DUST PARTICLE AND SOLAR RADIATION

J. KLAČKA and J. KAUFMANNOVÁ

Department of Astronomy and Astrophysics, Faculty for Mathematics and Physics, Comenius University, Mlynská dolina, Bratislava, Czech and Slovak Federal Republic

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Abstract. Influence of the solar radiation (electromagnetic and corpuscular – solar wind) on the motion of the interplanetary dust particle is investigated. The ratio 'time of inspiralling toward the Sun: time of inspiralling neglecting the change of mass of the particle' is presented as a function of initial eccentricities.

1. Introduction

The effect of the solar electromagnetic radiation on the motion of the interplanetary dust particles (IDPs) is well-known as the Poynting–Robertson effect. Similar effect of the solar wind is generally known as 'corpuscular drag'. Moreover, noncatastrophic destruction of the IDPs due to the action of the solar wind is known as 'corpuscular sputtering'. Poynting–Robertson drag and corpuscular drag cause the inspiralling of the IDP toward the Sun. This paper deals with comparisons of times of inspiralling toward the Sun for the case of neglecting corpuscular sputtering and for the case of the complete effect of the solar wind. The special case of formally circular orbit was investigated by Klačka and Kapišinský (1992).

2. Mathematical Formulation of the Problem

Effects of the solar radiation (electromagnetic and corpuscular) represent only perturbations to the Keplerian motion for the system Sun – IDP. The process of in-spiralling toward the Sun can be expressed by secular changes of the orbital elements and radius of the particle (see Equations (21)–(23) in Klačka 1993). The most simple case yields the following equations:

$$\frac{da}{dt} = -1.25\eta \frac{2 + 3e^2}{a(1 - e^2)^{3/2}}, \tag{1}$$

$$\frac{de}{dt} = -1.25\eta \frac{5}{2} \frac{e}{a^2\sqrt{1 - e^2}}, \tag{2}$$

$$\frac{ds}{dt} = -\frac{K}{a^2\sqrt{1 - e^2}}, \tag{3}$$

(if $e \approx 0$ does not hold) where a is semi-major axis of the particle (in AU) e-

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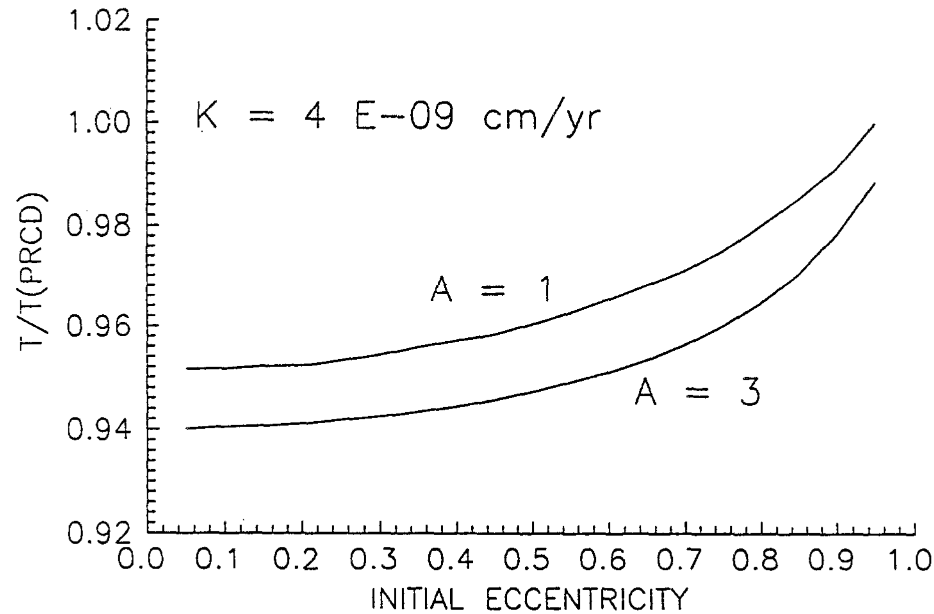

Fig. 1. Ratio 'time of in-spiralling toward the Sun: time of in-spiralling neglecting the change of mass of the particle' as a function of initial eccentricities.

eccentricity and s-radius of the particle (in cm). Time t is measured in *years*. The quantity η is given by

$$\eta = 3.61 \times 10^{-8}/(s\rho) , \tag{4}$$

where ρ is mass density of the particle, measured in $g\,\mathrm{cm}^{-3}$ (see Equations (7a)–(7c) and (9) in Klačka 1991b).

Equation (3) represents 'corpuscular sputtering'. The complete action of the solar radiation is given by Equations (1)–(3) (and also (4)). The system of these equations must be solved for the purpose of obtaining time of in-spiralling toward the Sun. The system of Equations (1) and (2) must be solved if we neglect (as it is generally done) disintegration of the particle.

3. Results and Discussion

The important results are shown in Figures 1 and 2. All calculations were done for $\rho = 3g\,\mathrm{cm}^{-3}$. Obtained results (ratio 'time of in-spiralling toward the Sun: time of in-spiralling neglecting the change of mass of the particle' as a function of initial eccentricities) are independent on initial radii of the particles (see, e.g., Klačka 1991a, or, Klačka and Kapišinský 1992) since the case 'radiation pressure force/gravitational attractive force <1' is supposed. Values $A = 3$ and $A = 1$ represent initial values of semi-major axes (measured in AU) used in the system of differential equations (1)–(4). Times of in-spiralling T and T_{PRCD} were obtained from

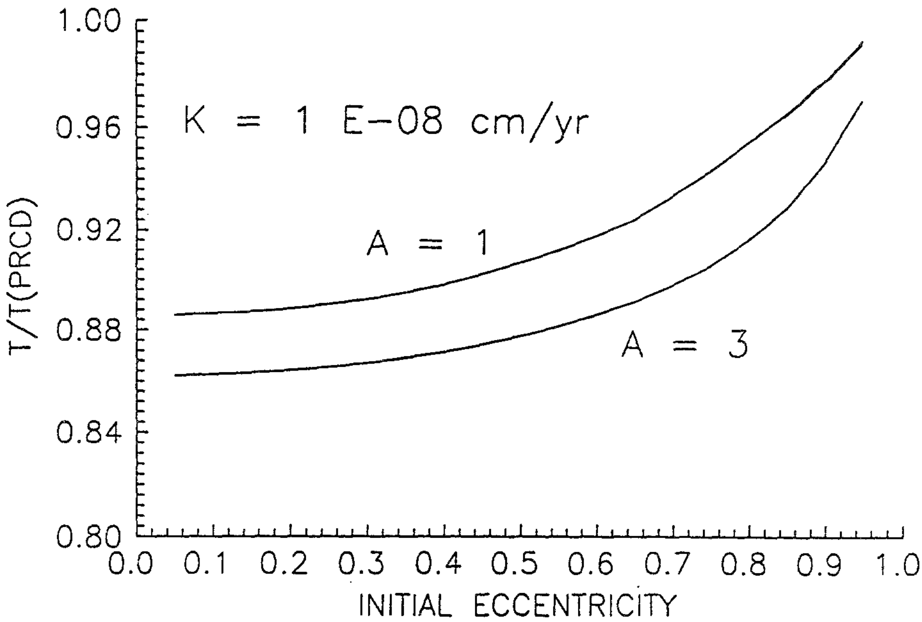

Fig. 2. Ratio 'time of in-spiralling toward the Sun: time of in-spiralling neglecting the change of mass of the particle' as a function of initial eccentricities.

Equations (1)–(4) for the case of final semi-major axis $A = 0.3$ AU, i.e., process of inspiralling toward the Sun is characterized by conditions $A = 3$ AU $\rightarrow A = 0.3$ AU or $A = 1$ AU $\rightarrow A = 0.3$ AU. One can easily obtain errors of standard calculations which do not take into account the change of mass of the particle.

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