A formula for calculating the rotational period of planet or star

xiaozhong zhai (✉ zxzdcyok@yahoo.com)

odense kommune <https://orcid.org/0000-0002-0004-4260>

Research Article

Keywords: acceleration, gravity, mass, period, rotation

Posted Date: September 7th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-859954/v2>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

A formula for calculating the rotational period of planet or star

Author: Xiaozhong Zhai

Affiliation: Odense kommune In Denmark

Abstract: This paper reports a formula for calculating the rotation period of planet or star. The rotational radius, mass and gravitational acceleration on its surface, the three factors, determine the rotational period of planet or star.

Key word: acceleration, gravity, mass, period, rotation.

1, Introduction

Thus far, a unique formula for calculating the rotation period of planet in the solar system and star, for example, the Sun, remains a challenge. This puzzles astronomer for centuries. The next section represents my attempt to derive such a formula from the traditional theory of physics.

2. Theory and formula

Suppose a planet or star is a sphere with a uniform distribution of matter. If we let its rotational speed in the tangential direction be equal to its orbit velocity, its radius would expand by X times. Then, we have the following equation.

$$2\pi rX = tv \quad (1)$$

The value of X may be calculated by the following equation:

$$X^2 = \frac{v^2 r}{Gm - gr^2} \quad (2)$$

So, t , the rotation period of a planet or star may be calculated by the following formula:

$$t^2 = \frac{4\pi^2 r^3}{Gm - gr^2} \quad (3)$$

The g is the gravity on the surface of a planet or star. G is the gravitational constant. m is its mass. t represents its rotation period. r is its radius and v its orbit average velocity.

3. Discussion

In the above equation or formula, the gravity (g) represents the difference $\left(\frac{Gm}{r^2} - \frac{v^2}{rx^2}\right)$ between centripetal acceleration coming from mass or mass distribution $\left(\frac{Gm}{r^2}\right)$ and the centrifugal acceleration $\left(\frac{v^2}{rx^2}\right)$ coming from the rotation, called net centripetal acceleration (Richard.B.2007, Hofmann-Wellenhof.B.etal.2006). In the process of rotation, two opposite effects form a pair to impart to the rotation object at the same times.

The value for g , $\frac{Gm}{r^2}$ and $\frac{v^2}{rx^2}$ of planet in solar system and of Sun are shown in table 1 and that for rotation period t and x in table 2.

The gravity (g) on the Earth's surface varies around from 9.7639 m/s^2 on the Nevado Huascarán mountain in Peru to 9.8337 m/s^2 at the surface of the Arctic Ocean (Christian.H.etal.2013) because the earth is a sphere with uneven distribution of matter. In 1901 the third General Conference on weights and Measures defined a standard gravitational acceleration (g) for the surface of the Earth : $g=9.80665$.

The average gravitational acceleration or the net gravity (g) at the surface of the Earth is $9.78638037 \frac{\text{m}}{\text{s}^2}$ (Qotze.H.2014) with even distribution of matter in table 1.

The rotation period (t) of planet calculated by the equations is 100 percent consistent with the observations in the literature (Helled.R.etal.2015, Kutna.M.L.2003, NASA, Wikipedia) in a accurate to seconds in table 2.

4, Conclusion

There are the three factors that determine the rotational period of planet or star. They are rotational radius (r), mass and gravitational acceleration (g) on the surface of planet and star.

Reference:

Christian. H. et al. 2013, New Ultrahigh-Resolution Picture of Earth's gravity field. Geophysical Research Letters. 40(16):4279-4283.

Helled. R., Galanti. E. and Kaspi. Y. 2015, Nature. 2015. 520, 202-204.

Hofmann-Wellenhof. B., Moritz. H. 2006, Physical Geodesy (2nd Ed). Springer. ISBN 978-3-211-33544-4. § 2.1.

Kutna. M.L. 2003, system, Physical perspective, 2nd Cambridge university

NASA planetary fact sheet and solar system by Wikipedia in internet.

Qotze.H. 2014, International Gravity Formula.In:Gupta H.K. Encyclopedia of Solid Earth Geophysics.Encyclopedia of Earth Science Series. Springer Dordrecht.

Richard. B. 2007, Precise Measurement of Mass (PDF). Sawe Paper No.3147. Arlington, Texas: S.A.W.E., INC. Retrieved.

Table 1: The value of the centripetal gravitational acceleration ($\frac{Gm}{r^2}$), of the centrifugal gravitational acceleration ($\frac{v^2}{r\omega^2}$) and of the gravitational acceleration (g) on the surface of object ($\frac{m}{s^2}$)

	Mercury	Venus	Earth	Mars	Ceres	Jupiter	Saturn	Halley	Uranus	Neptune	Pluto	Sun
$\frac{Gm}{r^2}$	3.701 49559	8.870 09425	9.820 25812	3.72 7854 37	0.28 0203 43	25.92 03022	11.18 60361 4	1.213 46909 $\times 10^{-4}$	9.00 7601 74	11.27 45662 4	0.617 21204	273.6 98125 09
$\frac{v^2}{r\omega^2}$	3.751 26284 $\times 10^{-6}$	5.418 15969 $\times 10^{-7}$	0.033 87777 6	0.01 7028 65	0.01 7495 93	2.162 62771	1.593 44308	1.202 15717 $\times 10^{-5}$	0.25 9947 2	0.289 39436	1.538 66659 $\times 10^{-4}$	0.005 86868
g	3.701 49184	8.870 09371	9.786 38034 4	3.71 0825 72	0.26 2707 5	23.75 76744 9	9.592 59306	0.000 10932 5	8.74 7654 54	10.98 51718 8	0.617 05817	273.6 92256 41

Note: the unit of g is $\frac{m}{s^2}$.

Table 2 : The X value calculated by formula, the rotation period (t) in second calculated by formula, the rotation period in second by Observations (t_b) and the accuracy rate between the calculating and the observed value.

	Mercury	Venus	Earth	Mars	Ceres	Jupiter	Saturn	Halley	Uranus	Neptune	Pluto	Sun
x	15824 .4389 467	19,34 0.185 37754	64.1 1126 23	100.4 36372 25	196. 8131 1443	1.06 1808 09	0.998 86312	19,395 .19834 975	2.647 26349 2	2.03 5560 73	350.75 202619	108.82 816
t	50679 75.86 51213 3	21129 193.4 88314 37	8616 4.10 0352	88645 .6804 1193	3266 9.45 7480 48	3572 4.13 6804 87	37983 .2781 9036	190062 .12631 611	62062 .4685 198	5795 5.74 5999 66	551856 .672	216431 7.9658 340
t_b	50679 75,91 7956	21129 192,1 79934	8616 4,07 1519 54	88645 ,6675 26916	3266 9,45 6439 186	3572 4,13 6766 504	37983 ,2781 36837	190059 ,46007 248	62062 ,4686 6021	5795 5,74 6459 929	551867 ,79218 384	2164 317,63 53269
$*$ $*$	100 %	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %

Note: ** the accuracy rate $rate\left(\frac{t}{t_b}100\%\right)$

Table 3: the value of mass (kg), average radius (m) and orbital velocity ($\frac{m}{s^2}$) by observation.

	Mercury	Venus	Earth	Mars	Ceres	Jupiter	Saturn	Halley	Uranus	Neptune	Pluto	Sun
r	2.43 97× 10 ⁶	6.05 18× 10 ⁶	6.3 71× 10 ⁶	3.38 95× 10 ⁶	4.73 × 10 ⁵	6.99 11× 10 ⁷	5.82 32× 10 ⁷	1.1× 10 ⁴	2.53 62× 10 ⁷	2.46 22× 10 ⁷	1.18 7× 10 ⁶	6.963 4× 10 ⁸
v	4787 2.40 8916 53	3502 1.02 2076 51	297 84. 860 790 3	1790 4.12 4374 61	1790 4.12 4374 61	1305 5.98 5798 55	9621 .773 0449 8	7052 .956 3108 7	6797 .222 8212 4	5433 .638 672	4740 .212 4793 3	22000 0
m	3.3011 × 10 ²³	4.8675 × 10 ²⁴	5.972 37× 10 ²⁴	6.4171 × 10 ²³	9.393 × 10 ²⁰	1.898 19× 10 ²⁷	5.683 × 10 ²⁶	2.2× 10 ¹⁴	8.681 × 10 ²⁵	1.0241 × 10 ²⁶	1.303 × 10 ²²	1.9885 × 10 ³⁰

Note: r represents radius, v is average orbital velocity and m mass.