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USING EQUINOCTIAL ORBITAL ELEMENTS AND QUASI-AVERAGE ELEMENT METHOD TO CONSTRUCT ANALYTICAL SOLUTIONS FOR GEOSTATIONARY SATELLITE

Abstract

The eccentricity and the inclination of the satellite in geosynchronous orbit are both small, under this condition, perturbations from the Earth's non-spherical gravitational field result in orbit resonances due to incommensurable small denominators, that is, the problem of small eccentricity, small inclination and commensurability small incommensurable denominator exist simultaneously. Usually we adopt the classic Kepler orbital elements to describe an orbit, However, in the case of small eccentricities and small inclinations, the geometric meaning of the perigee and ascending node of an GEO is no longer clear, and the equations of motion have small denominators which results in the failure of the usual mean orbit element perturbation solution. This phenomenon of singularity is caused by the inappropriate choice of independent variables and has nothing to do with the dynamics. Such singularities can be avoided by choosing the appropriate independent variables (called non-singularity orbital elements). Incommensurable singularity appears in the process of solving the perturbation equations by the mean element methodology. The quasi-average element methodology retains the main advantages of the mean element method and reasonably revises its definition. Quasi-average orbits, without short periodic terms, while including the long-term items are taken as the reference orbit. The reference orbit in this transformation has long-term variations which are similar to the long periodic terms within a short-time duration. So we can avoid the failure of the perturbation solution caused by the periodic terms when using the classical perturbation method or the mean element method. From the perspective of mechanics, it can eliminate the incommensurable singularity, and the perturbation solution will remain valid. This paper aims at introducing the calculation method to eliminate the singularity problem of e=0,i=0 and commensurability singularity by using the quasi-average element methodology based on equinoctial orbital elements. Also, considering the perturbation of J2 J3 J4 and J2,2 terms of Earth's non-spherical gravitational field, the lunar gravitational field and solar gravitational field, we try to derive a general perturbation solution, which can be applied in different conditions. Thus "zero mistake" in application can be realized to improve the security of the satellite operation. Also, this method can be extended to solve the problems of singularity caused by other perturbations.