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Author: Mr. Xiaosheng Xin
Beijing Institute of Tracking and Telecommunication Technology (BITTT), China, xiaoshengxin@outlook.com

Dr. Hou Xiyun
Nanjing University, China, xiyun.hou@gmail.com
Prof. lin Liu
Nanjing University, China, lliu@nju.edu.cn
Prof. Guangliang Dong
Beijing Institute of Tracking and Telecommunication Technology (BITTT), China, xiaoshengxin@outlook.com
Dr. Jingshi Tang
Nanjing University, China, jstang@nju.edu.cn

BOUNDED MOTIONS ABOUT SYNCHRONOUS BINARY ASTEROID SYSTEMS WITH APPLICATION TO 65803 DIDYMOS

Abstract

Binary asteroids are common in near-Earth asteroids (NEAs), which account to about 15% among those larger than 300 meters. Many of the known binaries are synchronous systems meaning that the secondary has a spin period synchronized to the mutual orbit period. The Asteroid Impact & Deflection Assessment (AIDA) mission, a joint effort between ESA and NASA, is scheduled to explore an asteroid of this kind, 65803 Didymos, in 2022. Enough knowledge of the dynamical environment about this binary system is critical to the successful planning as well as implementation of the mission. We systematically study the bounded motions about Didymos in this contribution.

The system of Didymos is modeled as a constant polyhedron (the primary) and a constant-density triaxial ellipsoid (the secondary). The full dynamics of the orbital and rotational motion of the binary together with the Keplerian orbit of the binary barycenter around the Sun is considered in the study. Through FFT analysis, basic frequencies n_i of the motion of the binary system are first obtained from long-time integration of the dynamics of the system. The geometrical triangular libration points, which are obtained in the framework of the CRTBP when the binary is considered as spheres, no longer exist in the real model. In analogous to the research on quasi-periodic motions around the collinear libration points in the real Earth-Moon system, equations of motion (EOMs) about these fictitious geometrical triangular libration points can still be constructed, with the right hand side of the equations dividing into parts that are constant with respect to time and that are related to the basic frequencies. Special solutions of the EOMs, which are also quasi-periodic orbits, are commonly known as dynamical substitutes in literature. By first solving the linearized form of the EOMs, then adding in higher order terms, higher order analytical approximation of the dynamical substitutes can be obtained. With the aid of the parallel shooting method, dynamical substitutes lasting a long time can be obtained. The stability properties of the dynamical substitutes corresponding to different amplitudes are systematically studied via maximum Lyapunov exponent. In addition, stability against solar radiation pressure perturbation is also discussed.