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# BIFURCATION OF PERIODIC ORBITS AND EQUILIBRIUM POINTS OF CONTACT BINARY ASTEROIDS AND ITS APPLICATION TO 1996 HW1

**Abstract**

Holding the key to the origin of universe, asteroids have attracted more and more interests from scientists and engineers. In order to provide ideal position for observations on asteroid's surface, many experts are devoted to the dynamics near asteroids, especially, the topological structure of equilibrium points (EPs) and the construction of periodic orbits (POs). For example, Jiang et al. classified the EPs near asteroids into eight cases and discussed their submanifolds and POs (Jiang et al. 2014). Ni et al. investigate the multiple bifurcations in PO families in the potential field of a irregular-shaped asteroid and found binary period-doubling bifurcations in POs around 433 Eros (Ni et al. 2016). However, Ni's results do not consider an abnormally rotating asteroid, i.e., the dependence of stability of POs or EPs on the rotating rate, which is worthy to be investigated from the viewpoint of both astrodynamics and engineering. To reveal the bifurcation of EPs and POs in the case of increasing or decreasing rotation rate, this paper adopts a contact binary asteroid model to approximate the gravity field of a binary system. Based on the data of 1996 HW1, analytical results show that in planar cases, two collinear EPs are saddles with one-dimensional stable/unstable manifolds and two-dimensional center manifolds, referred to as 1+1+2 type while two non-collinear ones have two-dimensional stable/unstable manifolds and zero-dimensional center manifolds, referred to as 2+2+0 type. They turn to center-center type as rotating rate crosses a specific value. The bifurcation of EPs is illustrated by the distribution of eigenvalues of characteristic equations. According to Lyapunov center theorem, there exist families of POs in the case of 1+1+2-type and center-center-type EPs. Subsequently, the POs are constructed by continuation. The characteristic multipliers and topological classifications of POs around a contact binary asteroid are discussed. According to Jiang (2015), there are four kinds of bifurcations of POs in the potential field of irregular shaped asteroids, including period-doubling bifurcations, tangent bifurcations, real saddle bifurcations, and Neimark-Sacker bifurcations, which are discussed in this paper in contact binary model with varying rotation rate. Furtherly, the evolution of a PO as rotation rates changes at several selected level of Jacobian energy is illustrated on Poincaré sections. Furthermore, the bifurcation of non-collinear EPs is applied to asteroid exploration missions, where a low-energy transfer trajectory is obtained to maintain the spacecraft hovering above the surface of the 1996 HW1 as the asteroid rotates abnormally.