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TRAJECTORY DESIGN TO MARS FROM EARTH-MOON SYSTEM WITH THREE-DIMENSIONAL TRANSIT ORBITS

Abstract

Global interest in exploring the far side of the Moon has increased in recent years. For example, the gateway project to build a space station on the lunar orbit is underway. Furthermore, planetary exploration mission utilizing the established space station is under planning. In such missions, designing low-energy trajectories are required to reduce the fuel. Howell and Kakoi (2014) introduced the useful trajectory design method under various scenarios from the Moon L_2 point orbit to Mars using low-energy trajectories in the circular restricted three-body problem (CRTBP). In this method, low-energy trajectories are designed by connecting Earth-Moon system to Sun-Earth system, but it does not mention transfer with less ΔV or use of three-dimensional transit orbit. Therefore this study focuses on the trajectory design which reduces the total ΔV using three-dimensional transit orbits. As an example, the designed trajectory from Moon L_2 point orbit to Mars is shown.

Transit orbits are trajectories inside an invariant manifold. There are two benefits of using transit orbit, the first being that the design is easier than connecting manifolds of different three-body systems. The other is that a trajectory suitable for transfer to Mars can be selected by considering transit orbits with various energy. Moreover, three-dimensional transit orbits can significantly increase the freedom of trajectory design. However, it is not easy to design transit orbits among those can connect to manifolds and save ΔV because there is currently no clear criterion to decide which transit orbit can save ΔV. Therefore, this paper presents a method to exploit a three-dimensional transit orbit that can transfer from the Earth-Moon region to Mars with a small ΔV, focusing on the mechanical energy of the spacecraft as a new index.

The simulation results are compared with different scenarios including direct transfer and transfer via manifold-to-manifold regarding total transfer time and total ΔV. The proposed method can be used as a general method in other subjects and our future work includes applying this method to transfer between various planets and comparing other transition methods