Paper ID: 85204
oral

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

Author: Prof. Yue Wang
Beihang University, China

Mr. Yongjie Chen
School of Astronautics, Beihang University, China
Mr. Tao Fu
Beihang University, China

LONG-TERM ORBITAL DYNAMICS SURROUNDING AN ECCENTRIC BINARY ASTEROID SYSTEM BY TRIPLE AVERAGING

Abstract

As advancements in space technology continue to progress, there is a growing fascination with exploring various multi-body systems within the solar system. Consequently, extensive research has been conducted on the long-term orbital evolution of satellites surrounding Mars, Jupiter, and other systems by using semi-analytical model. However, the semi-analytical orbital dynamics surrounding a binary asteroid system, in which asteroids act as inner eccentric perturbers, remain unstudied. This could prove valuable in understanding the typical dynamical characteristics near irregular binary systems.

The outer problem in the hierarchical restricted three-body problem, i.e., the inner third-body perturbation, is a complex field of study with important applications in understanding the evolution of trans-Neptune objects and particle disks in stellar systems. Researchers have investigated a variety of orbital evolution mechanisms, including orbital flip, periapsis longitude, and inverse Lidov-Kozai resonances. It has been demonstrated that, in the circular synchronous binary configuration, the classical Lidov-Kozai constant is conserved after the double averaging even with non-spherical perturbations. However, when two non-spherical bodies orbit each other with an eccentricity, the precession of their mutual orbit changes the semi-analytical model significantly. If the secondary is coplanar to the primary's equator, the apsidal line of secondary's orbit will precess at a much faster rate compared to the periodic evolution of the outer orbital plane. This suggests that a third averaging is applicable, and the system remains one degree of freedom, which means that the outer orbit's right ascension of ascending node is eliminated, preventing orbital flip resonance. Consequently, the inverse Lidov-Kozai resonance will become the dominant mechanism. The phase structure of equilibrium points will be analyzed in various situations, including the polar, critical-inclination, and circular orbits, to discuss the feasibility of frozen orbits. When the secondary is inclined to the primary's equator, the symmetry of the system is broken, and the third averaging is unworkable. After the double averaging, the system turns to two degrees of freedom, which leads to more intricate resonances. The coplanar and inclined problems will be approximated up to the hexadecapole term to reflect the long-term evolution mechanisms accurately.

Finally, the semi-analytical models are verified in 2003 YT1 with accurate spherical harmonic model data. The results and models can also be utilized in exoplanetary systems with a similar perturber configuration in the outer problem.