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ORBITAL FLIPS DUE TO SOLAR RADIATION PRESSURE FOR ORBITAL DEBRIS IN NEAR-CIRCULAR INCLINED ORBITS

Abstract

We investigate the orbital plane flips (flips from prograde to retrograde motion or vice versa) phenomenon due to solar radiation pressure. We consider initial near-circular orbits with different inclinations from the GNSS to the geosynchronous region. We study the dynamical evolution of orbital debris from a numerical simulation. Initial data correspond to nearly circular orbits with the eccentricity $e = 0.001$. The initial inclination is varied from 0° to 80°. Initial values of longitude of ascending node Ω are varied from 0° to 350°. Area-to-mass ratio γ corresponds to orbital debris and is varied from 8 to 80 m^2/kg. Dynamical evolution covers spans 24 and 240 years.

We modeled orbital evolution of objects with the help of "Numerical Model of Motion of Artificial Satellites" developed at the Tomsk State University. The model of perturbing forces takes into account the major perturbing factors: the gravitational field of the Earth (EGM96 model, harmonics up to the 27^{th} order and degree, inclusive), the gravitation of the Moon and the Sun, the tides of the Earth, the direct radiation pressure (coefficient of reflection of the satellite surface is 1.44) taking into consideration the shadow of the Earth, the Poynting–Robertson effect, and the atmospheric drag. The equations of motion are integrated by the Everhart's method of the 19^{th} order.

A minimum value of the initial inclination, which leads to the orbital flips, is increased when the semi-major axis is raised. There is a dependence of the long-period evolution of objects with a high area-to-mass ratio on the initial value of the ascending longitude. Flips of the orbits due to the effect of solar radiation pressure have been observed for the initial value of the longitude of ascending node in vicinity 180°. We obtain that flips are possible only for objects with a high area-to-mass ratio ($\gamma > 8$ m^2/kg). Moreover, the flips studied in this work are caused precisely by light pressure, and not by the Lidov-Kozai effect.

Those orbits for which flips were noticed cannot be recommended as orbits for long-term storage of space debris.

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