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ORBITAL FLIPS DUE TO SOLAR RADIATION PRESSURE FOR SPACE DEBRIS IN ORBITS WITH MODERATE ECCENTRICITY

Abstract

We study the dynamical evolution of space debris with a high area-to-mass ratio in medium, high, and geosynchronous orbits. We investigate the orbital plane flips (flips from prograde to retrograde motion or vice versa) affected by solar radiation pressure. We consider initial low and moderate eccentricity orbits with different initial inclinations. Initial data correspond to orbits with the semi-major axes from 25500 to 42200 km and the eccentricities from 0.001 to 0.4. The initial inclination is varied from 55° to 75°. Initial values of the ascending node's longitude vary from 0° to 360°. The area-to-mass ratio corresponds to orbital debris and is varied from 7 to 40 m^2 kg^{-1}. Dynamical evolution is over 24 years. We used the "Numerical Model of Motion of Artificial Satellites". The model of perturbing forces includes the major perturbing factors: the gravitational field of the Earth (EGM96 model, harmonics up to the 27th order and degree, inclusive), the gravitation of the Moon and the Sun, the tides of the Earth, the direct solar 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 19th order.

A minimum value of the initial inclination, which leads to the orbital flips, is decreased 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 ascending node longitude's initial value. The maximum inclination of the orbit is achieved when the longitude of the pericenter is sun-synchronous. Flips of the orbits due to solar radiation pressure have been observed for the initial value of the ascending node's longitude in the vicinity of 180°. The minimum area-to-mass ratio leading to orbital flips decreases with the initial inclination. Minimum initial inclination leading to orbital flips increases with increasing the initial eccentricity. Maximum inclination increases with increasing the initial inclination and semi-major axis. Moreover, the flips studied in this work are caused precisely by solar radiation pressure and not by the Lidov–Kozai effect. The Lidov–Kozai effect is suppressed by solar radiation pressure perturbations, affecting high area-to-mass ratio objects due to a secondary apsidal-nodal secular resonance.

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