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ILIAS: A TOUR TO TROJAN ASTEROIDS

Abstract

Asteroids and their complex dynamics is nowadays a topic of interest in the scientific community. A recently approved mission, Lucy, features a tour of the Trojan Asteroids of the Jovian system. Meanwhile, at Politecnico di Milano, a team of students developed a feasibility study for a similar mission. The goal was to properly design a spacecraft which, once reached the stable Lagrangian points, would map and visit the highest number of bodies.

From this study, it appears that the main characteristics of a mission of this kind are strongly related to the trajectory design. Major issues are the distance from the Sun (more than 5 AU) and the intrinsic stability of $L4$ and $L5$ lagrangian points. As a consequence, solar panels and electric powered propulsion are not accounted as feasible options. Instead, an RTG is chosen as the primary power source, while the main propulsion system relies on a chemical solution.

Given these constraints, it is decided to hop from one asteroid to the other, following precise rationales. The present work focus on an exhaustive analysis of all the possible combinations, exploiting a database of hundreds of bodies and an N-body integrator. This approach leads to several solutions which are optimal in terms of costs, time of flight or scientific return (i.e solutions which involve binaries and asteroids with different known spectral classes). It is observed that tours including fly-bys are characterized by costs of tens of meters per second, while orbit closure around an asteroid requires costs of hundreds of meters per second. It follows a study of the behaviour of the spacecraft in the neighborhood of irregular shaped and low attractive bodies, which potential is modeled as a proper combination of potentials of simpler geometrical shapes. Finally, a sensitivity analysis has been carried on to prevent impacting or escaping their sphere of influence. The overall design of the tour is a fundamental step for the definition of power and mass budgets.

In this paper the authors present the evolution of ILIAS Team's work at Politecnico di Milano for what regards trajectory optimization. It highlights the feasibility of transfers between asteroids in $L4$ and $L5$ region of the Sun-Jupiter system and includes a study of the motion around them. It proposes a quantitative approach to the problem, providing optimal solutions that are prone to further refinements in higher fidelity models.