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BARICENTRIC MOTION OF THE SUN

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Abstract. The baricentric motion of the Sun is calculated for 51 years (1939-1990.). Obtained path presents spiraloid curve which a half of period opens, second part closes, with mean period of 11,86 years. This motion of the Sun can not be neglected in nano-gravity scale of influence, because its amplitude is up to 2,175 solar radius, and velocity 9 to 16 m/s. Authors propose name for the curve of baricenter orbit: pulsating spiral of Kepler.

1. INTRODUCTION

Solar system, in the first approximation can be treated as a system consisting of the Sun and big planets, with mass of the Sun 744 times bigger than the sum of planetary masses. Considering from the point of view of mass ratio it is usually to say that planetary orbits are ellipses with the Sun in one of the focal points (1st Kepler's law). 3rd Kepler's law has, for motion in two bodies system, the form containing mass of both bodies:

$$G(m_1 + m_2) = a^3\omega^2 \tag{1}$$

G – gravity constants, $\omega = 2\pi/T$ – angular velocity, a – big half-axis of the orbit, T – period. Planetary masses often were neglected even as the sum, because of big difference between planetary and solar mass: for biggest planet - Jupiter 1/1047, for smallest - Pluton, only 1/ 3 000 000. But, in solving of the problem of three bodies appears the third mass too (e. g. Vernic, 1953), what implies that for the description of the motion for all nine planets around the Sun must be included mass of each of nine planets. In other words, mass of the Sun and big planets must be taken, as equal to:

$$M = M_S(1 + \frac{1}{744}) = 1,001344 \cdot M_S \tag{2}$$

In this case it is useful to calculate the baricentric distance of Solar system to the Sun, what was made in the calculation of planetary efemerides (e. g. Grin, 1998). For our research of the celestial nano-gravity phenomena on the Earth's surface was important just the determination of the orbit and period of the Sun refered to the baricenter.

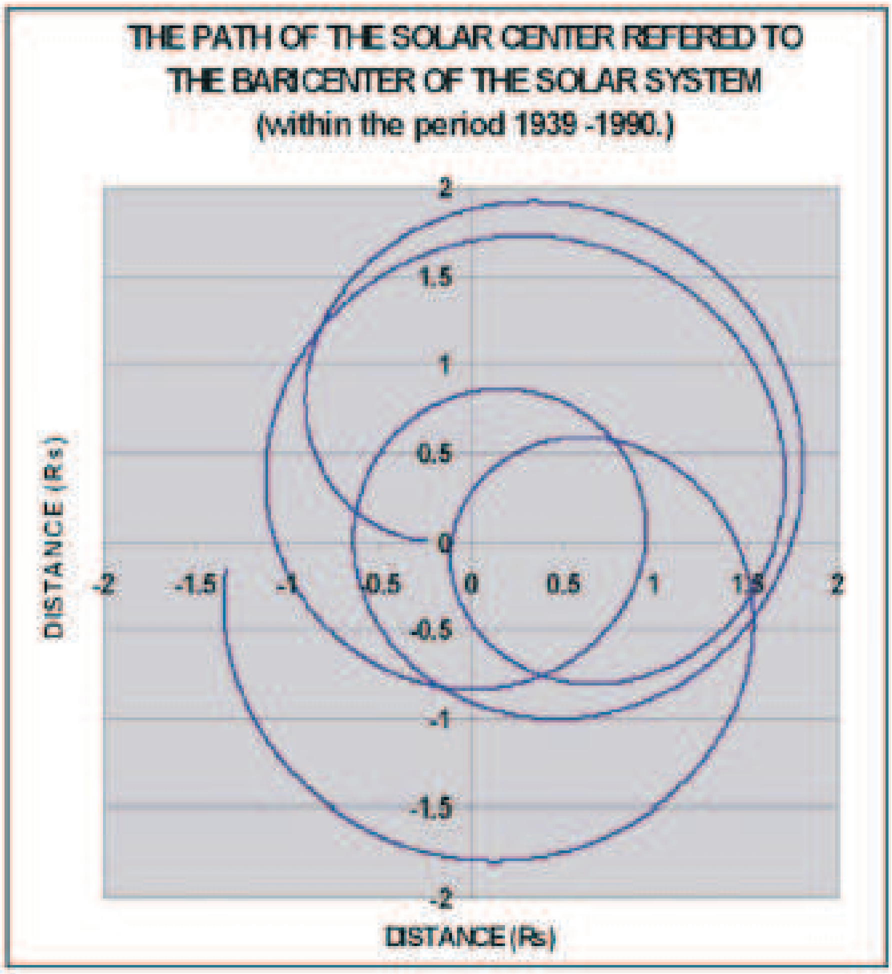

Figure 1: Motion of the baricenter of the Solar system between years 1939 - 1990. Starting position is on the left.

2. DETERMINATION OF SOLAR BARICENTRIC DISTANCE

Within a system of two bodies the baricentric position is determined by a classical formula:

$$r_B = (m_1 \cdot r_1 + m_2 \cdot r_2)/(m_1 + m_2) \tag{3}$$

where: m_1, m_2 – are masses, r_1, r_2 – are Solar and planetary distances in an arbitrary coordinate frame. For example, if the beginning of the frame is in the Solar center, and the second body is Jupiter, the formula gives the baricentric distance with the Solar radius as the unit (R_S):

$$r_B = [0 \cdot 1 + 5,2 \cdot 215 \cdot (1/1047,58)]/[1 + (1/1047,58)] = 1,066 \cdot R_S \tag{4}$$

what refered to the mean Jupiter distance to the Sun, of 1118 R_S, can be neglected for many purposes. But, it can not be told a priori that it could be neglected in all cases. From heliocentric planetary motion we have calculated the position of the baricenter, as:

$$x_B = [\sum_{i=1}^{9} a_i \frac{m_i}{M} \cos(\omega_i \cdot t + \lambda_i)]/[1 + \sum_{i=1}^{9} \frac{m_i}{M}] \tag{5}$$

$$y_B = [\sum_{i=1}^{9} a_i \frac{m_i}{M} \sin(\omega_i \cdot t + \lambda_i)]/[1 + \sum_{i=1}^{9} \frac{m_i}{M}] \tag{6}$$

a_i, ω_i – big half-axis of the orbit, and angular velocity of each planet, λ_i – planetary longitude to the point in the beginning of the calculation, m_i, M – planetary masses and the mass of the Sun and planets. We calculated the path for 2000 days with the step of one day, begining with the year 1939, and we continued the obtained path up to 51 years. With the biggest - influence of Jupiter, and smal planetary orbits eccentricities, one obtains circular orbits as satisfactory. Unexpectedly nice picture is obtained. (Fig.1) Spatial motion of baricenter is often rectilinear, or negligible. Three resultantes of gravity forces of two bodies on the third, in system of three body, give cross-section into the same point - center of the attraction.

By the congruence the center of attraction with the baricenter resulting path is an ellipse (Milankovic, 1935). Here we present solar motion related to the baricenter, with a spiraloid orbit, which formula in polar coordinates is:

$$r^2 = \frac{\sum A_i^2}{A} + \frac{\sum A_i A_j \cos[(\omega_i - \omega_j) \cdot t + (\lambda_i - \lambda_j)]}{A} \tag{7}$$

$$A = 1 + \sum \frac{m_i}{M}, \quad A_i = \frac{a_i \cdot m_i}{M}, \quad A_j = \frac{a_j \cdot m_j}{M}, \quad i, j = 1, 2, \dots (9), \dots \tag{8}$$

what gives the amplitude of distance: $r_{MAX} = 2,175 \cdot R_S$. The corresponding velocity is variable, $(9 - 16)$ m/s (Fig. 2). Our search just for the velocity appearing in gravity potential waves of Lunar tidal influence at the Earth's surface (Koruga et al., 2003) was argument for the calculation of baricentric motion, since other motion between Sun, Earth and Moon gives not an explanation of this velocity.

We examined variation of the "period" of solar baricentric motion, which can be determined on the few manner. The period we use here is the temporal interval between two successive approaches to the extreme distance. Mean value of that period is approximately equal to the Jupiter's revolution or to the period of the Solar activity.

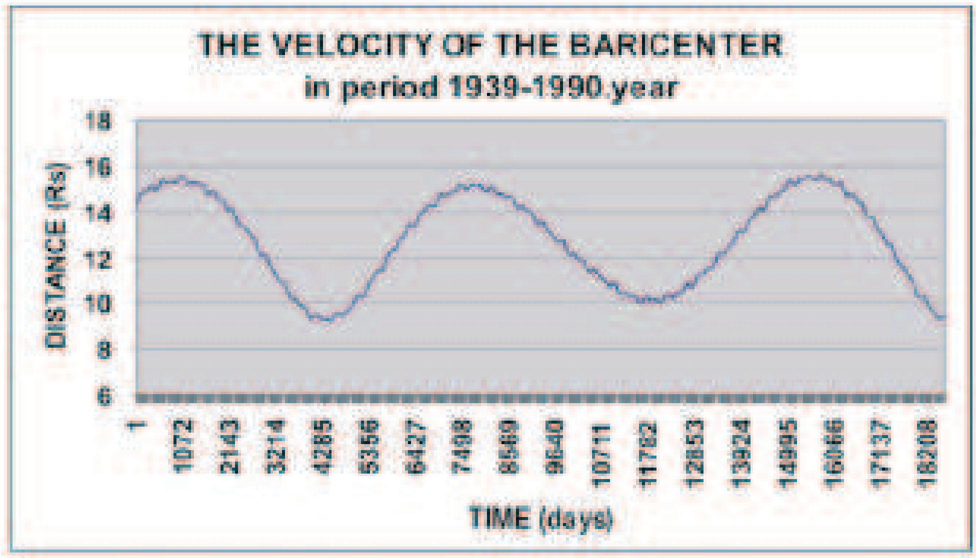

Figure 2: The velocity of the baricenter.

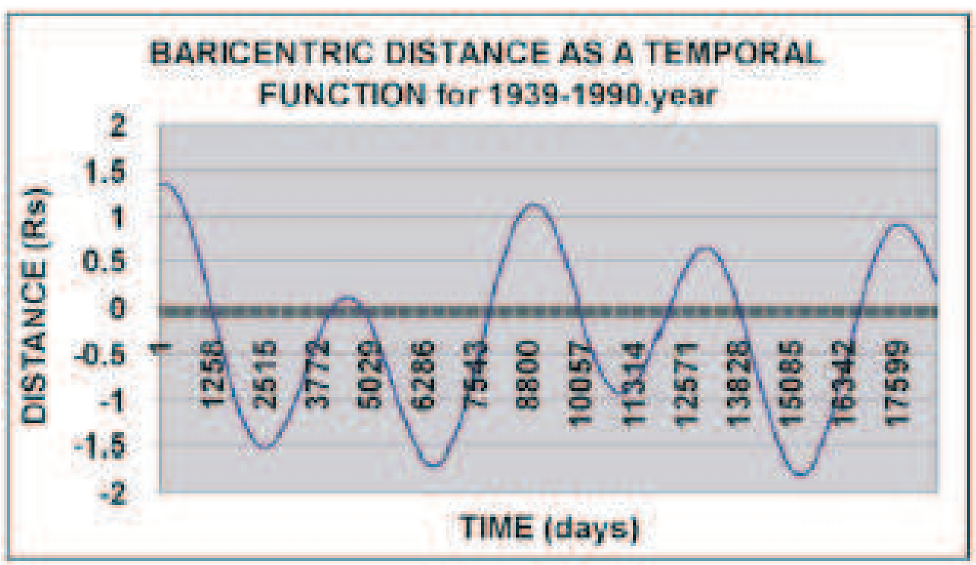

Figure 3: The baricentric distance as temporal function determines period.

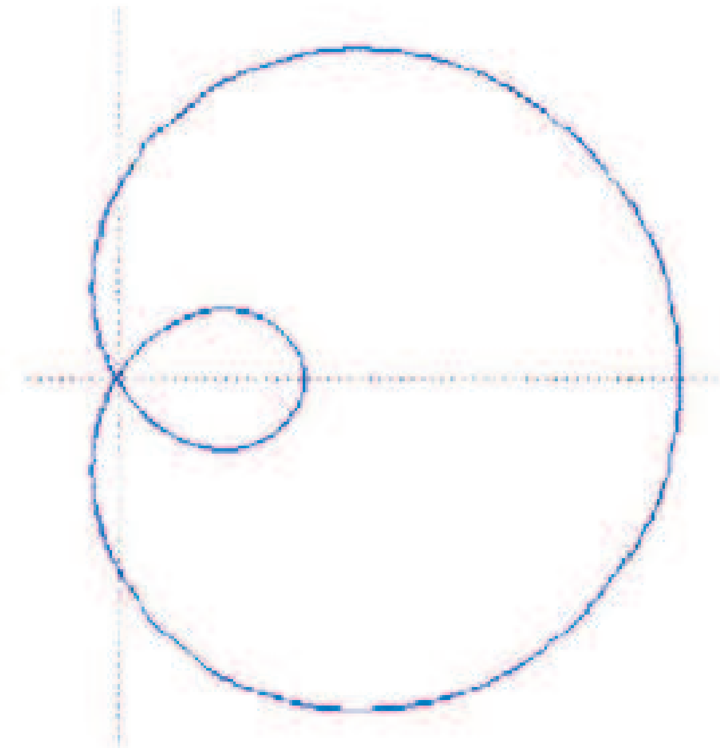

Figure 4: Limacon of Pascal.

3. A REMARK

The nearest curve by its form is known under the name of limacon of Pascal. It is a spiral form given by the formula:

$$r = b + 2a \cdot \cos(\omega \cdot t), \tag{9}$$

with exponent in amplitude for the unity smaller compared with our curve, in generalized form:

$$r^2 = b^2 + 2a^2 \cdot \cos(\omega \cdot t + \Delta), \tag{10}$$

Our curve is in form very similar to spiral of Archimedes, which half period opens and second half closes. We think that fact of mutually dependent parameters, connected by Kepler's law: $\omega_i^2 a_i^3 = GM/m_i = const$, caused the pulsating form of this curve. That is reason for our proposal that this curve would be denoted **as pulsating spiral of Kepler**.

4. CONCLUSIONS

The baricentric motion of the Sun with amplitude of 2.175 solar radius, and with period of 11.86 years have not remarkable influence to the orbital motion of planets. But, this motion is not negligible in some investigations, as it is nano-gravity at the Earth's surface. Effect of the baricentric motion of the Solar center can appear as a gravity potential wave in the Sun - Earth - Moon system, built-in into lunar tidal influence. (Koruga et all. 2003). Here we gave period, amplitude, velocity and form of orbit for this motion.

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