the planet and the sun, which is the center of the solar system. This confirms that the Spring laws apply to this force.

TABLE VII: Energy Stored Related to Our Velocity Calculation

	Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Mass (10^{24} kg)	0.330	4.87	5.97	0.073	0.642	1898	568	86.8	102	0.0130
Velocity avearge related to k (km/s)	48.65	35.015	29.784	1.019	24.2	12.15	9.63	6.8	5.42	4.85
Energy KE (J)	3.9×10^{32}	2.98×10^{33}	2.64×10	3.79×10^{28}	1.879×10^{32}	1.4×10^{35}	2.63×10^{34}	2.0×10^{33}	1.49×10^{33}	1.43×10^{29}

4. Conclusion

In a polyatomic gas, we may choose to think of the molecule as consisting of a number of masses (atoms) connected by springs [3]. Mathematically, the gravity between the planet and the center around which it rotates behaves like a spring. This is because the force of gravity between two objects is linked to the product of their masses. It is inversely proportional to the square of the distance between them. This is the same relationship as Hooke's law, which describes the force of a spring as proportional to the distance it is stretched or compressed. The spring constant measures spring stiffness. It is defined as the force required to stretch or compress the spring by a unit distance.

The force of gravity between a planet and the sun can be determined as the spring constant using the law $F = kx$.

The orbital speed is the speed at which the planet travels around the sun. This can be determined using the law $v = A\sqrt{k/m}$.

The orbital period is the time it takes for the planet to complete one revolution around the sun. This can be determined using the law $T = 2\pi\sqrt{m/k}$.

The potential energy of a planet is the energy it has due to its position in the sun's gravitational field. The potential energy is stored in spring. When the planet moves away from the sun, potential energy is released and converted into kinetic energy. Kinetic energy can be determined using the law $U = 1/2kx^2$.

Spring laws can also be used to explain galaxies and other astronomical objects' motion.

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Ethical Compliance Statement

All procedures involving human participants in this study were conducted in accordance with the ethical standards of the institutional and/or national research committee, as well as the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

Conflict of Interest

Author declares no conflict of interest.

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