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LONG-TERM ORBITAL EVOLUTION SURROUNDING A BINARY ASTEROID SYSTEM

Abstract

Since the discovery of asteroids in the solar system, people have carried out a lot of challenging scientific research. Binary asteroid systems, which have two members orbiting around each other, are particularly prominent among the asteroids because they are believed to contain the secret of planetary evolution. They have also been the hot targets of deep space explorations, such as the DART and Hera missions. Due to the irregular shapes and coupled attitude-orbit dynamics of the two members, orbital dynamics and control problems about binary asteroid systems are quite complex, which involve the full two-body problem (F2BP) and the restricted full three-body problem (RF3BP).

Unlike most previous studies focused on libration point orbits, this study will be focused on the perturbed Keplerian orbit surrounding a binary asteroid system in the framework of the two-body problem. The long-term orbital evolution will be revealed based on a semi-analytical model, which takes into consideration of the oblateness of the primary and the third-body gravitational perturbation of the secondary to the hexadecapole order. The Lidov-Kozai resonance with an interior perturber, which is accompanied by the oscillations of eccentricity and inclination, will be discussed specifically in the scenario of a binary asteroid system. To study the essence of resonance evolution, the phase space structure of the dynamical system with four degrees of freedom will be analyzed, mainly on the eccentricity, argument of periapsis, inclination, and right ascension of ascending node. The orbital stability will be studied by investigating the oscillation of the eccentricity, and the existence of frozen orbits will be also discussed.

The binary system 2003 YT1 with accurate spherical harmonic model data will be used as an example for our analysis. The model can be applied to other binary systems that have a synchronous configuration. The results can be used for the mission design about a binary asteroid system, and also can advance the research on the hierarchical restricted three-body problem.