PHYSICAL MODEL OF THE ORBITAL MOVEMENT OF THE JUPITER SATELLITE SINOPE

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ABSTRACT. The physical models of orbital movement of heavenly body have limited application. On the one hand, it is very difficult to take into account all effects of gravitational interaction in complex systems. Therefore the physical models cannot compete on accuracy of calculation of ephemeris with statistical models. On the other hand, the known equation of world gravitation of Newton strictly corresponds only to gravitational interaction of two bodies. With its use it is impossible, for example, to explain a movement of the Moon around the Earth, as the Moon is in sphere of Sun gravitation. The similar situation exists and in case of the external satellites of Jupiter: Pasiphe and Sinope. In the given work is used the original equation for the description of gravitational interaction in system of many bodies (for system of two bodies it is converted in the Newton equation), that eliminates the known contradiction.

Keywords: celestial mechanics, generalised equation of gravitational interaction, Jupiter, Sinope.

Introduction

The physical models of orbital movement of heavenly body have limited application. On the one hand, it is very difficult to take into account all effects of gravitational interaction in complex systems. Therefore the physical models cannot compete on accuracy of calculation of ephemeris with statistical models (see, for example, Chapront&Francou, 1996). On the other hand, the known equation of world gravitation of Newton (1):

$$F_{12} = Gm_1m_2/r_{12}^2 \tag{1}$$

where: G – universal gravitational constant, m_1 and m_2 - masse of interacting bodies, r_{12} – distance between interacting bodies,

strictly corresponds only to gravitational interaction of two bodies. With its use it is impossible, for example, to explain a movement of the Moon around the Earth, as the Moon is in sphere of Sun gravitation. The similar situation exists and in case of the external satellites of Jupiter: Pasiphe and Sinope. In the given work is used the original equation for the description of gravitational interaction in system of many bodies (for system of two bodies it is converted in the Newton equation) (Ostrovskiy, 2003a):

$$\vec{F_{12}} = Gm_1r_{12}\sum m_i/\vec{r_{1i}^3}, \tag{2}$$

where: $m_i/\vec{r_{1i}^3}$ – is vector.

Equation (2) eliminates the known contradiction. This work Illustrate the use of equation (2) on example of system Sun-Jupiter-Sinope.

1. The base model

As the base for making this model was used a model earlier used for systems of two bodies (Ostrovskiy, 2003b). In the basis model a body move along a radius – vector (radial movement) and on a curve (linear movement) independently. The change of speed of a radial movement is determined by radial acceleration:

$$\vec{a}_R = \vec{a}_G + \vec{a}_C \tag{3}$$

The centrifugal acceleration is calculated on the equation:

$$a_C = v^2/r, \tag{4}$$

where: v – linear speed of a body, r – radius of curvature of a trajectory.

The acceleration of gravitation for system from two bodies is Calculated proceeding from the equation of Newton (1). The change Of speed of a linear movement is determined by change of length of a radius – vector:

$$vr = const \tag{5}$$

Step-by-step procedure is used for calculation sizes of radial Speed, lengths of a radius-vector, meanings of linear speed, and Accelerations by the equations (1), (4), (3).

The basis model for system Sun-Earth has convergence with Astrometric dates from $n \cdot 10^{-5}$ for one revolution (Ostrovskiy, 2003b) up to $n \cdot 10^{-3}$ for period of 100 years (Ostrovskiy, 2003b). For system a Sun – Jupiter results of calculation on author's model there were are compared to others statistical methods (Ostrovskiy, 2004). The calculation was begun from perigee 1 Jun 1904. After 190 terrestrial years (11 of Jun, 2094) corner of tumbling became is according to author's model 5754.7 degree (Ostrovskiy, 2004), according to "Planeph 4.2" (Chapront&Francou, 1996) – 5770.0, according to model of The Natural Satellites Data Center (NSDC, Paris, http://www.bdl.fr/ephemeride.html) – 5762.8. Radius of orbit ($m \cdot 10^{11}$) – 7.40888, 7.41118 and 7.41129 accordingly. Angular velocity (sec./day) – 329.75 accordingly author's model and 329.83 accordingly Planeph 4.2. Model of NSDC does not give Value of angular velocity. Difference in corners of tumbling For System Earth-Moon for time of orbital period the Moon makes the Tumbling on 351,85 degree only (Ostrovskiy, 2003b). Bay use of the base model for System Jupiter-Sinope were are received unsatisfactory results. The Sinope orbit, described in known parameters (T=758 days, $R_{Mid} = 2.37 \cdot 10^{10}$ m, $e = 0.28$) for isolated system Jupiter-Sinope cannot exist. Two lasts example point that for reception of more exact results necessary to take into account the influence of the Sun. But account the influence of the Sun with use of Newton equation give more bad results (Ostrovskiy, 2004). For one orbital period corner of tumbling changes from 62 to 220 degree depending on initial location of satellite of Jupiter in space. By that length of orbit radius increases up to $9.7 \cdot 10^{11}$ m. This indicate that the Newton equation (1) not applicable for description of gravitational interactions in complex systems.

2. Model for system of three bodies with use of generalised equation of gravitational interaction

The equation (2) for interaction between Sinope and Jupiter gives the followed:

$$F_{12} = Gm_1 r_{12} \left[M_2/r_{12}^3 + (M_3/r_{13}^3)\cos\alpha\right], \qquad (6)$$

where: 1 – the Sinope, 2 – the Jupiter, 3 – the Sun, α – a corner between radius-vector of Sinope comparatively Jupiter and radius-vector of Sinope comparatively the Sun.

The equation (6) was used for calculation of acceleration of Gravitation of Sinope. For calculation of acceleration of Gravitation of Jupiter was used equation (1). In the equation (6) Was used a normal component of Sun gravitation:

$$g_{SN} = (Gr_{JSin} M_S / r_{SSin}^3)\cos\alpha. \qquad (7)$$

The tangential component of Sun gravitation:

$$g_{ST} = (Gr_{JSin} M_S / r_{SSin}^3)\sin\alpha \qquad (8)$$

must use on vector of linear velocity directly, reason its offset and, hereunder, offset of satellite orbit plane. This leads to offset of line of nodes (where: $\Delta\gamma$ – change longitude of top-down node):

$$\Delta\gamma = g_{ST}\Delta t^2 / v\Delta t. \qquad (9)$$

If we "start" a body on a flat circular orbit with radius, equal to average radius of Sinope orbit, its orbit gets eccentricity for one revolution depending on initial position of a body. Dependency has two minimum at initial longitude of body 20 degree relatively of Jupiter ($e = 0.060$) and at 180 degree ($e = 0.052$) and two maximum at initial longitude 90 and 270 degree (eccentricity 0.077 and 0.073 accordingly). The influence of orbit plane inclination to the ecliptics plane is various for a various situation of an nodes line. So, if an initial longitude of descending node concerning a radius-vector of the Jupiter the wound to zero, eccentricity for one revolution varies in a range from 0.051 up to 0.066. If the initial longitude of descending node equal 90 degrees, the range of change eccentricity is increased up to 0.019-0.078. The minimum corresponds to a corner of an inclination 90 degrees, and maximum – 180 degrees.

The influence of the Sun, as well as in case of the Moon, results to osculating of an orbit, as its parameters in each moment of time depend on a corner between radius-vectors of the Jupiter and Sinope. Accounts have shown, that to an orbit with average orbital Period (for 190 terrestrial years), equal 758 days and inclination Equal 150 degrees, corresponds average radius $2.52 \cdot 10^{10}$ m. Herewith average value of eccentricity of an orbit will be 0.29 (maximum 0.40), and the line of units makes a complete revolution for 29000 terrestrial days. What it was possible to calculate ephemeris of Sinope it is necessary to know rather precisely in a determined moment of time its linear and radial speeds, length of a radius – vector and situation in space.

Conclusion

Use of the generalised equation of gravitational interaction (2) allows: To explain character of interaction in system of three bodies Sun – Jupiter – Sinope.

To construct dynamic model, including the movement of the Jupiter around the Sun and movement of the Sinope around the Jupiter.

To specify orbital parameters of Sinope.

To explain osculating of orbits of the external satellites of the Jupiter.

To explain displacement perigee and rotation of units line of the Satellites at the expense of influence of the Sun.

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