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ORBITAL TRANSFER BETWEEN INVARIANT MANIFOLDS IN THE CIRCULAR RESTRICTED FOUR-BODY PROBLEM

Abstract

A three-body problem has been used as a movement model in an orbital design. However, a movement model, which is more similar to reality, is necessary to be used in the many-body system with sensitivity to the initial condition. It is not strict for mission execution to design an orbit in a three-body system. Therefore, we consider an orbital transfer between periodic orbits in the four-body system that adds the effect of the moon to the Sun-Earth-Spacecraft three-body system. Each periodic orbit, manifold, and transfer orbit is designed in the four-body system because a dynamical structure is different between the three-body and the four-body systems. Furthermore, we consider generating a connected orbit between manifolds and transfer orbit from periodic orbit around the L1 point of the Sun-Earth system to the L2 point.

Firstly, we design the periodic orbit in the four-body system by using the single shooting method. The orbital period is about 178 days and six times as long as the synodic period. Then, stable manifolds and unstable manifolds are calculated one thousand each. The L2 norm of state vectors between those manifolds in the Poincare section, which is set to be at the center of the Earth, is minimum in selecting a manifold. Finally, a transfer orbit between the stable manifold and the unstable manifold is designed using the multiple shooting method.

The total time of flight is about 240 days. Moreover, the dimensionless control inputs of a spacecraft are between -2×10^{-6} and 2×10^{-6}. It shows that when the spacecraft of several tons class is transferred, the necessary thrust is of the order of 10^{-5}, which is a possible value.

We design periodic orbits and a transfer orbit in a four-body system and confirm that the spacecraft is adequately transferred between periodic orbits through the numerical simulation.