

## Spinning and Rotation of Earth, Sun and planets

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If a small body of mass (m) orbits a large body of mass (M) then, may be we can calculate the sidereal rotation period of the large body (T) by the rotational equation. The rotational equation can calculate the rotation period for a Star of mass (M) which circled by another mass (m). The nine Planets orbit our sun so, we can calculate the rotation period of our sun. Also, from the rotation Equation we can calculate the rotation period of Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto because all these planets are circled by another moons. The Earth rotation period is going to be faster as a result of increasing Earth- Moon distance. The Earth rotation period increases when the moon orbit inclination plane is perpendicular to the Earth equator. The Earth rotation period decreases when the moon orbit inclination plane reaches to it's max. inclination.

### 1-The rotation Equation:

$$\omega^2 = \frac{G m a k^6}{3.4^2 r_p^4} \left(\frac{\rho_2}{\rho_1}\right)^3$$

Equation 1

For spherical planets and moons (the small body orbits the large body in a circular pass)

From equation 1 and a planet density=mass/volume

$$\left(\frac{T}{2\pi}\right)^2 = \frac{3.4^2 r_p^4}{G m a k^6} \left(\frac{M}{m}\right) \left(\frac{r_e}{R_e}\right)^9$$

Equation 2

The small body orbits the large body in a circular pass

From equation 2

$$k^6 = \frac{457 r_p^4}{G m a T^2} \left(\frac{M}{m}\right) \left(\frac{r_e}{R_e}\right)^9$$

Equation 3

The small body orbits the large body in a circular pass

Where:

- $\omega$  The angular velocity of The large body
- $\rho_1$  The density of the large body
- $\rho_2$  The density of the small body

T=Sidereal rotation period of the large body (sec)

K=Moment of inertia factor of the large body.

G=gravitational constant = 6.67300 × 10<sup>-11</sup> m<sup>3</sup> kg<sup>-1</sup> s<sup>-2</sup>.

M=Large body mass (kg)

Re= Equatorial radius for the large body (meter)

a=Semi major axis of the mass center of all satellites that orbit large body (meter)

m=Total mass of all satellites that orbit the large body (kg)

re =Equatorial radius of all satellites that orbit large body (meter)

rp =Polar radius of all satellites that orbit large body (meter)

### 1-2-The equation results:

The rotation period (T) results from equation (2)

Large bod	Rotation period	
	hr	hr
	T	
	Observed	Calculated
Earth	23.9	24.0
Mars	24.6	24.4
Jupiter	9.93	9.95
Saturn	10.7	9.4
Uranus	17.2	17.1
Neptune	16.1	16.9
Sun	609.1	609.1

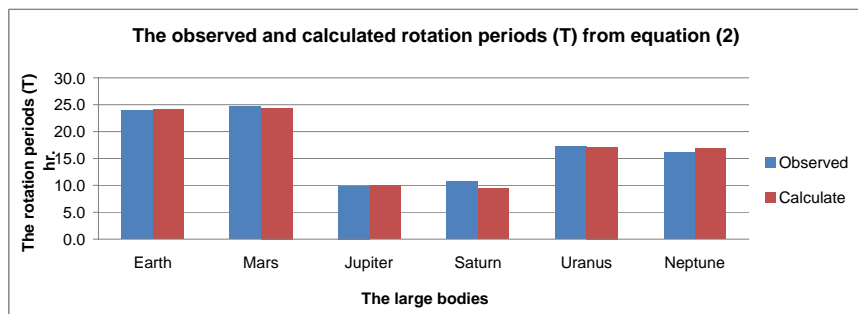


Figure (1). The observed and calculated rotation periods (T) from equation (2)

Large bod	Rotation period	
	hr	hr
	T	
	Observed	Calculated
Sun	609.1	609.1

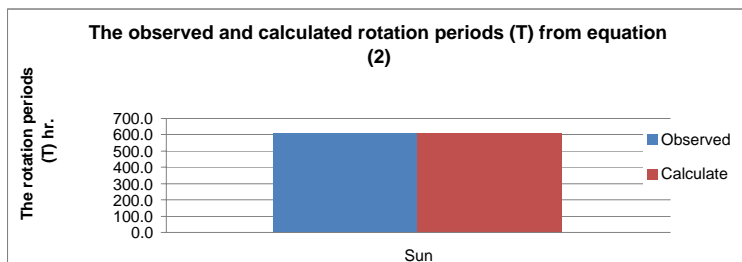


Figure (2). The observed and calculated rotation periods (T) from equation (2)

1-1 The moment of inertia factor (K) results from equation (3)

Table (3)

Large bod	Mom. Of inertia factor	
	K	
	Observed	Calculated
Earth	0.331	0.331
Mars	0.364	0.362
Jupiter	0.260	0.260
Saturn	0.200	0.192
Uranus	0.260	0.259
Neptune	0.270	0.275
Pluto	0.310	0.283

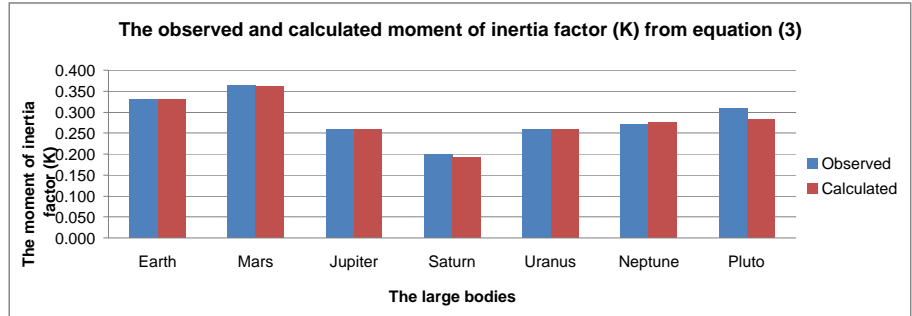


Figure (3). The observed and calculated moment of inertia factor (K) from equation (3)

Table (4)

Large bod	Mom. Of inertia factor	
	K	
	Observed	Calculated
Sun	0.060	0.060

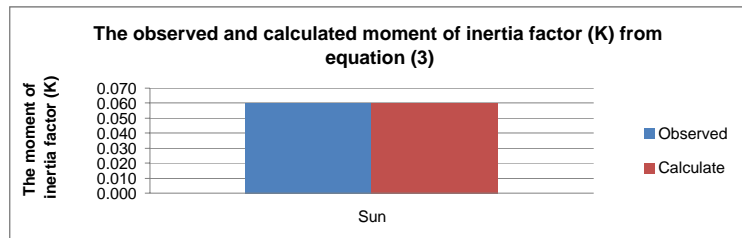


Figure (4). The observed and calculated moment of inertia factor (K) from equation (3)

1-2-The errors of equation (2):

Table (5) The rotation period (T) results from equation (2)

Large body	Rotation period		
	T		
	Observed	Calculated	Error
	hr	hr	%
Earth	23.9345	24.007	-0.3%
Mars	24.623	24.360	1.1%
Jupiter	9.925	9.95	-0.3%
Saturn	10.656	9.442	11.4%
Uranus	17.24	17.097	0.8%
Neptune	16.11	16.944	-5.2%
Pluto	153.3	116.200	24.2%
Sun	609.12	609.086	0.0%

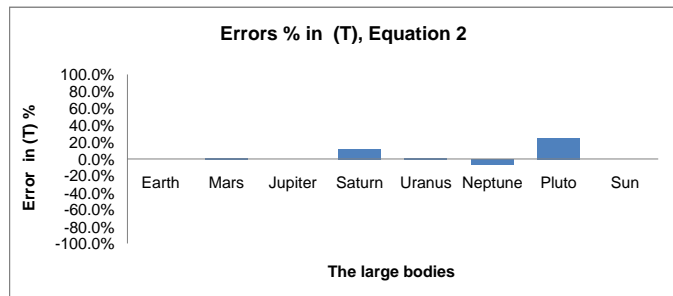


Figure (5). The errors in (T) form equation (2).

1-3-The errors of equation (3):

Table (6) The moment of inertia factor (K) results from equation (3)

Large body	Moment of inertia factor (K)		
	K		
	Measured	Calculated	Error
	hr	hr	%
Earth	0.3308	0.3312	-0.1%
Mars	0.364	0.362	0.5%
Jupiter	0.260	0.260	-0.1%
Saturn	0.200	0.192	3.9%
Uranus	0.260	0.259	0.5%
Neptune	0.270	0.275	-1.7%
Sun	0.060	0.060	0.0%
Pluto	0.310	0.283	8.7%
Haumea	?	0.37	?

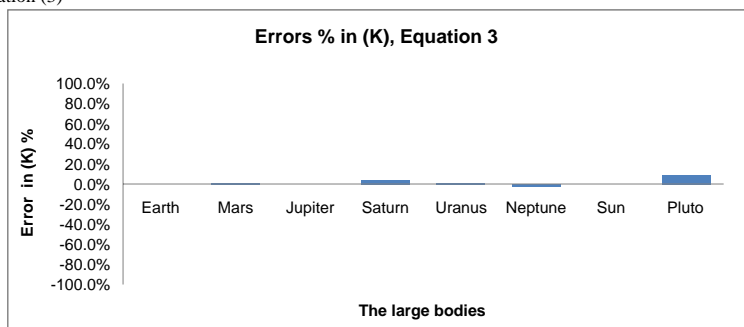


Figure (6). The errors in (K) form equation (3).

2-Determination of Earth rotation period:

M=5.9736E+24 (kg)

Re= 6.3781E+6 (meter)

The Earth has one satellite (the Moon)

a=3.844E+8 (meter)

m=7.35E+22 (kg)

re =1738100 (meter)

rp =1736000 (meter)

From equation 2 (T) of Earth is 24.007

From equation 3 (K) of Earth is 0.3312

**2-1-The Earth rotation**

The Earth rotation period is going to be faster as a result of increasing Earth- Moon distance.

From equa.2, the Earth is fastening it's rotation period by **-0.43** milliseconds/century (3.82 cm/year) fig.7 (If the moon orbits the Earth in a circular pass) Lambeck estimated that the Length of the Day decreases by about -0.7 milli-seconds per century. (Ref.20)

<http://rsta.royalsocietypublishing.org/content/287/1347/545.abstract>

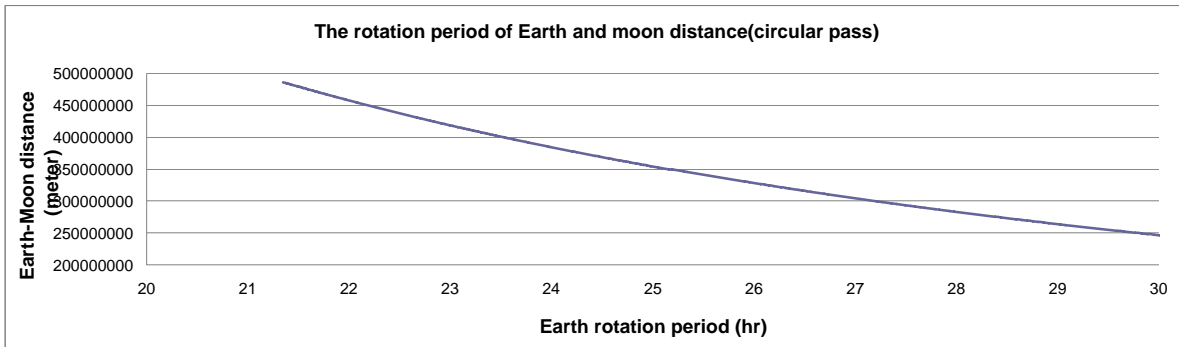


Figure (7). The rotation period of Earth and moon distance relationship.

**2-3-The Earth rotation is going to be faster according to international Earth rotation service data. (fig 8)**

<http://tycho.usno.navy.mil/systime.html>

<http://tycho.usno.navy.mil/leapsec.html>

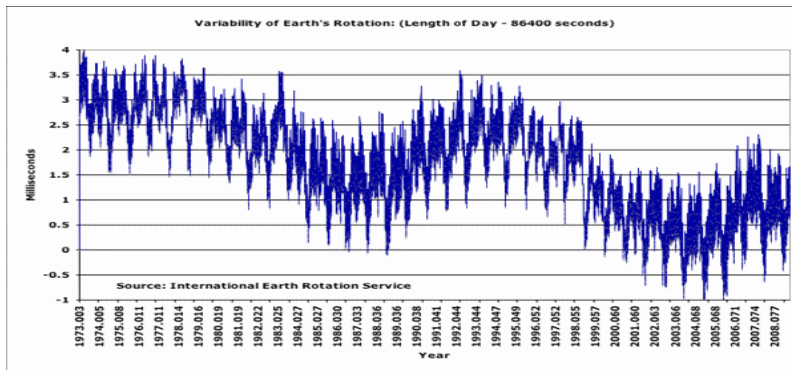


Figure (8). The rotation period of Earth is decreased by 2.7 milliseconds.

**3-Determination of Mars rotation period:**

$M=6.4185E+23$  (kg)

$R_e= 3397000$  (meter)

There are two satellites orbit Mars

$m=$  Total mass of all satellites that orbit the large body Mars (kg)

$= m_1$  (Phobos)+ $m_2$  (Deimos) = $1.3E+16$

$a=$ semi major axis of the center of mass of all satellites that orbit Mars (meter)

$=(m_1 a_1 +m_2 a_2 )/(m_1 +m_2 )=1.1977E+7$  (meter)

$r_e=$  Equatorial radius of the total satellites (meter)

$r_e=[(r_1)^3+(r_2)^3]^0.3333=[(13400)^3+(7500)^3]^0.3333=14128$  (meter)

$r_p=$  Polar radius of the total satellites (meter)

$r_p=[(r_1)^3+(r_2)^3]^0.3333=[(9200)^3+(5200)^3]^0.3333=9714$  (meter)

From equation 2 (T) of Mars is 24.36

From equation 3 (K) of Mars is 0.362

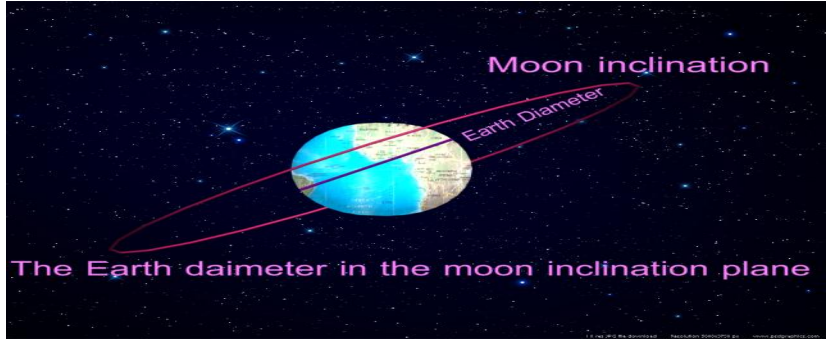
**3-2-Mars rotation is going to be slower:**

Mars rotation period is going to be slower as a result of decreasing the distance of it's moons' mass center. From the rotation equation, Mars is slowing its rotation period by 0.67 second/century (1.8 meter/year) A positive 0.67 leap second may be inserted every 100 year

**3-3-Determination of Jupiter, Saturn, Uranus, Neptune, Pluto, Haumea and sun rotation periods:**

By the same way, we can calculate the rotation period (T) from equation 2 as shown in table (7) By the same way, we can calculate the moment of inertia factor (K) from equation 3 as shown in table (8) All moons of small masses are negligible according to the equation results.

**4-The relationship between Earth rotation rate and lunar declination**



**4-1-The period is from 10/Jul/2006 to 23/Nov./2006 (lunar declination is 29 degree)**

The Earth diameter is in the moon inclination plane

Fig. (9)--((UT1-UTC) today)-((UT1-UTC) yesterday) from 10/Jul/2006 to 23/Nov/2006 (source IERS)

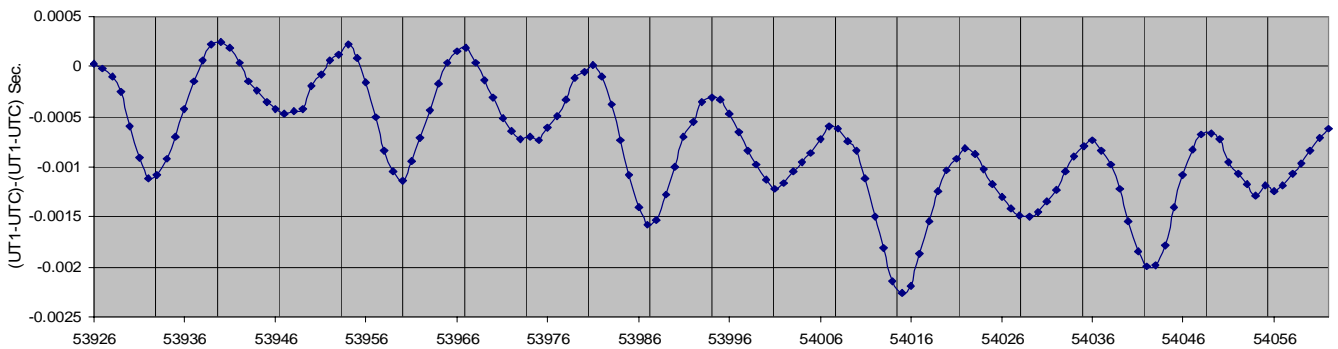


Fig.(10)--Lunar declination from 10/Jul/2006 to 23/Nov/2006

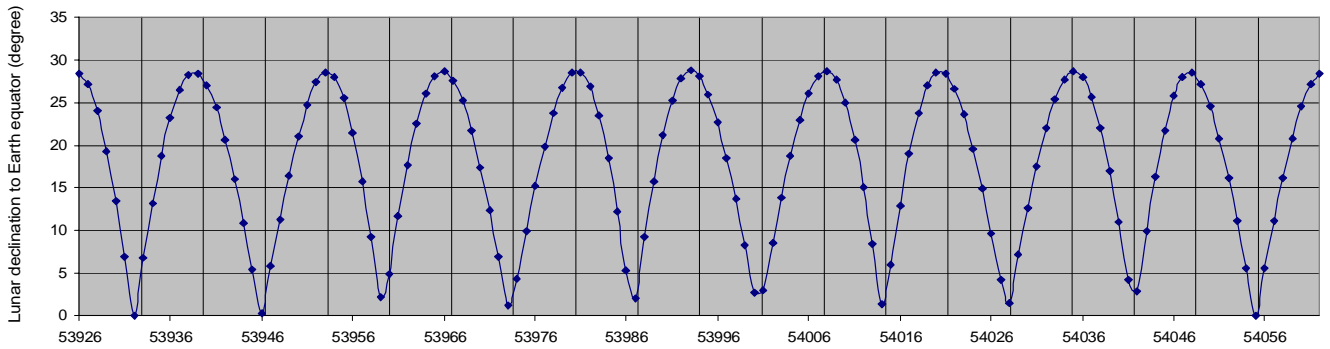
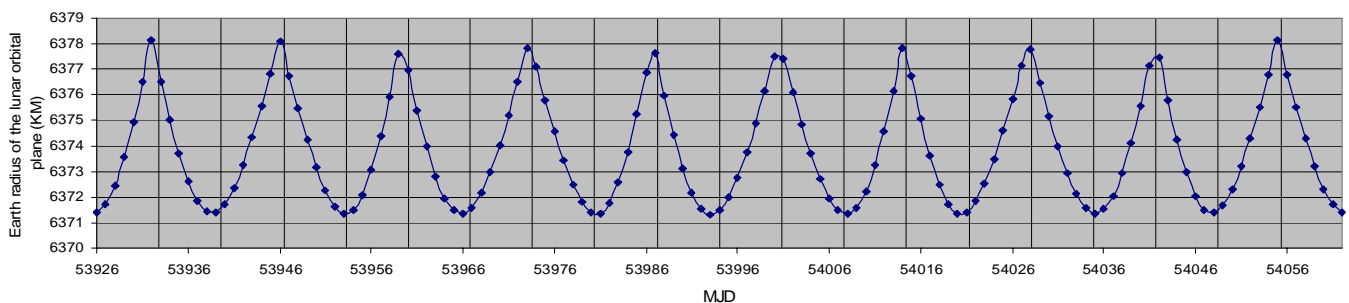


Fig.(11) Earth radiies in the same Lunar orbital plane from 10/Jul/2006 to 23/Nov/2006



From UT-UTC, the Earth rotation period increases when the moon orbit inclination plane is perpendicular to the Earth equator

From UT-UTC, the Earth rotation period decreases when the moon orbit inclination plane reaches to it's max. inclination

The Low points in Fig.(9) represents the highest speed of the earth rotation. (close to the earth equator)

The Low points in Fig.(10) represents the Min. Lunar declination.

The Peak points in Fig.(11) represents the Max.earth radius in the lunar orbital plane.(the equator radius)

The Earth rotation rate reaches to it's Max. when lunar declination is zero. (the highest Earth diameter)

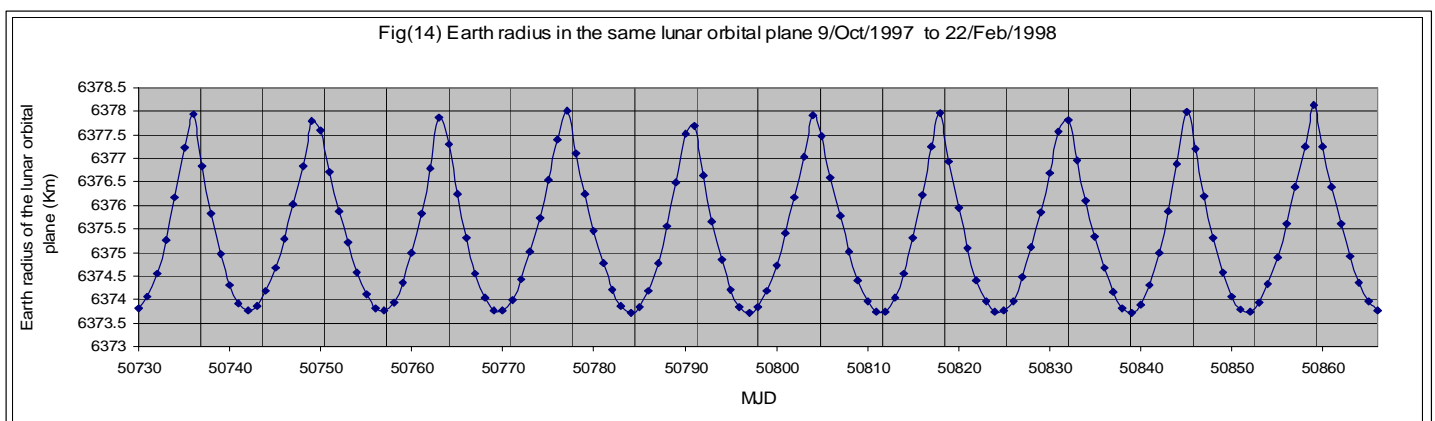
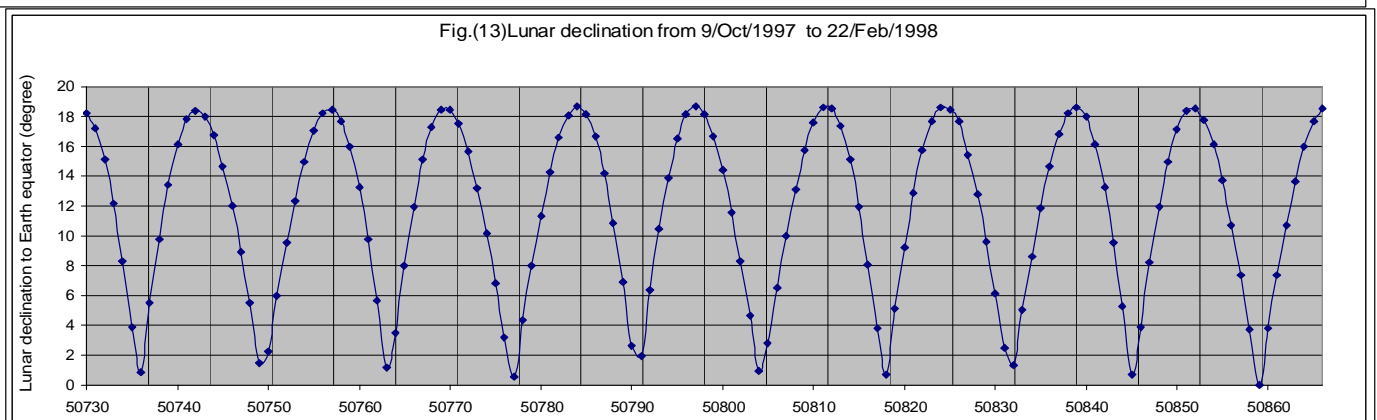
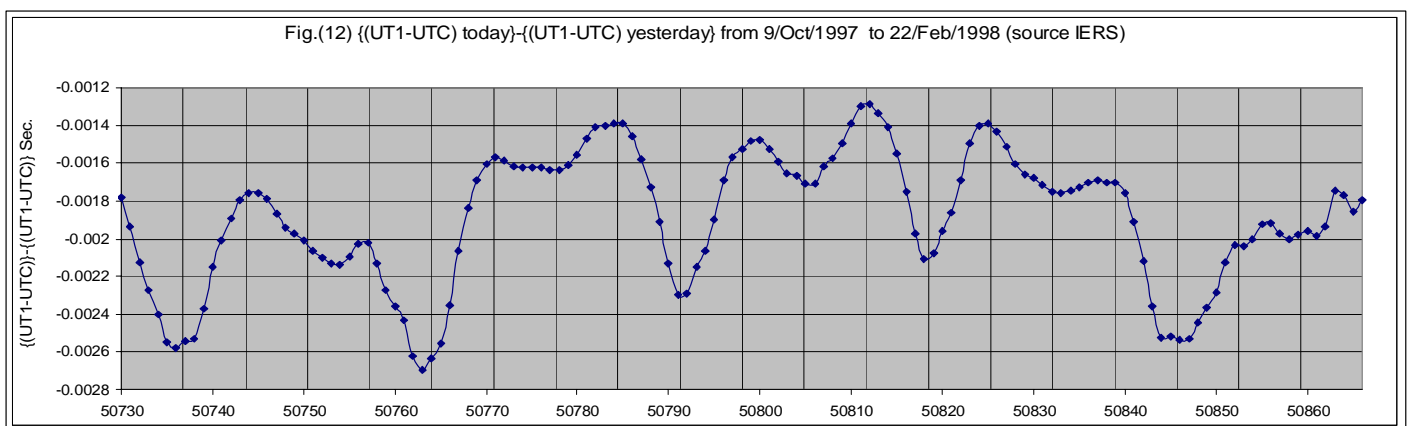
There is a perfect correlation in the three curves.

From Fig.(9), (10) and (11), the Earth speed increased when the lunar declination decreased.

**The Earth diameter is in the moon inclination plane**

**4-2-The period is from 9/Oct/1997 to 22/Feb./1998 (moon declination is 18 degree)**

**The Earth diameter is in the moon inclination plane**



From UT-Utc, the Earth rotation period increases when the moon orbit inclination plane is perpendicular to the Earth equator

From UT-UTC, the Earth rotation period decreases when the moon orbit inclination plane reaches to it's max. inclination

The Low points in Fig.(12) represents the highest speed of the earth rotation.(close to the earth equator)

The Low points in Fig.(13) represents the Min. Lunar declination.

The Peak points in Fig.(14) represents the Max.earth radius in the lunar orbital plane.

The Earth rotation rate reaches to it's Max. when lunar declination is zero. (the highest Earth diameter)

There is a perfect correlation in the three curves.

From Fig.(12), (13) and (14), the Earth rotation speed increased when the lunar declination decreased.

### **The Earth diameter is in the moon inclination plane**

#### **5-Acknowledgements**

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7-Another tables

7-1-Table (7) total planets and sun calculation.

Table (7) Total rotation equation results and solar system parameters to calculate (T), (Equation 2).

	Large body properties							Small body properties			
	Rotation period			Grav.		Equatorial	M. of Inertia	Semi.Maj.	Equatorial	Polar	
	T			Const.	Mass	Radius	Factor	Mass	Axis	Radius	Radius
	Observed	Calculated	Error	G	M	Re	K	m	a	re	rp
	hr	hr	%		Kg	meter		Kg	meter	meter	meter
<b>Earth</b>	23.9345	24.007	-0.30%	6.67E-11	5.97E+24	6.38E+06	0.3308	7.35E+22	3.84E+08	1.74E+06	1.74E+06
Moon								7.35E+22	3.84E+08	1.74E+06	1.74E+06
<b>Mars</b>	24.623	24.360	1.1%	6.67E-11	6.42E+23	3.40E+06	0.364	1.30E+16	1.20E+07	1.41E+04	9.72E+03
Phobos								1.06E+16	9.38E+06	1.34E+04	9.20E+03
Deimos								2.40E+15	2.35E+07	7.50E+03	5.20E+03
<b>Jupiter</b>	9.925	9.950	-0.3%	6.67E-11	1.90E+27	7.15E+07	0.260	3.93E+23	1.10E+09	3.48E+06	3.47E+06
Io								8.93E+22	4.22E+08	1.82E+06	1.82E+06
Europa								4.82E+22	6.71E+08	1.56E+06	1.57E+06
Ganymede								1.48E+23	1.07E+09	2.63E+06	2.63E+06
Callisto								1.08E+23	1.88E+09	2.41E+06	2.40E+06
<b>Saturn</b>	10.656	9.442	11.4%	6.67E-11	5.68E+26	6.03E+07	0.200	1.40E+23	1.23E+09	2.64E+06	2.63E+06
Mimas								3.97E+19	1.86E+08	2.09E+05	1.91E+05
Enceladus								7.30E+19	2.38E+08	2.56E+05	2.45E+05
Tethys								6.22E+20	2.95E+08	5.36E+05	5.26E+04
Dione								1.10E+21	3.77E+08	5.64E+05	5.64E+05
Rhea								2.31E+21	5.27E+08	7.68E+05	7.68E+05
Titan								1.35E+23	1.22E+09	2.58E+06	2.58E+06
Hyperion								5.50E+18	1.48E+09	1.85E+05	1.13E+05
Iapetus								1.59E+21	3.56E+09	7.26E+05	7.26E+05
<b>Uranus</b>	17.24	17.097	0.8%	6.67E-11	8.68E+25	2.56E+07	0.260	9.12E+21	4.24E+08	1.10E+06	1.10E+06
Miranda								6.60E+19	1.29E+08	2.40E+05	2.33E+05
Ariel								1.35E+21	1.91E+08	5.81E+05	5.78E+05
Umbriel								1.17E+21	2.66E+08	5.85E+05	5.85E+05
Titania								3.52E+21	4.36E+08	7.89E+05	7.89E+05
Oberon								3.01E+21	5.84E+08	7.61E+05	7.61E+05
<b>Neptune</b>	16.11	16.944	-5.2%	6.67E-11	1.02E+26	2.48E+07	0.270	2.14E+22	3.55E+08	1.35E+06	1.35E+06
Triton								2.14E+22	3.55E+08	1.35E+06	1.35E+06
<b>Pluto</b>	153.292	116.212	24.2%	6.67E-11	1.31E+22	1.13E+06	0.310	1.50E+21	1.96E+07	6.41E+05	6.41E+05
Charon								1.50E+21	1.96E+07	6.42E+05	6.42E+05
<b>Haumea</b>	3.915	-	-	6.67E-11	4.01E+21	1.53E+06	????	3.58E+19	3.78E+07	6.42E+05	6.42E+05
Hi'iaka								1.79E+19	4.99E+07	1.55E+05	1.55E+05
Namaka								1.79E+19	2.57E+07	8.50E+04	8.50E+04
<b>Sun</b>	609.12	609.085	0.0%	6.67E-11	1.99E+30	6.96E+08	0.060	2.67E+27	1.13E+12	8.51E+07	7.88E+07
Mercury								3.30E+23	5.79E+10	2.44E+06	2.44E+06
Venus								4.87E+24	1.08E+11	6.05E+06	6.05E+06
Earth								5.97E+24	1.50E+11	6.38E+06	6.36E+06
Mars								6.42E+23	2.28E+11	3.40E+06	3.38E+06
Jupiter								1.90E+27	7.79E+11	7.15E+07	6.69E+07
Saturn								5.68E+26	1.43E+12	6.03E+07	5.44E+07
Uranus								8.68E+25	2.87E+12	2.56E+07	2.49E+07
Neptune								1.02E+26	4.50E+12	2.48E+07	2.43E+07
Pluto								1.31E+22	5.91E+12	1.13E+06	1.13E+06

K= 0.3635 for Mars (Ref.6)

K= 0.26 for Jupiter (Ref.12)

K= 0.2 for Saturn (Ref.12), (Ref.5)

K= 0.26 for Uranus (Ref.13)

K= 0.27 for Neptune (Ref.5)

(Ref.9,12)

(Ref.9,12)

(Ref.16)

(Ref.16)

K= 0.06 for Sun (Ref.12.5)

7-2-Table (8) total planets and sun calculation.

Table (8) Moment of inertia results to calculate (k), (Equation 3).

	Large body properties								Small body properties			
	Rotation		Grav.		Equatorial	Moment of inertia factor K				Semi.Maj.	Equatorial	Polar
	Observed		Const.	Mass	Radius	Calculated	Current	Error	Mass	Axis	Radius	Radius
	T		G	M	Re	Value	Value	%	m	a	re	rp
	hr	Sec.		Kg	meter				Kg	meter	meter	meter
<b>Earth</b>	23.9345	86164	6.673E-11	6.0E+24	6.38E+06	0.3312	0.3308	0.1%	7.35E+22	3.84E+08	1.74E+06	1.74E+06
Moon									7.35E+22	3.84E+08	1.74E+06	1.74E+06
<b>Mars</b>	24.6230	88643	6.673E-11	6.4E+23	3.40E+06	0.3623	0.3635	-0.3%	1.30E+16	1.20E+07	1.41E+04	9.72E+03
Phobos									1.06E+16	9.38E+06	1.34E+04	9.20E+03
Deimos									2.40E+15	2.35E+07	7.50E+03	5.20E+03
<b>Jupiter</b>	9.9250	35730	6.673E-11	1.9E+27	71492000	0.2603	0.260	0.1%	3.93E+23	1.10E+09	3.48E+06	3.47E+06
Io									8.93E+22	4.22E+08	1.82E+06	1.82E+06
Europa									4.82E+22	6.71E+08	1.56E+06	1.57E+06
Ganymede									1.48E+23	1.07E+09	2.63E+06	2.63E+06
Callisto									1.08E+23	1.88E+09	2.41E+06	2.40E+06
<b>Saturn</b>	10.656	38362	6.673E-11	5.7E+26	60268000	0.1921	0.20	-3.9%	1.40E+23	1.23E+09	2.64E+06	2.63E+06
Mimas									3.97E+19	1.86E+08	2.09E+05	1.91E+05
Enceladus									7.30E+19	2.38E+08	2.56E+05	2.45E+05
Tethys									6.22E+20	2.95E+08	5.36E+05	5.26E+04
Dione									1.10E+21	3.77E+08	5.64E+05	5.64E+05
Rhea									2.31E+21	5.27E+08	7.68E+05	7.68E+05
Titan									1.35E+23	1.22E+09	2.58E+06	2.58E+06
Hyperion									5.50E+18	1.48E+09	1.85E+05	1.13E+05
Iapetus									1.59E+21	3.56E+09	7.26E+05	7.26E+05
<b>Uranus</b>	17.24	62064	6.673E-11	8.7E+25	25559000	0.2593	0.260	-0.3%	9.12E+21	4.24E+08	1.10E+06	1.10E+06
Miranda									6.60E+19	1.29E+08	2.40E+05	2.33E+05
Ariel									1.35E+21	1.91E+08	5.81E+05	5.78E+05
Umbriel									1.17E+21	2.66E+08	5.85E+05	5.85E+05
Titania									3.52E+21	4.36E+08	7.89E+05	7.89E+05
Oberon									3.01E+21	5.84E+08	7.61E+05	7.61E+05
<b>Neptune</b>	16.11	57996	6.673E-11	1.0E+26	24764000	0.2746	0.2700	1.7%	2.14E+22	3.55E+08	1.35E+06	1.35E+06
Triton									2.14E+22	3.55E+08	1.35E+06	1.35E+06
<b>Pluto</b>	153.292	551851	6.673E-11	1.3E+22	1133000	0.2827	0.31	-8.8%	1.50E+21	1.96E+07	6.41E+05	6.41E+05
Charon									1.50E+21	1.96E+07	6.42E+05	6.42E+05
<b>Haumea</b>	3.915	14096	6.673E-11	4.0E+21	980000	0.3696	?	?	3.58E+19	3.78E+07	1.63E+05	1.63E+05
Hi'iaka									1.79E+19	4.99E+07	1.55E+05	1.55E+05
Namaka									1.79E+19	2.57E+07	8.50E+04	8.50E+04
<b>Sun</b>	609.12	2192832	6.673E-11	2.0E+30	695500000	0.060	0.06	0.02%	2.67E+27	1.13E+12	8.51E+07	7.88E+07
Mercury									3.30E+23	5.79E+10	2.44E+06	2.44E+06
Venus									4.87E+24	1.08E+11	6.05E+06	6.05E+06
Earth									5.97E+24	1.50E+11	6.38E+06	6.36E+06
Mars									6.42E+23	2.28E+11	3.40E+06	3.38E+06
Jupiter									1.90E+27	7.79E+11	7.15E+07	6.69E+07
Saturn									5.68E+26	1.43E+12	6.03E+07	5.44E+07
Uranus									8.68E+25	2.87E+12	2.56E+07	2.49E+07
Neptune									1.02E+26	4.50E+12	2.48E+07	2.43E+07
Pluto									1.31E+22	5.91E+12	1.13E+06	1.13E+06

7-2-Table (9) the effect of one moon on the rotation period when the other moons omitted.

The results as shown in table (9)

- 1-The rotation period of Mars may be 8.4 when Deimos only orbits Mars.
- 2-The rotation period of Jupiter may be 4.63 when IO only orbits Jupiter
- 3-The rotation period of Saturn may be 0.3 when Tethys only orbits Saturn.
- 4-The rotation period of Sun may be 19.2 when Mercury only orbits sun.
- 5-The rotation period of Sun may be 8.3 when Pluto only orbits sun.

Why this small planet (Pluto) can rotate alone the sun with 8.3 hr rotational period?

The distance between Sun and Pluto is too large (the torque arm is too large).

Table (9) Rotation equation results when one small body rotates around the large body, (equation 2).

	Large body properties							Small body properties			
	Rotation period			Grav.		Equatorial	M. of Inertia	Semi.Maj.	Equatorial	Polar	
	T			Const.	Mass	Radius	Factor	Mass	Axis	Radius	Radius
	Observed	Calculated	Error	G	M	Re	K	m	a	re	rp
hr	hr	%		Kg	meter		Kg	meter	meter	meter	
<b>Earth</b>	23.9345	24.007	-0.30%	6.67E-11	5.97E+24	6.38E+06	0.3308	7.35E+22	3.84E+08	1.74E+06	1.74E+06
Moon								7.35E+22	3.84E+08	1.74E+06	1.74E+06
<b>Mars</b>	24.623	24.360	1.1%	6.67E-11	6.42E+23	3.40E+06	0.364	1.30E+16	1.20E+07	1.41E+04	9.72E+03
Phobos		29.093		6.67E-11	6.42E+23	3.40E+06	0.364	1.06E+16	9.38E+06	1.34E+04	9.20E+03
Deimos		8.416		6.67E-11	6.42E+23	3.40E+06	0.364	2.40E+15	2.35E+07	7.50E+03	5.20E+03
<b>Jupiter</b>	9.925	9.950	-0.26%	6.7E-11	1.899E+27	71492000	0.260	3.93E+23	1.10E+09	3.48E+06	3.47E+06
Io		4.625		6.7E-11	1.899E+27	71492000	0.260	8.93E+22	4.22E+08	1.82E+06	1.82E+06
Europa		4.676		6.7E-11	1.899E+27	71492000	0.260	4.82E+22	6.71E+08	1.56E+06	1.57E+06
Ganymede		11.601		6.7E-11	1.899E+27	71492000	0.260	1.48E+23	1.07E+09	2.63E+06	2.63E+06
Callisto		9.325		6.7E-11	1.899E+27	71492000	0.260	1.08E+23	1.88E+09	2.41E+06	2.40E+06
<b>Saturn</b>	10.656	9.442	11.4%	6.7E-11	5.685E+26	60268000	0.200	1.40E+23	1.23E+09	2.64E+06	2.63E+06
Mimas		17.812		6.7E-11	5.685E+26	60268000	0.200	3.97E+19	1.86E+08	2.09E+05	1.91E+05
Enceladus		19.078		6.7E-11	5.685E+26	60268000	0.200	7.30E+19	2.38E+08	2.56E+05	2.45E+05
Tethys		0.303		6.7E-11	5.685E+26	60268000	0.200	6.22E+20	2.95E+08	5.36E+05	5.26E+04
Dione		12.365		6.7E-11	5.685E+26	60268000	0.200	1.10E+21	3.77E+08	5.64E+05	5.64E+05
Rhea		17.651		6.7E-11	5.685E+26	60268000	0.200	2.31E+21	5.27E+08	7.68E+05	7.68E+05
Titan		8.934		6.7E-11	5.685E+26	60268000	0.200	1.35E+23	1.22E+09	2.58E+06	2.58E+06
Hyperion		66.404		6.7E-11	5.685E+26	60268000	0.200	5.50E+18	1.48E+09	1.85E+05	1.13E+05
Iapetus		9.944		6.7E-11	5.685E+26	60268000	0.200	1.59E+21	3.56E+09	7.26E+05	7.26E+05
<b>Uranus</b>	17.24	17.097	0.829%	6.7E-11	8.683E+25	25559000	0.26	9.12E+21	4.24E+08	1.10E+06	1.10E+06
Miranda		27.807		6.7E-11	8.683E+25	25559000	0.26	6.60E+19	1.29E+08	2.40E+05	2.33E+05
Ariel		17.864		6.7E-11	8.683E+25	25559000	0.26	1.35E+21	1.91E+08	5.81E+05	5.78E+05
Umbriel		21.216		6.7E-11	8.683E+25	25559000	0.26	1.17E+21	2.66E+08	5.85E+05	5.85E+05
Titania		12.838		6.7E-11	8.683E+25	25559000	0.26	3.52E+21	4.36E+08	7.89E+05	7.89E+05
Oberon		12.050		6.7E-11	8.683E+25	25559000	0.26	3.01E+21	5.84E+08	7.61E+05	7.61E+05
<b>Neptune</b>	16.11	16.944	-5.2%	6.7E-11	1.024E+26	24764000	0.27	2.14E+22	3.55E+08	1.35E+06	1.35E+06
Triton								2.14E+22	3.55E+08	1.35E+06	1.35E+06
<b>Pluto</b>	153.292	116.212	24.2%	6.67E-11	1.31E+22	1.13E+06	0.310	1.50E+21	1.96E+07	6.41E+05	6.41E+05
Charon								1.50E+21	1.96E+07	6.42E+05	6.42E+05
<b>Haumea</b>	3.915	-	-	6.7E-11	4.006E+21	1531000	????	3.58E+19	3.78E+07	1.63E+05	1.63E+05
Hi'iaka								1.79E+19	4.99E+07	1.55E+05	1.55E+05
Namaka								1.79E+19	2.57E+07	8.50E+04	8.50E+04
<b>Sun</b>	609.12	609.085	0.0%	6.7E-11	1.989E+30	695500000	0.06	2.67E+27	1.13E+12	8.51E+07	7.88E+07
Mercury		19.193		6.7E-11	1.989E+30	695500000	0.06	3.30E+23	5.79E+10	2.44E+06	2.44E+06
Venus		23.698		6.7E-11	1.989E+30	695500000	0.06	4.87E+24	1.08E+11	6.05E+06	6.05E+06
Earth		18.709		6.7E-11	1.989E+30	695500000	0.06	5.97E+24	1.50E+11	6.38E+06	6.36E+06
Mars		21.733		6.7E-11	1.989E+30	695500000	0.06	6.42E+23	2.28E+11	3.40E+06	3.38E+06
Jupiter		474.557		6.7E-11	1.989E+30	695500000	0.06	1.90E+27	7.79E+11	7.15E+07	6.69E+07
Saturn		1196.192		6.7E-11	1.989E+30	695500000	0.06	5.68E+26	1.43E+12	6.03E+07	5.44E+07
Uranus		159.701		6.7E-11	1.989E+30	695500000	0.06	8.68E+25	2.87E+12	2.56E+07	2.49E+07
Neptune		76.215		6.7E-11	1.989E+30	695500000	0.06	1.02E+26	4.50E+12	2.48E+07	2.43E+07
Pluto		8.254		6.7E-11	1.989E+30	695500000	0.06	1.31E+22	5.91E+12	1.13E+06	1.13E+06

7-3-Table (10) the effect of the giant planets on the rotation of Sun.

The results as shown in table (10)

From the rotation equation, it is very clear that the giant planets control the sun rotation,

The rotation period of the sun may be 612 hr when the giant planets only orbit the sun.

Table (10) Rotation equation results when the Giant planets only orbit Sun, (equation 2).

	Large body properties					Small body properties		
	Rotation period	Grav.		Equatorial	M. of Inertia	Semi.Maj.	Equatorial	Polar

	T			Const.	Mass	Radius	Factor	Mass	Axis	Radius	Radius
	Observed	Calculated	Error	G	M	Re	K	m	a	re	rp
	hr	hr	%		Kg	meter		Kg	meter	meter	meter
<b>Sun</b>	609.12	612.033	-0.5%	6.7E-11	1.989E+30	695500000	0.06	2.66E+27	1.13E+12	8.51E+07	7.88E+07
Mercury											
Venus											
Earth											
Mars											
Jupiter		474.557		6.7E-11	1.989E+30	695500000	0.06	1.90E+27	7.79E+11	7.15E+07	6.69E+07
Saturn		1196.192		6.7E-11	1.989E+30	695500000	0.06	5.68E+26	1.43E+12	6.03E+07	5.44E+07
Uranus		159.701		6.7E-11	1.989E+30	695500000	0.06	8.68E+25	2.87E+12	2.56E+07	2.49E+07
Neptune		76.215		6.7E-11	1.989E+30	695500000	0.06	1.02E+26	4.50E+12	2.48E+07	2.43E+07
Pluto											

7-4-Table (11) the effect of the terrestrial planets on the rotation of sun.

The results as shown in table (11)

The rotation period of the sun may be 25 hr when the terrestrial planets only orbit the sun.

Table (11) Rotation equation results when the terrestrial planets only orbit sun, (equation 2).

	Large body properties						Small body properties				
	Rotation period			Grav.		Equatorial	M. of Inertia	Semi.Maj.	Equatorial	Polar	
	T			Const.	Mass	Radius	Factor	Mass	Axis	Radius	Radius
	Observed	Calculated	Error	G	M	Re	K	m	a	re	rp
hr	hr	%		Kg	meter		Kg	meter	meter	meter	
<b>Sun</b>	609.12	25.316	95.8%	6.7E-11	1.989E+30	695500000	0.06	1.15E+25	1.38E+11	8.12E+06	8.10E+06
Mercury		19.193		6.7E-11	1.989E+30	695500000	0.06	3.30E+23	5.79E+10	2.44E+06	2.44E+06
Venus		23.698		6.7E-11	1.989E+30	695500000	0.06	4.87E+24	1.08E+11	6.05E+06	6.05E+06
Earth		18.709		6.7E-11	1.989E+30	695500000	0.06	5.97E+24	1.50E+11	6.38E+06	6.36E+06
Mars		21.733		6.7E-11	1.989E+30	695500000	0.06	6.42E+23	2.28E+11	3.40E+06	3.38E+06
Jupiter											
Saturn											
Uranus											
Neptune											
Pluto											

7-5-Table (12) the effect of Pluto on the rotation of sun.

The results as shown in table (12), and (9)

Table (12) Rotation equation results when all planets except Pluto orbit sun, (equation 2).

	Large body properties						Small body properties				
	Rotation period			Grav.		Equatorial	M. of Inertia	Semi.Maj.	Equatorial	Polar	
	T			Const.	Mass	Radius	Factor	Mass	Axis	Radius	Radius
	Observed	Calculated	Error	G	M	Re	K	m	a	re	rp
hr	hr	%		Kg	meter		Kg	meter	meter	meter	
<b>Sun</b>	609.12	609.094	0.0%	6.7E-11	1.989E+30	695500000	0.06	2.67E+27	1.13E+12	8.51E+07	7.88E+07
Mercury		19.193		6.7E-11	1.989E+30	695500000	0.06	3.30E+23	5.79E+10	2.44E+06	2.44E+06
Venus		23.698		6.7E-11	1.989E+30	695500000	0.06	4.87E+24	1.08E+11	6.05E+06	6.05E+06
Earth		18.709		6.7E-11	1.989E+30	695500000	0.06	5.97E+24	1.50E+11	6.38E+06	6.36E+06
Mars		21.733		6.7E-11	1.989E+30	695500000	0.06	6.42E+23	2.28E+11	3.40E+06	3.38E+06
Jupiter		474.557		6.7E-11	1.989E+30	695500000	0.06	1.90E+27	7.79E+11	7.15E+07	6.69E+07
Saturn		1196.192		6.7E-11	1.989E+30	695500000	0.06	5.68E+26	1.43E+12	6.03E+07	5.44E+07
Uranus		159.701		6.7E-11	1.989E+30	695500000	0.06	8.68E+25	2.87E+12	2.56E+07	2.49E+07
Neptune		76.215		6.7E-11	1.989E+30	695500000	0.06	1.02E+26	4.50E+12	2.48E+07	2.43E+07
Pluto											

When all planets orbit the Sun, the rotation period of the Sun =609.085 hr.

When all planets except Pluto orbit the Sun, the rotation period of the Sun =609.094 hr.

So, Pluto can fasting the rotation period of Sun by only 0.009 hr. if it rotates with all planets around Sun.

This is because the Giant planets can control the rotation of Sun very well.

### 8-Conclusion:

If a small body of mass (m) orbits a large body of mass (M) then, may be we can calculate the sidereal rotation period of the large body (M).

The moons are "driving" the rotation of their parent planet in the same way, as sun's rotation is being controlled by the planets.

The Earth rotation period is going to be faster as a result of increasing Earth- Moon distance.

From the rotation equation, the Earth is fastening it's rotation period by **0.43** milliseconds/century.(if the moon orbits the Earth in a circular pass)

If a small body of mass (m) orbits a large body of mass (M) then, the rotation period of (M) increased by decreasing the moment of inertia factor (K) for (M).

The Moment of inertia factor of Haumea may be expected to be 0.37 from the rotation equation.

A perfect correlation between lunar declination and the changes of leap seconds.(UT1-UTC)-(UT1-UTC)

From UT-UtC, the Earth rotation period increases when the moon orbit inclination plane is perpendicular to the Earth equator

From UT-UTC, the Earth rotation period decreases when the moon orbit inclination plane reaches to it's max. inclination