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SOLAR SAIL THREE-BODY TRANSFERS USING INVARIANT MANIFOLDS

Abstract

The paper discusses design methods of solar sail transfer trajectories from different near earth orbits to artificial Lagrange points and transfers between different artificial Lagrange points by using manifolds and an integral constant of the system. A new integral constant exists while invariant manifolds can be calculated for solar sail with a fixed attitude in Hill's Restricted Three Body Problem. As a matter of fact, the new integral constant and invariant manifolds are employed to design transfer trajectories. Both numerical and analytical methods are discussed for different transfer missions with the results of both methods being identical with each other. For the transferes from earth orbits to artificial Lagrange point, ompared with direct transfers from earth orbits to target points using rocket, the impulse method saves tens to hundreds of meters per second velocity increment, depending on target points. The propellantless transfer with no velocity increment consumption is investigated. The result shows that the time of active control stage can be minimized to about several percent of the whole transfer time and even no active control is required for missions of some target points. For the transfers between different artificial Lagrange points, transfer trajectories of solar sail with both active and passive control are designed and the time of active control stage is minimized. The solar sail flies along the invariant manifold during the passive stage. Then, transfer trajectories with the only passive control are investigated. The solar sail leaves the initial point along the unstable manifold and flies with a fixed attitude until it enters the stable manifold of the target point. At last, it flies to the target point with another fixed attitude. For points symmetrical with respect to sun-earth line, symmetrical transfer trajectories exist , moreover they are designed according to the symmetry of the dynamic equation. In general, the trajectories are obtained through optimization. Finally, a differential correction process is developed to find the transfer trajectories originated from an existing reference one. The correction method is also employed to eliminate the attitude error during the passive flying stage along the invariant manifold. The results show that the sail can arrive a point that is not far from the target point when the error is small.