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Author: Dr. Daniel Garcia Yarnoz
Advanced Space Concept Laboratory, University of Strathclyde, United Kingdom,
Daniel.Garcia-Yarnoz@strath.ac.uk

Dr. Joan Pau Sanchez Cuartielles
Advanced Space Concept Laboratory, University of Strathclyde, United Kingdom, jpau.sanchez@upc.edu
Prof. Colin R. McInnes
University of Strathclyde, United Kingdom, colin.mcinnes@glasgow.ac.uk

APPLICATIONS OF SRP DOMINATED HIGHLY NON-KEPLERIAN TRAJECTORIES AROUND MINOR BODIES

Abstract

Asteroids have lately drawn considerable attention because of their scientific interest as one of the most primitive bodies in the Solar System, and the fact that they are very attractive destinations for future space exploration, with the benefit of not requiring the capability to land and take-off from a deep gravity well. In addition, they may well be the most affordable source of extra-terrestrial in-situ resources. Understanding the dynamics around minor bodies is key for future science missions to asteroids and, in the long-term, also for asteroid exploitation.

Depending on the size of the asteroid and its spin state, the effective ambient gravitational acceleration experienced by an orbiter spacecraft or particle around a minor body can range from micro-gravity to milli-gravity. Under such conditions, the solar radiation pressure (SRP) perturbation becomes the largest non-gravitational force affecting the orbital motion around an asteroid.

Various authors have proposed the use of terminator orbits for spacecraft mapping the surface of these bodies. They are one of the few long-term quasi-stable orbits around asteroids when SRP is dominant. Most other orbits experience great excursions in eccentricity that cause them to re-impact or escape after a small number of orbits. However, these other trajectories are not completely devoid of interest and will be the focus of this paper.

The evolution of eccentricity and solar phase angle of a high-area-to-mass ratio spacecraft or particle on a plane perpendicular to the terminator can be well-described by a simple Hamiltonian, that was first proposed by Hamilton and Krikov (1996) to study circumplanetary dust dynamics. Multiple revolutions, direct re-impact or escape are among the possible orbiting regimes enabled by the SRP perturbation. This paper proposes novel applications for these highly non-Keplerian orbits to be used for scientific exploration or resource exploitation.

Multiple revolution orbits of varying eccentricity would allow a “hopper” spacecraft to map sub-solar point regions not visible from terminator orbits at various altitudes and resolutions. Besides, we can also envisage a method for passively sorting material as a function of its grain size or density where SRP is used as a passive in-situ ‘mass spectrometer’. The analysis shows that this novel method allows an effective sorting of regolith material. This has immediate applications for sample return, and in-situ resource utilisation to separate different regolith particle sizes.