PSEUDOSTABLE ORBITS OF DUST GRAINS AROUND COMETARY NUCLEI.

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Introduction: Dust particles released from cometary nucleus surfaces are ejected due to several forces acting upon them [1]. Some of them will fall back to the surface, while another ones will constutite the coma. But there are some other particles which are injected into pseudostable orbits. We will describe the dust particle equation of motion and will give ranges of latitude in which we have found particles in pseudostable orbits. Our model is an improved version of a previous model [2], including those terms due to nucleus rotation. We will give a comparison between them.

Model: To state the equation of motion, we have to include all forces acting on the particles. Dust particles are affected by gravitational forces due to comet and Sun, radiation pressure due to electromagnetic field coming from the Sun, gas drag force and those Coriolis terms due to nucleus spin. The largest particle that can be lifted from the surface has a diameter d given by the equation:

$$d = \frac{1}{\rho_d(\frac{GM_c}{R^2} - \Omega^2 Rcos(\phi))}\frac{3C_D\dot{m}_g v_g}{16\pi R^2},$$

where G is the gravitational constant, M_c the comet mass, R the comet radius, Ω the angular speed, ϕ the latitude, C_D the drag coefficiente, $\dot{m}_g$ the gas production rate and v_g the gas velocity. $\dot{m}_g v_g$ is modeled by [2]:

$$\dot{m}_g v_g = 2(\alpha+1)(\dot{m}_g v_g)_o(\frac{r_o}{r})^\gamma(cos(Z))^\alpha,$$

where r is the heliocentric distance, $r = a(1-e^2)/(1+e\cos\nu)$, a being the semimajor axis, e the eccentricity, and ν the true anomaly, Z the zenital angle, $(\dot{m}_g v_g)_o$ and r_o are obtained by observational data [6], and α and γ are obtained by the fits of the DIDSY data made by Fulle [7]. Following Sekanina [4], we have:

$$\cos Z = \cos\nu(\cos\phi\cos\theta) + \sin\nu(\cos\phi\sin\theta\cos I + \sin I\sin\phi),$$

where θ is the longitude. In this way, the largest particle that can be lifted can be related to the true anomaly by the above expressions.

Results: As in Fulle [2], we have studied dust particle in possible orbits around 46P/Wirtanen ($\alpha = 3$, $\gamma = 6$) and 1P/Halley ($\alpha = 3$, $\gamma = 3$). The values of β (ratio of solar radiation pressure force to solar gravity force), I (obliquity) and ϕ (latitude) have been varied. The particle is ejected when the sum of inertial force due to spin and gas drag force is greater than cometary gravitational force. But when that particle is released, the inertial forces do not act anymore, and it may occur that the particles falls back again to the surface owing to the fact that comet gravity is greater than gas drag force. This is the reason why there appear various "jumps" before the dust particles definitely fly far away from the nucleus.

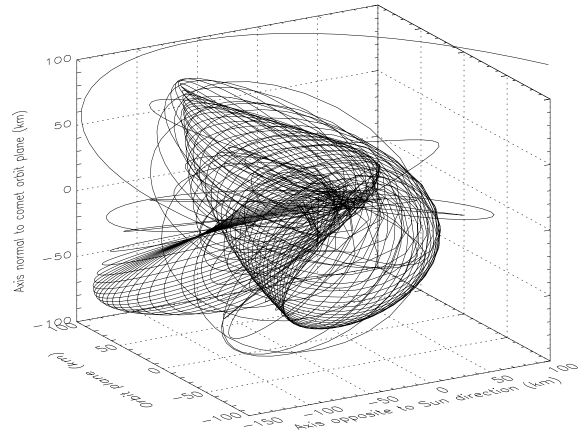

Figure 1: Pseudostable orbit of a dust particle around comet 46P/Wirtanen having the following parameters: $\beta = 4.1 \cdot 10^{-6}$, $\phi = 7°$, $\theta = 0°$ and $I = 40°$. Its flying time lasted three perihelion passages.

We compared bound orbits including nucleus rotation with those models in which rotation is neglected. In general, dust particles with non-zero nucleus spin could be slightly greater than those released from a zero spin nucleus because of inertial forces. Using this this model, we could find some pseudostable orbits in specific latitude ranges, depending only on the obliquity. For example, if I = 0°, the latitude ranges are symmetric to the cometary equator -19° to -14° and +14° to +19°. But if I = 40°, bound orbits latitude ranges varying from 2° to 15°. But the main difference between models is that there are much less particles going into pseudostable orbits, and their flying time is reduced to a few degrees in cometary true anomaly. There are some exceptional cases (as shown in Figure 1) in which particles lasted three perihelion passages, but those orbits are uncommon. We will extend the results to the study of some other comets with different physical properties.

References: [1] Finson, M. and Probstein, R. (1968) *ApJ, 154, 327* [2] Fulle, M. (1997) *A&A, 325, 1237* [3] Whipple, F.L. (1984) *ApJ, 113, 464* [4] Sekanina, Z. (1981) *ARE&PS, 9, 113* [5] Richter, K. et al. (1995) *Icarus 114, 355* [6] Jorda, L. et al (1995) *Planet.Space Sci., 43 , 575* [7] Fulle, M. et al (1995) *A&A, 304, 622*