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SYSTEMATIC ANALYSIS OF CISLUNAR ESCAPE OPPORTUNITIES FOR EXPLORATION AND PLANETARY DEFENCE MISSIONS

Abstract

In the coming decade, the Cislunar environment is set to become a hotbed for both manned and unmanned missions, paving the way for human exploration of the Moon and Mars, and enabling the commercialization of various space activities. The Lunar Orbital Platform-Gateway (LOP-G) is being considered as a potential hub for Mars missions and activities that support exploration and planetary defence.

This paper sets out to explore potential escape mechanisms and routes from the Cislunar space to the Near-Earth Asteroids (NEA) region, evaluating the potential of the Lunar Gateway as a launch point for missions related to planetary defence and exploration. The dynamical environment in this region is complex and diverse, making trajectory design a challenging task. This complexity necessitates the creation of a trajectory modelling framework, where a variety of transfers can be used and sampled as required, based on the designated heliocentric transfer. The study systematically investigates escape opportunities from the LOP-G 9:2 Near Rectilinear Halo Orbit (NRHO). The process begins with the establishment of a design framework within the scope of the Bicircular Restricted Four-Body Problem (BCR4BP). This is succeeded by an extensive parametric simulation, leveraging advanced GPU propagation routines. A machine learning approach is then employed to cluster and categorize the results and form the transfer database. Numerical continuation techniques are then employed to extend the database transfers to different departure or escape conditions. The various transfer families are finally characterized based on distinct figures of merit, enabling a comprehensive understanding of the escapes and their connections to heliocentric transfers.