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LONG-TERM DYNAMICAL EVOLUTION ANALYSIS AND LUNI-SOLAR RESONANCES FOR INCLINED GEOSTATIONARY TRANSFER ORBITS

Abstract

Space debris mitigation has drawn much attention of the community, since the growing number of space debris poses a significant threat to operational spacecraft. The most valuable spaces that need the most protection are the low Earth orbit (LEO) region and geostationary orbit (GEO) region. Many efforts, national and international, have been made to ease the worsening situation.

Geostationary transfer orbits (GTOs) have been used broadly to launch geostationary orbit satellites, however, with one or more upper stages left in the GTO during every launch. These upper stages have large sizes and large relative velocities with respect to objects in LEOs and GEOs, and then are a potential source for collisions and future debris. In this aspect, knowledge of the GTO dynamical evolution under natural perturbations is urgent for predicting the distribution, decay, and lifetime of the space debris in GTOs.

Many studies have been devoted to dynamical evolution of GTOs. Due to its low perigee and high apogee, dynamical evolution of GTOs is governed by multiple perturbations and their complicated interactions, including the atmospheric drag, Earth's oblateness, and luni-solar perturbations. As a result, the dynamical evolution is highly sensitive to the initial conditions and model parameters. Previous studies have shown that the high sensitivity of the dynamics can be attributed to the solar apsidal resonance, which appears in the singly-averaged model and is difficult to predict or manage.

Current studies have been focused on low-inclination GTOs. Actually, there is a kind of inclined geostationary transfer orbits (IGSOs) with a high inclination, e.g., the IGTOs used to launch inclined geosynchronous orbit (IGSO) satellites of the Chinese Beidou navigation system. The high inclination makes the IGTOs encounter the secular luni-solar resonances dependent only on inclination. The secular resonances appear in the doubly-averaged orbital model, and cause long-term variation of eccentricity, affecting the orbital lifetime significantly. The secular resonances have mainly been studied for medium Earth orbits (MEOs) and IGSOs. The high eccentricity of IGTOs will make the effects of secular luni-solar resonances even more significant.

As stated above, the long-term dynamical evolution of IGTOs with both the solar apsidal resonance and secular luni-solar resonances has not been studied yet. This study will be focused on this issue, especially the crucial effects of the two resonance and their interactions. The results will provide useful insights for the space debris mitigation in IGTOs relating to the Chinese Beidou navigation system.