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SOLAR SAIL TRANSFER TRAJECTORY FROM L1 POINT TO SUB L1 POINT

Abstract

Solar sail is a novel method of propulsion and using a solar sail for trajectory transfers is the most promising application. Besides being considered as a transportation device, solar sail propulsion enables special missions. A restricted three-body analysis shows that large sets of new artificial equilibria exist. In the Geostorm mission, a sail operating inside the Earth's L1 point is used to increase the warning time for geomagnetic storms. In this paper, we turn to a new way to achieve the transfer from L1 halo orbit to sub L1 region. The invariant manifolds of L1 halo orbit and Sub L1 are utilized to design the transfer trajectory. In restricted three body problem, the stable and unstable invariant manifold tubes associated to libration point orbits are the phase space structures that provides a conduit for spacecraft to and from the smaller primary body and between primary bodies for separate three-body systems. Furthermore, these invariant manifold tubes can be used to produce new techniques for constructing low energy spacecraft trajectories. These include mission concepts such as a low energy transfer from the Earth to the Moon. Similarly, the invariant manifolds exist in the neighborhood of artificial Lagrange points and the center manifolds are used to generate periodic orbits around the points. In this study, the transfer phase from the L1 point to Sub L1 point is achieved by matching the unstable manifolds of L1 halo orbit and stable manifolds of Sub L1 point. The sailcraft departs from the halo orbit along one of its unstable manifold and the sail is deployed at some point, where the sail enters the stable manifold of the Sub L1 point or periodic orbit around Sub L1 point. Firstly, the invariant manifolds of the L1 halo orbit and Sub L1 point are introduced. Then, the possibility of transfer trajectory is checked from the point of view energy. Lastly, the trajectory design problem is transformed into a parameter optimization problem. Both 2 dimensional (2D) and 3 dimensional (3D) cases are investigated and numerical examples are used to validate the design method. The results show that the method is effective. Most important of all, the sailcraft attitude need not be changed during its flight to the target point. The sail attitude keeps fixed with respect to sunlight when flying along the manifold of sub L1 point.