Abstract

Near-future space missions demand the delivery of massive payloads to deep space destinations. Given foreseeable propulsion technology, this is feasible only if we can design trajectories that require the smallest possible propulsive energy input. This research aims to design interplanetary space missions by using new low-energy trajectory methods that take advantage of the natural dynamics of the solar system. This energy efficient trajectory technology, called the Interplanetary Super Highway (IPSH), allows long duration space missions with minimum fuel requirements. To develop the IPSH trajectory design method, invariant manifolds of the three-body problem are used. The invariant manifolds, which are tube-like structures that issue from the periodic orbits around the $L_1$ and $L_2$ Lagrangian points, can be patched together to achieve voyages of immense distances, while the spacecraft may expend little or no energy. In the present work, dynamical symmetries are used to develop computationally simplified methods for IPSH trajectory designs.

These streamlined IPSH trajectory design methods would be useful in designing many types of interplanetary missions. As one of its applications, my research is focused on Near-Earth Asteroids (NEAs) rendezvous mission design for exploration, mitigation, and mining. In a second application study, a solar sail mission for Mars exploration is considered. By using the solar radiation pressure, the solar sails provide a propulsive power. This thrust affects the three-body system dynamics such that the Sun-Mars $L_1$ and $L_2$ Lagrangian points are shifted toward the Sun and the geometry of the invariant manifolds around $L_1$ and $L_2$ points is changed. By taking advantage of these features, a low-energy trajectory for Mars exploration is developed.

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