COMETS AS INDICATORS FOR EXISTENCE OF FARTHEST UNOBSERVED MINOR BODIES. N. I. Perov, Astronomical Observatory, State Pedagogical University, Respublikanskaya St, 108. Yaroslavl, 150000. Russia. E-mail: n.perov@yspu.yar.ru

Introduction: In the works [1] and [2] we considered the celestial mechanical models of the "slow" and the "fast" processes of comets migration from one region of the Solar system to another. Some practical applications of the considered models as well as the modern models of comets origin are presented in [3]. Here we pay attention the restricted 3-body parabolic problem: a major body of the Moon mass m_2 (in order of the value) moves in the gravitational field of the Sun (mass of which equals m_1) along a parabolic orbit and the minimal distance r_p – in perihelion - of this major body from the Sun is varied in our numerical experiments in limits from 100 AU to 10,000 AU; a cometary nuclei, with negligible small mass m_3, in initial moment of time moves along a circular orbit around the Sun with radius r_{c0}, which is lied in the numerical experiments in region from 500 AU to 50,000 AU. Below we investigate - the quantity conditions of the comet's transition from the circular orbits to elliptical ones, comet's migration into the internal part of the Solar system and comet's bringing near the Sun. Only the gravitational forces of the major body (m_2) and the Sun (m_1) act upon the comet.

Fundamental Equations: For the considered celestial mechanical model we have the differential equations of the bodies with mass m_2 and m_3 motion respectively [4]

$$d^2\mathbf{r}_2/dt^2=-G(m_1+m_2)\mathbf{r}_2/r_2^3; \quad (1)$$

$$d^2\mathbf{r}_3/dt^2=-Gm_1\mathbf{r}_3/r_3^3-Gm_2[(\mathbf{r}_3-\mathbf{r}_2)/|\mathbf{r}_3-\mathbf{r}_2|^3+\mathbf{r}_2/r_2^3]. \quad (2)$$

Here G is the gravitational constant, $\mathbf{r}_2$ and $\mathbf{r}_3$ are heliocentric vectors of the major body (m_2) and the comet (m_3) in respect of the Sun (m_1).

Let's put a new variable *u depended* on time *t*:

$$(u^6-1)/(6u^3)= (1/2)\, tg(v_0/2)+(1/6)tg^3(v_0/2)+ + (G(m_1+m_2)/p^3)^{1/2}t. \quad (3)$$

So,

$$dt/du=(u^6+1)/(2u^4)\,(p^3/(G(m_1+m_2)))^{1/2} \quad (4)$$

and the equation (2) we present in the form with only one (!) nondependent variable u.

Below we put G=1; m_1=1; r_p=1.

Numerical experiments: Geometrically we put out the similar trajectories of the cometary nuclei in the units pointed above. For example, for r_p=1,000 AU, r_{c0}=5,000 AU, r_{20} =6000 AU $m_2=10^{-8}m_1$, $d\varphi=7.5\cdot10^{-9}$ rad – the trajectory and the parts of this trajectory of the comet are presented in the figures 1, 2, 4. In the figure 3 the variation of the distance between the major body (m_2) and the comet (m_3) is presented graphically for the interval $0.41421354533<u< 0.41421354537$. For $d\varphi=6\cdot10^{-9}$ rad the corresponding trajectory near the Sun is presented in the figure 5. Here, $d\varphi$ is a the difference between mean anomalies of the comet for the perturbed and unperturbed motions at the initial moment of time.

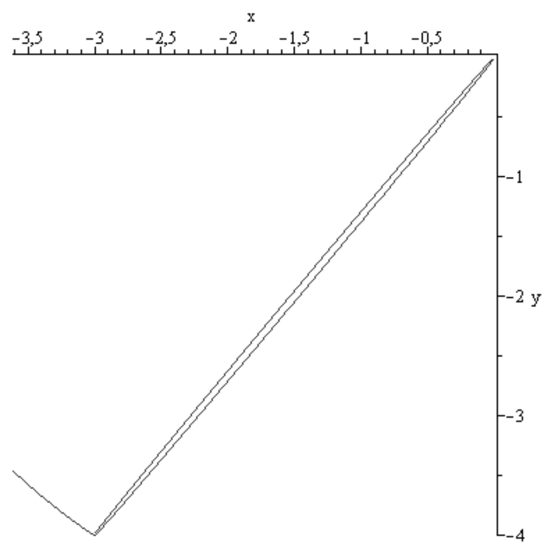

Fig. 1. The total perturbed trajectory of the comet for $0.382<u<3.2$

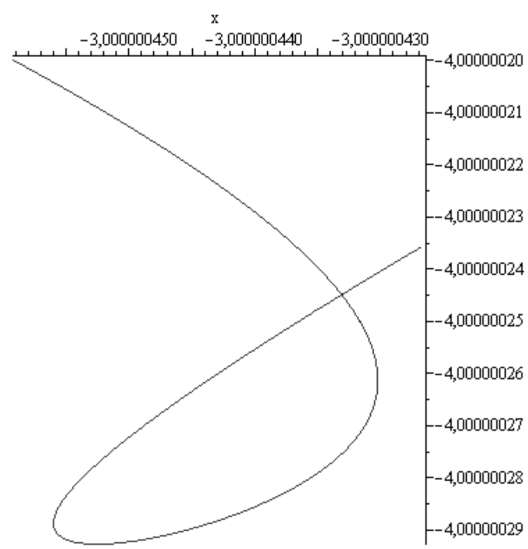

Fig.2. The part of the perturbed cometary trajectory for the interval $0.414213542<u<0.41421360$ (The sphere of action of the major body m_2).

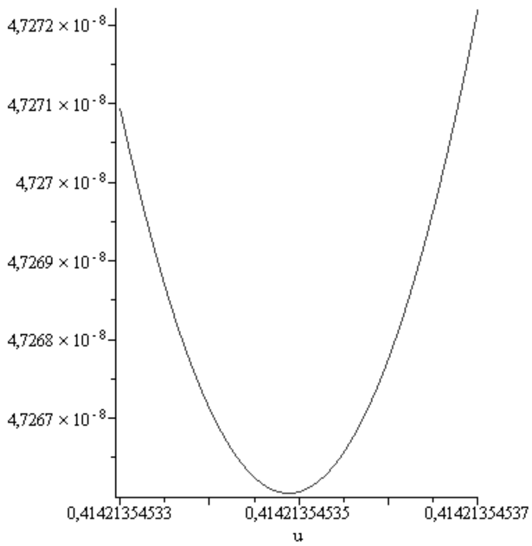

Fig. 3. The closest approaching of the major body m_2 and the comet (m_3) for the interval $0.41421354533<u<0.41421354537$. $r_{23}(u)=((x_2-x_3)^2+(y_2-y_3)^2)^{1/2}$. The extremely perturbed motion of the comet takes place in the sphere of action of the major body m_2 .

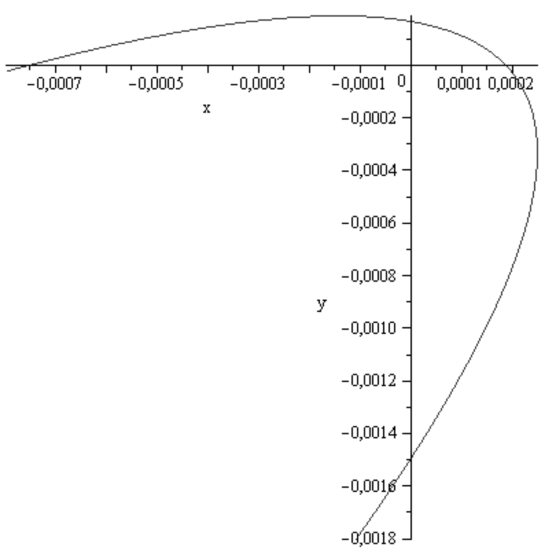

Fig.4. The part of the cometary trajectory for the interval $2.16503<u<2.165039$.

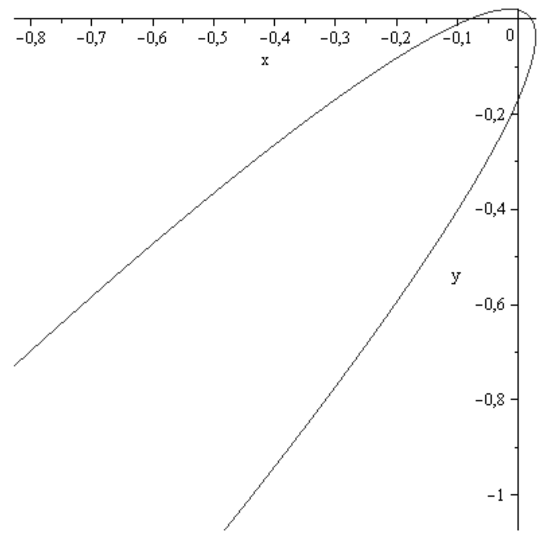

Fig.5. The part of the cometary trajectory for the interval $2.0<u<2.2$. $d\varphi=6\cdot 10^{-9}$.

Conclusion: It should be noted for $r_p=1$ and corresponding values of r_{c0} and r_{20}, which are varying from 10^2 to 10^5 AU, figures (1) – (5) for units $G=1$; $m_1=1$; $r_p=1$are geometrically identity. So, the equations (1)-(4) may be considered as “unified” one’s for describing with help of the variable u of the “fast” process of cometary nuclei migration from Oort’s and Hills’ clouds into the internal parts of the Solar system.

Moreover, the considered model shows - minor unobserved bodies, with perihelion distance $r_p>100$ AU masses (m_2) of which are less in comparison with the mass of the Moon, and which cross the reservoirs of the cometary nuclei, may transform the comets (m_3) into hazardous bodies [5] for the earth’s civilization (Fig.4).

References: [1] Perov N. I. (2003) *Solar System Research, 37*, *2,* 165–174. [2] Perov N. I. (2005) *Solar System Research, 39*, *3,* 281–287. [3] Finkelstein A.M., Huebner W.F., Shor V.A. *Eds.* (2010) *Protecting the Earth against Collisions with Asteroids and Comets Nuclei*. Saint Petersburg. Nauka, 427. [4] Roy A. (1978) *Orbital Motion.* Adam Higler Ltd. Bristol, 545. [5] Perov N. I. et.al. (2011) *Theoretical methods of localization in the space-time of undiscovered celestial bodies.*YSPU. Yaroslavl. 204 pp. (In Russian).