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LONG TERM CAPTURE OF ASTEROIDS FOR RESOURCES AND SCIENTIFIC EXPLOITATION USING HYPERBOLIC OBJECTS IN THE SOLAR SYSTEM

Abstract

Asteroid missions have gained increasing attention as asteroids provide deeper insights into the formation of the Solar System, may be a future source of raw materials, and also because they may represent the closest threat to Earth. In nature, the long term capture of minor bodies is usually related to the existence of domains of effective stability in the Solar System. Many examples appear in nature such as the Trojan asteroids that follow the orbit of Jupiter around the Sun, the sharp-edged rings of Uranus with shepherd moons, and the motion of some comets and asteroids known as NEO (Near Earth Objects). The dynamical structures which account for the long term behavior of such objects are the stable and unstable manifolds of high-dimensional hyperbolic objects. For example, the quasi-confined orbits around the triangular Lagrangian points occur due to the disposition of the invariant manifolds of hyperbolic two-dimensional tori in the center manifold of L3 and also of a family of tori associated to periodic orbits which bifurcate from the vertical Lyapunov orbits in the central manifold of L5. Concerning mission applications, methods to retrieve asteroids have been recently studied, including employing invariant manifolds techniques and low-thrust propulsion to allow for scientific exploration and future resource utilization purposes. In this paper we will explore the invariant structures which account for long term confinement in several sub-systems of the Solar System in order to establish how long term capture can be achieved and maintained both under natural dynamics and by using small maneuvers to fulfill specific mission requirements, namely, missions to study the formation of the Solar System, to exploit their mineral resources, or to prevent threats for the Earth.