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MISSION STRATEGY TO AWAIT COMETS BY LEVERAGING MANIFOLDS AND LOW THRUST

Abstract

In recent years, comet exploration missions attract our attention to unravel the origin of our solar system. Comet Interceptor selected as ESA's new fast-class mission aims to visit a long-period comet or an interstellar object as soon as possible after it is detected in the inner solar system. In the Comet Interceptor mission, the spacecraft parks on a halo orbit around the Sun-Earth L2 point and departs to the target comet for interception. To reach the target, the Hohmann transfer is adopted, but it requires large fuel consumption. To deal with this problem, designing a low-energy transfer for an unpredictable comet is required.

This paper develops an alternative mission strategy utilizing invariant manifolds as parking and transfer trajectories based on a circular restricted three-body problem (CRTBP). By generating a low-energy transfer to a target comet based on invariant manifolds, the proposed strategy needs less ΔV than the conventional one. However, this strategy has the following problems: the accessible regions of manifolds are limited, and the transfer time becomes longer than the conventional one. To address these shortcomings and enhance the feasibility of the proposed strategy, the following two solutions are presented: enlarging the accessible regions of invariant manifolds with low thrust and forming a constellation of interceptors along manifolds.

To broaden accessible regions by manifolds, the optimal control problem to maximize the sweep regions is formulated for a spacecraft equipped with low thrust. To deal with the problem, a two-point boundary value problem (TBVBP) with constraints on the shape and size of the manifolds is solved.

In order to shorten the transfer time to a target comet, a spacecraft constellation on multiple parking orbits is designed by leveraging manifold structures. In forming the constellation, manifolds emanating from not only periodic but also quasi-periodic orbits are utilized to increase the flexibility in flybys around the target comet. The usefulness of the constellation is examined by comparing a transfer time with the current mission. The proposed alternative mission strategy improves the feasibility of the future comet exploration mission.