Scientific Research Publishing

World Journal of Mechanics, 2023, 13, 73-77
https://www.scirp.org/journal/wjm
ISSN Online: 2160-0503
ISSN Print: 2160-049X

Remarks about External Forces Acting on Earth's Rotation Axis

Monica Zoe Ciobanu

Astronomical Institute of the Romanian Academy, Bucharest, Romania
Email: mzciobanu@yahoo.com

How to cite this paper: Ciobanu, M.Z. (2023) Remarks about External Forces Acting on Earth's Rotation Axis. *World Journal of Mechanics*, **13**, 73-77.
https://doi.org/10.4236/wjm.2023.132003

Received: December 26, 2022
Accepted: February 25, 2023
Published: February 28, 2023

Abstract

It is well known that a variation in the direction of Earth's rotation axis is a real astronomical phenomenon, named nutation. It is interesting if a variation of this axis can take place only in intensity, in the simplest theoretical case of only two rigid body dynamics. This paper presents two positions of the Moon during its monthly orbit, where a sudden variation of Earth's rotation axis in intensity can take place. The duration of this phenomenon is limited in time, maybe an instant or a day, and then a vortex can appear.

Keywords

Nutation, Variation in Intensity of Earth's Rotation Axis, Chandler's Wobble

1. Introduction

The variation in the direction of Earth's rotation axis (the so-called "nutation") was discovered by Bradley in 1747. In 1790, Euler published the theory of a rigid body with a fixed point and gave a wonderful mechanical explication of this phenomenon; even more, he also presented the nutation consequences on terrestrial geographical coordinates through his well-known "Euler's angles". [1]

After some decades, Binet gave the mathematical formulas in the case of a central force, which made us understand more easily the dynamic of Earth's rotation axis. Indeed, it is known that in a curvilinear movement, the force acting on the attracted body can be regarded as being composed of a tangential component force to the attracted body's trajectory and a central component [2]. The tangential components represent the so-called "The external forces which do not pass through the gravity centre of rigid body" as Euler wrote in his theory of the rigid body with a fixed point.

2. After the Beginning of XX Century, Variations in Intensity of Earth's Rotation Began to Be Detected

In consequence it is interesting to know if can take place a variation in intensity of Earth's rotation axis, in the simplest problem of the dynamic of two rigid bodies. For this, it must be known the mechanical moment of the above-mentioned tangential force is related to the axis of the main attractive body and not the mechanical moment to its fixed point as in nutation case [2].

Indeed it is very known that the mechanical moment of a force related to an axis, which represents the vectorial product between the force and its distance to axis. If the force is located entirely in a plane normal to the axis, the resultant of the mechanical moment will be located on the support of the axis and act on its rotation with intensity (as in a vertical action of the feed when the crank rotates strictly horizontally).

When the main body has a great kinetic moment and during a long time its axis has only a very little wobble (for instance an average under 0.01" arc second daily) it can be admitted that in a short time and in a special position of external forces, the wobble can be missing at all; in consequences than, the body's rotation axis can be supposed as being a simple rotation axis without a fixed point.

Looking for stars' parallax, Bradley found a periodical variation of 18.6 years period in stars' positions related to the celestial equatorial frame. Knowing that this period is also the period of retrogradation of Moon nodal points, Euler used the following formula (1):

$$DK/DT = M \tag{1}$$

where K, now, is the kinetic moment of the solid rotating body and M the moment of that external forces which do not pass through its gravity centre, as it was mentioned above.

In a solidary frame with the Earth, when the origin of reference system is situated in the gravity centre of the rotating Earth, the components of M are: Mx and My both situated in the celestial equatorial plan and Mz on the axis which is normal to celestial equatorial plan.

Naturally a variation of Earth's rotation axis only in intensity, is possible when Mx and My are null. In the dynamic of Earth-Moon system, this is possible only when, in a short time, the Moon traverses its two turning points. Then the tangential forces of Moon orbit are parallel with the celestial equatorial plan.

In this case noting by C the principal moment of inertia of the rotating solid body related to the Oz axis, the Euler formula gives (2):

$$C\,\mathrm{d}r/\mathrm{d}t = \mathrm{Mz} \tag{2}$$

where, r in this case is the diurnal rotation vector situated on Earth's rotation axis and $\mathrm{d}r/\mathrm{d}t$ represents its variation in intensity only, in this case.

Briefly:

When Earth is supposed to be a solid body with a fixed point, and is submitted to tangential forces of Moon's orbit,

Then

- If Mz only is null, then the Earth's rotation axis and the Earth's kinetic moment have a variation in direction only, causing a wobble (nutation),
- If Mz only is not null, then the Earth's rotation axis stops in direction for a short time and a vortex can appear.

If the Moon's orbit were situated all time in the celestial equatorial plan, all mechanical moments of tangential forces where situated on Earth's rotation axis itself and could act only on his intensity; naturally then variation of Earth's rotation axis in direction could not take place (that means, no nutation).

But, the Moon's orbit's plan has very known inclinations related to the celestial equatorial plan, this is why the Earth's nutation exists as a real astronomical phenomenon, considering being very important from an astronomical and geodesical point of view.

3. The Moon's Orbit

It is well known, in the simplified case of the dynamic of two rigid bodies (for instance in the Earth-Moon case), that the tangential forces on the orbit of the attracted body could act in the direction of Earth's rotation axis in accordance with Euler's equation.

But it is also very well known that when the Moon in its four-week orbital period traverses the northern zodiacal constellations of Taurus and Gemini, or in the south, Sagittarius, the tangential force of the Moon's orbit crosses a turning point and its direction changes, related to the celestial equatorial plane.

For instance the Moon's declination can grow in a week from zero degree to its greatest value (between 18.3˚ to 28.6˚, depending on nodal point ecliptic longitude) and after crossing the turning point its declination begins to diminish. During the time interval when the Moon traverses this turning point, the tangential component of central force may be parallel with the celestial equatorial plan and may cause a change in intensity of Earth's rotation axis. The duration spent by the Moon to traverse these turning points depends first on the Moon's orbit eccentricity, the longitude of the nodal point and the Moon position inside his complicated orbit; it can be some instants, some hours or even a day or two.

For instance: some values for Moon's declination around in turnings points at 0 h ET are: [3]

Around 3 VIII 1986	2 VIII: +27˚52'49" 3 VIII: +27˚58'45" 4 VIII: +26˚44'33"
Around 6 VII 1982	5 VII: −22˚03'43" 6 VII: −22˚45'30" 7 VII: −22˚25'46"
Around 23 I 1982	22 I: −21˚01'41" 23 I: −21˚52'32" 24 I: −21˚42'57"
Around 7 VI 1978	6 VI: +18˚01'15" 7 VI: +18˚25'01" 8 VI: +18˚01'29"

The longitude of the nodal point is then around: 25˚ in August 1986: 106˚ in July 1982; 112˚ in January 1981: 182˚ in June 1978.

Naturally, the moment when the Moon traverses the turning point it marks also its highest <height> (greatest distance) from the celestial equatorial plan (between 110 000 to 190 000 km on top). In consequence it can be admitted that

then the tangential forces in the turning point, being parallel whit the celestial equatorial plan, may act only on the intensity of Earth's rotation axis in that short limited time interval.

It can be remarked two possibilities:

- If the time interval is longer, for instance, one day or two, then a diurnal forced nutation cannot take place in that time interval [4];
- If the time interval is very short, then a sudden change in direction of tangential forces may cause the appearance of a vortex. Often in communications of airplane paranormal disasters, a sudden vortex is mentioned. When a paranormal ship disaster happens, due to turbulence, very cold air is sometimes noticed.

4. The Chandler's Yearly Period

By introducing a new technique using full latitude in geodetic determination, Chandler published in 1893 not only his known period of 14 months in latitude variation, but also the annual one [5].

About this yearly period, Chandler wrote: "To the Greenwich meridian the maximum and minimum latitude variation took place around 10 days before the spring and autumn equinoxes and no latitude variation was when solstices began". Supposing now that the variation in latitude is due only to a nutation phenomenon, then it must be remarked that during solstices the tangential forces of the apparent Sun's orbit are parallel with the celestial equatorial plan; in consequence the Earth's rotation axis can have a variation but only in intensity, due to the second Kepler's law.

5. The Chandler's Wobble

Usually, the 14 months period found by Chandler in latitude variation is often named Chandler's wobble. During the XX century the Chandler wobble was regarded as a consequence of a free nutation (due to Euler-Poinsot equations [6]). But in accordance with Euler's formula, this phenomenon is due to a forced nutation caused first by the tangential forces of Moon's orbit. These forces act not only on Earth's rotation axis but also on Earth's atmosphere and were found also as a meteorological periodical phenomenon. In 1989 Hameed S Currie R.G. noted: a couple of ocean-atmosphere general circulation models display also a 14.7-month signal, whose amplitude is similar to the found by Maximov (1960) in station date, the authors identifying it as the atmospheric Chandler wobble and either earthquakes nor the fluid core are significant contributions [7].

6. Conclusions

It must be admitted that the great influence of the Moon and Sun in the formation of ocean and land tides has always been readily accepted; but, naturally, there are also other dynamic perturbations submitted by our planet from these celestial bodies.

Only about three centuries ago, due to Bradley and Euler, we began to accept the periodical changing in the direction of Earth's rotation axis due to the retrograde motion of the Moon's nodal point, the nutation constant being 9", 2,052,331; indeed, this is a small but very important value for an accurate celestial reference system, which is necessary for space astronomy.

This paper just wants to draw attention in a simple way that the rotation axis of the Earth can also be subject to a variation in intensity. From a theoretical point of view, this means knowing the mechanical moment of the attracted body, relative only to the axis of rotation of the main body of attraction.

Indeed, in his four weeks orbital period, the Moon passes, in a limited time interval, through two turning points, one in Sagittarius (in the southern sky) and the other in Taurus-Gemini border (in the northern sky). In that short interval, the tangential forces of the Moon's orbit may be parallel to the celestial equator. This means that then the forces are located in a plane normal to the axis of rotation of the Earth and their mechanical moment related to this axis of rotation is therefore located on the same axis, causing a variation in its intensity. Consequently this phenomenon can place a vortex.

Searching through a list of disasters, believed to be paranormal, involving airplanes and ships, one can find some cases that happened when the Moon crosses the turning points. Could it be a mere coincidence?

It must be also noted that the Bermuda Triangle and the Pacific Devil Triangle are situated between 18˚ to 30˚ latitude, the correspondence of 18˚ to 30˚ celestial declination. May it be also a simple coincidence?

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Euler, L. (1790) Theoria motus corporum solidorum sei ridigorum.

[2] Valcovici, V., Balan, St. and Voinea, R. (1963) Mecanica Teoretica. Editura Tehnică, Bucureşti.

[3] Astronomical Almanacs. Astronomical Yearbook, Romanian Academy.

[4] Ciobanu, M.Z. (2021) About the Free and Forced Nutation: The Daily Nutation. *American Journal of Astronomy and Astrophysics*, **9**, 18-21. https://doi.org/10.11648/j.ajaa.20210902.12

[5] Chandler, S. (1893) On the Variation of Latitude, VIII. *The Astronomical Journal*, **13**, 159-162. https://doi.org/10.1086/101956

[6] Ciobanu, M.Z. (2019) A Rigorous Astrometrical Solution in the Case of the Euler-Poinsot Equations System. *Romanian Astronomical Journal*, **29**, 103-108. https://ui.adsabs.harvard.edu/abs/2019RoAJ...29..103C/abstract http://www.astro.ro/~roaj/29_2/10-mciobanu_1905.pdf

[7] Hameed, J. and Currie, R.S. (1989) Simulation of the 14-Month Chandler Wobble in a Global Climate Model. *Geophysical Research Letters*, **16**, 247-250. https://doi.org/10.1029/GL016i003p00247