On the Stability of the Zodiacal Cloud

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Motion of small nonspherical interplanetary dust particle (meteoroid) under the action of solar gravity and solar electromagnetic radiation is investigated. Rapid rotation of the particle about defined axis of rotation is considered.

Comparison of resulting particle motion with the well-known Poynting-Robertson (P-R) effect leads to significantly different conclusions. The P-R effect's deceleration term is in one to two orders in magnitude less important than terms corresponding to nonforward (or nonbackward) radiation scattering. Generally, it depends mainly on particle size, shape, and composition. While the P-R effect yields spiraling toward the Sun (decrease of semimajor-axis with time), motion of real meteoroid is much more complicated. Inspiraling toward the Sun during some time interval is followed by spiraling outward the Sun. This process can be repeated for many times. It could be essentially affected by chosen starting geometry of the solved system particle-Sun, i.e. by selected particle rotation axis, current particle orientation, and its position relatively to the Sun. Absence of any relation between semimajor-axis and eccentricity is a consequence of such problem complexity.

The results are important for application to the stability of Zodiacal cloud. While the P-R effect (valid for spherical particles) yields instability of the cloud due to monotonous inspiraling of the particles toward the Sun, our numerical simulations show that particle nonsphericity could radically modify its resulting motion in the Solar System. There was found a specific kind of particles characterized by the relatively stable trajectories. Therefore the particle source (comets, asteroids) is no necessary to explain the stability of dust envelope consisting of such bodies.