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QUASI-PERIODIC INVARIANT TORI OF TIME-PERIODIC DYNAMICAL SYSTEMS: APPLICATIONS TO SMALL BODY EXPLORATION

Abstract

Recent developments in computational dynamical systems theory have made it possible to compute higher-dimensional manifolds known as quasi-periodic invariant tori in a fast and reliable way. These dynamical structures are typically found in the center manifold about periodic orbits and can be applied to a number of relevant astrodynamics problem, including the establishment of bounded relative motion in nontrivial dynamical environments (Baresi et al., 2015).

In this paper, we review the methodology originally introduced by Gómez and Mondelo (2001) and recently enhanced by Olikara and Scheeres (2012) to compute families of quasi-periodic invariant tori in time-periodic dynamical systems. Examples of such systems include the dynamical evolution of a mass particle in the proximity of a complex rotator (Scheeres et al., 1998), or the Hill approximation of the Elliptic Restricted Three Body Problem (Voyatzis et al., 2012). Both of these systems are of great interest for small body exploration as many asteroids and comets of the Solar Systems are found in complex rotation states and/or in elliptic orbits about the Sun. However, work in the literature is typically limited to the computation of periodic orbits and two-dimensional quasi-periodic invariant tori in the vicinity of the target body (Farrés & Jorba, 2012).

Fortunately, because of the capabilities of the GMOS algorithm, quasi-periodic invariant tori of dimension greater than two can now be found and characterized (Baresi et al., 2016). Furthermore, the possibility of computing stable and unstable invariant manifolds emanating from the surface of unstable quasi-periodic tori can also be leveraged to improve the understanding of the system dynamics and enable better mission design. To that end, we investigate the dynamics in the proximity of 4179 Toutatis (Hudson & Ostro, 1995) and of the Elliptic Hill Problem. In all of the scenarios, GMOS succeeds in generating new interesting solutions that may be strong candidates for future small body exploration missions.