THE CHANDLER WOBBLE OF THE POLES AND ITS AMPLITUDE MODULATION

N. SIDORENKOV
Hydrometcentre of Russian Federation
B. Predtechensky pereulok, 11–13, Moscow 123242, Russia
e-mail: sidorenkov@mecom.ru

ABSTRACT. It is shown that the period of the Chandler wobble of the poles (CWP) is a combined oscillation caused by three periodic processes experienced by the Earth: (a) lunisolar tides, (b) the precession of the orbit of the Earth's monthly revolution around the barycenter of the Earth - Moon system, and (c) the motion of the perigee of this orbit. The addition of the 1.20 - year Chandler wobble to sidereal, anomalistic, and synodic lunar yearly forcing gives rise slow periodic variations in the CWP amplitude with periods of 32 to 51 years.

1. INTRODUCTION

It is well known that the Earth and the Moon revolve around their center of mass (barycenter) with a sidereal period of 27.3 days. The orbit of the Earth's center of mass (geocenter) is geometrically similar to the Moon's orbit, but the orbit size is roughly 1/81 as large as that of the latter. The geocenter is, on average, 4671 km away from the barycenter. In the Earth's rotation around the barycenter, all its constituent particles trace the same nonconcentric orbits and undergo the same centrifugal accelerations as the orbit and acceleration of the geocenter. The Moon attracts different particles of the Earth with a different force. The difference between the attractive and centrifugal forces acting on a particle is called the tidal force. The rotation of the Earth-Moon system around the Sun (Fig. 1) leads to solar tides. The total lunisolar tides vary with a period of 355 days (13 sidereal or 12 synodic months). This period is known as the lunar or tidal year.

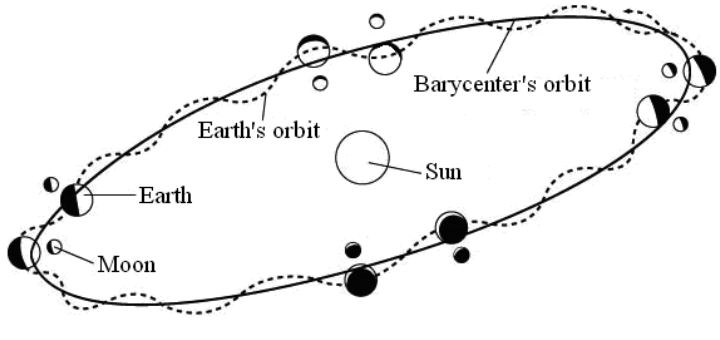

Figure 1: Revolution of the Earth-Moon system around the Sun.

It is well known that the lunar nodes precess westward around the ecliptic, completing a revolution in 18.6 years. Lunar perigee moves eastward, completing a revolution in 8.85 years. Because of these opposite motions, a node meets a perigee in exactly in 6 years.

2. QUASI-BIENNIAL OSCILLATION

In my books (Sidorenkov, 2002, 2009) it was shown that the Earth, the ocean, and the atmosphere exhibit consistent oscillations, influencing each other, i.e., joint oscillations initiated by tides occur in the

Earth-ocean-atmosphere system. Visual manifestations of these oscillations include the wobble of the Earth's poles, El Nino and La Nina in the ocean, and the Southern Oscillation and the quasi-biennial oscillation in the atmosphere.

The wobble of the poles is the movement of the Earth's daily rotation axis inside of the Earth's body.

The quasi-biennial oscillation (QBO) is a quasiperiodic oscillation of the equatorial zonal wind between easterlies and westerlies in the tropical stratosphere with a mean period of 28 months.

Figure 2 shows power spectra of the pole coordinate x (top) and the QBO indices (bottom). A surprising feature is that the spectrum of QBO indices is similar with a factor of 2 to that of the pole's coordinates x and y. If the horizontal-axis scale in the spectrum of the pole's coordinates is doubled as shown in Fig. 2, then all the details in the spectrum of QBO indices coincide with those in the polar motion spectrum; that is the oscillation in the polar motion is reflected as the doubled-period QBO in the atmosphere. In the equatorial stratosphere, the duration of the all the Earth's polar motion cycles is doubled.

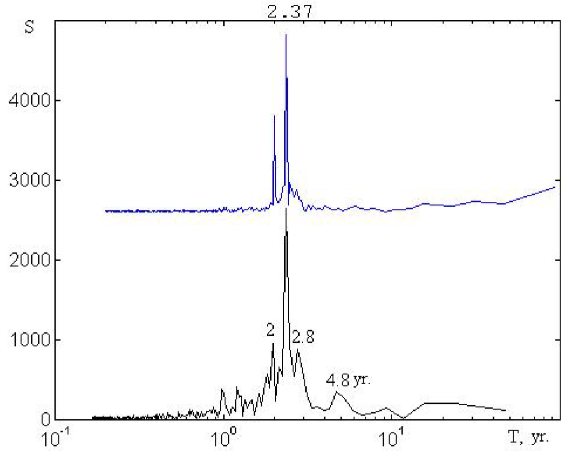

Figure 2: Power spectra of the pole coordinate x (top) and the QBO indices (bottom). To demonstrate the curves' similarity, the pole's curve was transformed as follows: $T = 2T_0$ and $S = 30S_0 + 2600$, where T_0 and S_0 are the actual values of the periods T and spectral densities S, respectively.

These facts testify that the Chandler wobble of the poles and the QBO cyclicity of the stratospheric winds are likely to have the common mechanism of excitation that is due to the geodynamic processes in the Sun-Earth-Moon system. The mechanism of QBO excitation is associated with the absorption of lunisolar tidal waves in the equatorial stratosphere. The QBO period is equal to a linear combination of the frequencies corresponding to the doubled periods of the tidal year (0.97 year), of the node regression (18.6 years), and of the perigee motion (8.85 years) of the Earth's monthly orbit:

$$\frac{1}{2}\left(\frac{1}{0.97} - \frac{1}{8.85} - \frac{1}{18.61}\right) = \frac{1}{2.3}$$

In other words, the quasi-biennial oscillation of the wind direction in the equatorial stratosphere is a combined oscillation caused by three periodic geodynamic processes experienced by the atmosphere: lunisolar tides, the precession of the orbit of the Earth's monthly revolution around the barycenter of the Earth-Moon system, and the motion of the perigee of this orbit.

3. CHANDLER WOBBLE OF THE POLES

The wobble of the Earth's poles and the QBO in the atmosphere have similar spectra (with the ratio of the periods being 1:2) (Sidorenkov, 2002, 2009). The period of the Chandler wobble of the poles (CWP) is believed to differ from the Euler period of 305 days because of the elastic properties of the Earth. However, it is physically unlikely that both QBO and CWP are caused by the features of the Earth's internal structure. A natural assumption is that QBO and CWP have a single cause, namely, the features of the Earth's monthly revolution in the Earth-Moon system and the revolution of this system around the Sun. The wobble forcing with a solar year period of 365.24 days is modulated by the precession of the Earth's monthly orbit with a period of 18.61 years and by the motion of its perigee with a period of 8.85 years. Finally, the resulting solar annual forcing generates polar wobbles with a Chandler period of 1.20 year:

$$\frac{1}{2}\left(\frac{1}{1.0} - (\frac{1}{8.85} + \frac{1}{18.61})\right) = \frac{1}{1.2}$$

The amplitude modulation of CWP is clearly exhibited with a period about 40 years. It is known that the AAM and OAM functions are capable to account for about 90 % of the required CWP excitation. This excitation is believed to occur at the fundamental frequency of the climate system forcing with a period of 365.24 days. However, it was shown in the author's most recent works that, in addition to this basic forcing, the climate system experiences additional forcing caused by cloud amount variations with lunar-year periods (http://geoastro.ru). Climatic characteristics and the equatorial component of the atmospheric angular momentum h2 were found to oscillate with a period of 355 days (Sidorenkov, 2009; Sidorenkov and Sumerova, 2012a, 2012b). The wobble forcing with a lunar year period of 355 days (13 tropical months) is modulated by the precession of the Earth's monthly orbit with a period of 18.61 years and by the motion of its perigee with a period of 8.85 years. Finally, the resulting "lunar tropical year" forcing generates polar wobble with a period of 1.16 year:

$$\left(\frac{1}{355.18days/365.24(days/yr)} - (\frac{1}{8.85} + \frac{1}{18.61})\right) = \frac{1}{1.1606yr}$$

Interference of the 1.20-year Chandler oscillation and the 1.16-year oscillation leads to beats, i.e., to periodic variations in the polar wobble amplitude with a period of 35.3 years:

$$\left(\frac{1}{1.16} - \frac{1}{1.2}\right) = \frac{1}{35.3}$$

Similarly, the lunar synodic year (12 synodic months) must excite polar wobble with a period of 1.1574 year:

$$\left(\frac{1}{354.37days/365.24(days/yr)} - (\frac{1}{8.85} + \frac{1}{18.61})\right) = \frac{1}{1.1574yr}$$

Interference of this excitation and CWP generates beats with a period of 32.6 years.

The "lunar anomalistic" annual (13 anomalistic months) excitation can generate polar wobble with a period of 1.172 year:

$$\left(\frac{1}{358.21days/365.24(days/yr)} - (\frac{1}{8.85} + \frac{1}{18.61})\right) = \frac{1}{1.172yr}$$

Interference of this wobble with CWP can generate beats with a period of 50.9 years:

$$\left(\frac{1}{1.172} - \frac{1}{1.2}\right) = \frac{1}{50.9}$$

Thus, interference of CWP (1.20-year period) with these moon-caused oscillations gives rise to beats, i.e., to slow periodic variations in the CWP amplitude with periods of 32 to 51 years. They are observed in reality.

4. REFERENCES

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