IAF ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1) (3)

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INVARIANT STRUCTURES AND LONG TERM CONFINEMENT OF CAPTURED ASTEROIDS NEAR THE EARTH

Abstract

Near-Earth Asteroids (NEAs) are strategic assets to scientific exploration and a potential source of raw materials to aid continued human space exploration. Also, they may pose potential risks to Earth due to the closeness of their orbits. This contribution deals with capture trajectories for asteroids in the Restricted Three-Body Problem (RTBP) using the invariant solutions related to the effective stability regions near the Earth. These regions of the phase space of the RTBP contain trajectories that remain confined for long characteristic times and the boundaries of those regions are related transport in the phase space. Numerical inspection shows that these domains of practical stability can be quite large depending on the value of the mass parameter, and that different families of invariant objects play a key role in determining its boundaries. For small values of the mass parameter of the RTBP, the dynamical structures which account for the long term behavior of the orbits are either the invariant manifolds of hyperbolic two-dimensional tori in the center manifold of L_3, or those of a family of tori associated to periodic orbits which bifurcate from the vertical Lyapunov orbits near the central manifold of L_5. Preliminary work indicates that the long term stable solutions around the triangular points of the Earth-Moon RTBP can be used as safe parking orbits for asteroids of a class of NEAs known as temporarily captured asteroids. A case study for asteroid 2006RH$_{120}$ previously presented shows that an impulsive maneuver with $\Delta v = 956.6$ m/s would have redirected the asteroid into a stable final destination orbit that remains bounded around L_4 for over 785 years in an ideal scenario. Although that exploratory study demonstrates the viability of the proposed capture mechanism, deeper investigation is needed to validate the generalness of the approach and to refine both the Δv and the final trajectory in a multi-body environment, including additional relevant perturbations, and optimization methods. In this work, are interested in the applicability of the invariant structures that define the effective stability regions in the capture mechanisms that could be applied to obtain preliminary profiles for asteroid missions. In particular, we perform a systematic characterization of the invariant structures connecting Lagrangian point orbits around L_3 and $L_{4,5}$ with with a view to provide low-energy transport to effective stability domains near the Earth.