TO THE PROBLEM OF METEOR STREAMS AND COMETS RELATIONSHIP. E.N. Tikhomirova, Astronomical Observatory, State Pedagogical University, Respublikanskaya 108, Yaroslavl 150000, Russian Federation. E - mail: perov@yspu.yar.ru

Introduction: The interest to a problem of relationship of meteor streams and comets now has increased in connection with the intensive research in direction of Solar system origin and asteroid-comet-meteoroid hazard [1-3]. Parent bodies of many meteor streams are not identified. At the beginning of the XXI more than 4000 meteor streams were known but parent bodies were identified for several tens of them only.In work [5], analytically tractable, the evolution of meteor particles' elliptic orbits in a gravitational field of the Sun is considered in view of light pressure and the effect of Poynting - Robertson. Thus, the compact formulae connecting parameters of initial and final elliptic orbits of meteor particles are deduced and the method of an identification parent comets and meteor streams is submitted. Besides, the way of modernization of the given ratio in view of corpuscular analogue of Poynting - Robertson effect is specified. Below, the athor continues the investigation of this problem.

Fundamental Equation: Solution and Applications: The differential equation of motion submitted in the vector form, absolutely black spherical body, isotropic reradiating a solar energy and moving with velocity v, making an angle u with a direction of a heliocentric radius - vector **r** looks like [4] :

$$\ddot{\mathbf{r}} = -GM'\mathbf{r}/r^3 - 2\pi R^2 q r^2_{S-E}/(Mc^2) v \cos u\, \mathbf{r}/r^3 - \pi R^2 q r^2_{S-E}/(Mc^2 r^2) v \sin u\, \mathbf{e}_t \quad (1)$$

Here G - a gravitational constant, r - distance between the Sun and a particle, R - radius of a particle, c - speed of light, $q_{S\text{-}E}$ - a solar constant for average distance $r_{S\text{-}E}$ from the Sun up to the Earth, $\mathbf{e}_r$ и $\mathbf{e}_t$ – unit vectors of radial and transversal accelerations, M' – the reduced mass of the Sun [5] .

The effect of Poynting - Robertson is characteristic for particles with radii from 1 μm up to 1 cm, and effect of Yarkovskii becomes essential to bodies with radii from 10 cm up to 10 km. [2]. For a case of small perturbations from the equation (1), after averaging for one orbital evolution of a meteoric particle and the subsequent integration, we shall find:

$$a/a_0 - e^{4/5}(1-e_0^2)/(e_0^{4/5}(1-e^2)) = 0. \quad (3)$$

Identification of parent comets and meteor streams: For identification of meteoric showers and their parent comets in view of Poynting-Robertson effect we shall put criterion (3) and we shall believe, that inclinations of comets' and meteoric streams' orbits differ from each other a little (<10º) and close collisions of comets and meteoroids with major planets are also absent (at least, on a considered interval of time).

To estimate reliability of an identification of comets and meteor streams the method is considered in view of corpuscular analogue of Poynting - Robertson effect.

Analytical Description of the Poynting-Robertson Drag Caused by Solar Wind: In G.O.Rjabova's work [4] in semianalytical form influence of a solar wind on motion of meteoroids is taken into account. Mean value of velocity of Solar Wind (in radial direction) is w=400 km/s (for distance 0.3 AU<r<10 AU). The concentration of protons n_p in Solar Wind varies as $n_p = 8.1(r_{S\text{-}E}/r)^2(400/w)$ cm^{-3}. We also use ratios: U=w-v, $n_\alpha/n_p=0.05$. The action of electrons and heavy ions at meteoroids isn't taken into account. The parameter of the model is ψ, which takes on values: 1.6 (water ice), 1.4 (magnetite), 1.1 (obsidian).

We solve this problem analytically in view of simultaneous action of photons, protons and α-particles:

$$\frac{a}{a_0} - \frac{\left(1-e_0^2\right) e^{\frac{4+2k}{5+2k}}}{\left(1-e^2\right) e_0^{\frac{4+2k}{5+2k}}} = 0, \quad (4)$$

where $k=k_w/k_p$,

$k_w = 3.65 \cdot 10^3 \Psi \bar{U}$ (In system CGS),

$$k_p = \frac{\pi q_{S-E} r_{S-E}^2 a_0^{3/2}}{\sqrt{GM'} c^2 T_0},$$

a_0 and e_0 are initial values of semimajor axis and eccentricity of meteoroid's orbit, Ū – averaging value of |U| at period of time of meteoroid's moving. Let's pay attention, that for possible maximal value of k_w ($\bar{U}$=400·10^5 cm/s, ψ=1.6) and possible minimal value of k_p ($M'=M_S$, $a_0^{3/2}/T_0 = \sqrt{GM_S}/(2\pi)$). Here k_w and k_p are the values proportional to the accelerations of meteoroids, which are caused by the action of protons (of the solar wind) and photons, correspondingly; their ratio is not greater than 1.5, therefore it is possible to put $0 < k_w/k_p < 1.5$.

Let's find k :

$$k = \left(5\ln\frac{a\left(1-e^2\right)}{a_0\left(1-e_0^2\right)} - 4\ln\frac{e}{e_0} \right) / \left(\ln\frac{e}{e_0} - \ln\frac{a\left(1-e^2\right)}{a_0\left((1-e_0^2\right)} \right) \quad (5)$$

The criterion k allows estimating reliability of an identification of comets and meteor showers.

Let's consider average values *a, e, i* of some meteor streams and comets (see Table 1) and do a validation of criterion (5).

Table 1. The comets - candidates for parent bodies of meteor streams.

	Shower	Comet (Epoch 2000 01 01)	k
β Cancrids		3D/Biela	0.130
a, AU	2.105	3.533	
e	0.638	0.768	
i, deg	2.8	8.1	
λ Cygnids		73P/Schwassmann-Wachmann	0.622
a, AU	2.522	3.060	
e	0.641	0.694	
i, deg	11.2	11.4	
k Cygnids		177P	1.179
a, AU	3.533	24.065	
e	0.719	0.954	
i, deg	32.7	31.2	

For some identified meteor streams and their parent comets the parameter k is in the interval $0 < k < 1.5$.

In the Table 1 the attempt of identification the meteor streams β Cancrids and λ Cygnids and the comets 3D/Biela and 73P/Schwassmann-Wachmann correspondingly is made.

According to the analysis of calculation the variation of parameter k variates the value of eccentricity much more than the value of semimajor axis.

Let's pay attention, that meteoroid's averaging elements of heliocentric orbits can differ much individual meteoroids' orbit parameters. For interval k the values of parameters of meteor stream differ much their mean values. It means the subsequent identification of meteor streams and their parent bodies research is necessary.

Conclusion: The problem of identification of meteor streams and their parent comets is solved using the integrals of motion that have been found in the frame of the averaged perturbed two-body problem. The Poynting - Robertson drag caused by solar wind is taking into account.

References: [1] Ipatov S.I. and Mather J.C. (2005), (See 197th Coll. of IAU), P. 399 - 404. [2] Vokrouhlický D., Brož M., Bottke W.F., Nesvorný D., Morbidelly A. (2005), (See 197th Coll. of IAU), P. 145 - 156. [3] Gajdoš Š. , Porubčan V. (See 197th Coll. of IAU), P. 393 - 398. [4] Ryabova G.O. (2005), *Dynamics of populations of planetary systems* / Eds., Knežević Z. and Milani A. Proc. of the 197th Coll. of the International Astronomical Union. Belgrade, Serbia and Montenegro. Aug. 31 – Sept. 4, 2004. Cambridge University Press, 2005., P. 411 - 414. [5] Tikhomirova E.N. (2007) *LPS XXXVIII,* Abstract #1042.