EPSC Abstracts
Vol. 10, EPSC2015-8, 2015
European Planetary Science Congress 2015
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Small bodies of the Sun–Jupiter system and meteor showers

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1. Introduction

Some small bodies come close to the Earth's orbit so that any dust ejected from them, might be seen as a meteor shower. Sporadic meteoroids cannot be associated with a single parent body [1]. Below, we consider the region of motion of a particle with negligible small mass m_3 in the frame of the planar circular restricted three body problem [2]. Let us, m_1 and m_2 are mass of main bodies, r_{12} is a distance between these bodies, *and* G is the gravitational constant. We find the region of the point motion, – distance r_3, ($\mathbf{r_3}=\mathbf{r}_3(x_3, y_3)$) *in* respect of the system center mass, – and numerically investigate the region of the particle stability motion (in closed region), using method of Runge-Kutta integrating, where N=50000 is the number of points in the figures.

2. Fundamental Equation

In accordance with works [2] we have the vector differential equation (1) of the particle m_3 motion in the uniformly rotating system

$$d^2\mathbf{r_3}/dt^2+Gm_1(\mathbf{r}_3-\mathbf{r}_1)/(|\mathbf{r}_3-\mathbf{r}_1|)^3 + Gm_2(\mathbf{r}_3-\mathbf{r}_2)/(|\mathbf{r}_3-\mathbf{r}_2|)^3)-2[d\mathbf{r}_3/dt, \boldsymbol{\Omega}]-\Omega^2\mathbf{r}_3 = 0. \quad (1)$$

Here, $\mathbf{r}_3$ is the radius-vector determined the position of considered point in respect of the center mass of the system. $\mathbf{r}_1$ and $\mathbf{r}_2$ are radii – vectors in respect of the center mass of the system determined the positions of the Sun with mass m_1 and Jupiter m_2 correspondingly. Ω is the angular velocity of uniformly rotation of the major bodies.

$$\mathbf{r}_1=-(m_2/(m_1+m_2))\mathbf{r}_{12},\ \mathbf{r}_2=(m_1/(m_1+m_2))\mathbf{r}_{12}, \quad (2)$$

$$\Omega=\sqrt{\frac{G(m_1+m_2)}{r_{12}^3}}\ .$$

3. Examples

For the numerical experiments we put G=6.672·10^{-11} m^3/ (sec^2·kg), m_1=2·10^{30}kg (mass of the Sun), $m_2=m_1$/1048 is mass of a planet (Jupiter). In the process of the equation (1) solving we use the following units: m_1 is the unit of mass, r_{12} is the unit of length, the unit of time t is corresponded for the case G=1. Moreover, we put for all considered cases the following *initial* conditions: $x_1\neq0$, dx_1/dt=0, y_1=0, dy_1/dt=0, $x_2\neq0$, dx_2/dt=0, y_2=0, dy_2/dt=0, $x_3\neq0$, dx_3/dt=0, y_3=0, dy_3/dt=0. The results of the numerical experiments in intervals of time motion corresponded hundreds and thousands revolutions of major bodies are presented in Fig. 1 – 4.

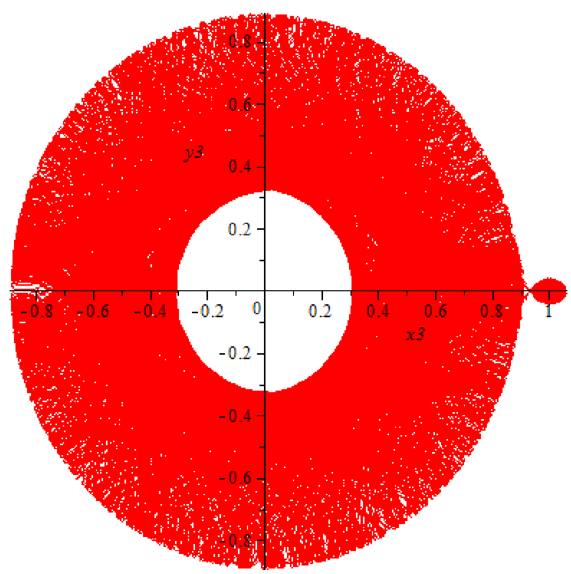

Figure 1: Migration of a meteoroid from Jupiter to Martian orbit. $x_{30}=\varepsilon$, ε=1.0578. t=5000 units of time.

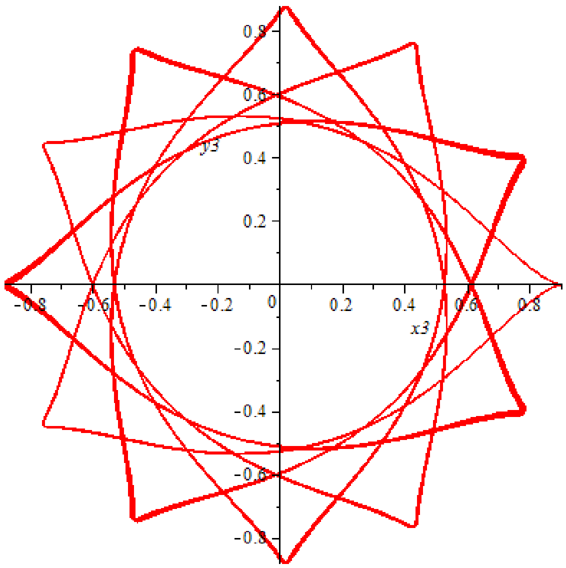

Figure 2: Migration of a meteoroid from Jupiter's orbit to the main belt of asteroids. $x_{30}=\varepsilon$, $\varepsilon=0.9$. t=5000 units of time.

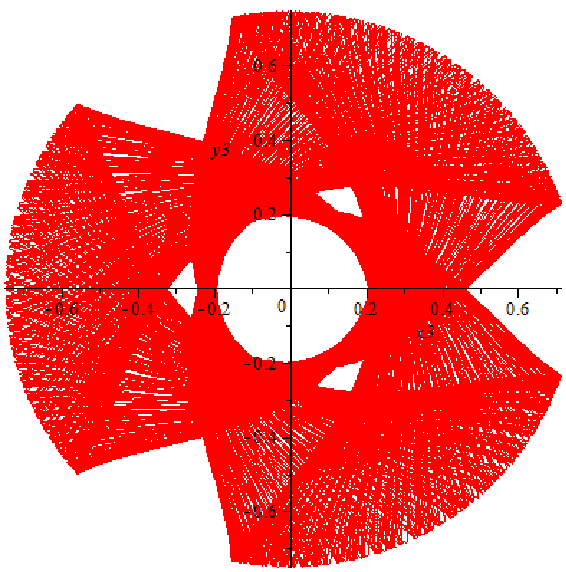

Figure 3: Migration of a meteoroid from the main belt of asteroids to the Earth. $x_{30}=-x_2+\varepsilon$, x_2 = 1048/1049, $\varepsilon=0.25$. $y_{30}=0$. t=2000 units of time.

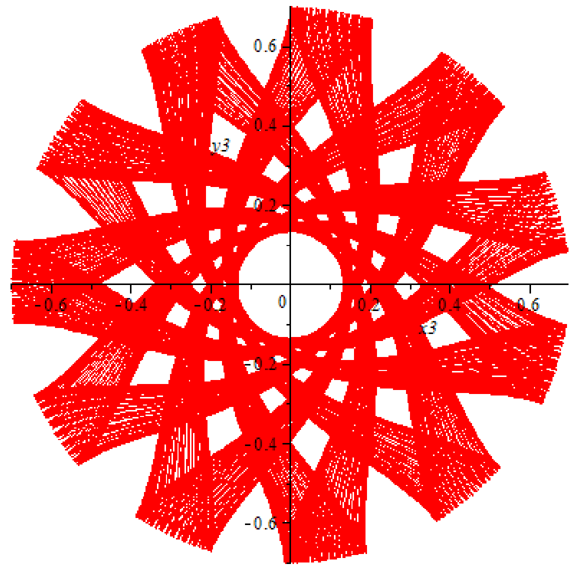

Figure 4: Migration of a meteoroid from the main belt of asteroids to the Earth. $x_{30}=-x_2+\varepsilon$, x_2 = 1048/1049, $\varepsilon=0.3$. t=1770 units of time.

4. Conclusions

a) Small bodies with zero velocity do not migrate from Jupiter to the Earth. In this case they migrate only to the Martian orbit (Fig. 1) and [2]; b) For the regions **(**Fig.1. – Fig.4.) the velocity of m_3 equals zero only in initial moment of time but in the work [2] the corresponding curves are plotted, mainly, only for V≡0; c) In Fig. 2. "Strange" closed trajectory of small body m_3 in the system "the Sun and Jupiter" is presented; d) Fig. 1 is not contradicted with the celestial mechanical model of some meteoroids origin (transfers from planet centrically to heliocentrically orbits and vise – verse).

References

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