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Study of Interplanetary Transfer Trajectories via Vicinity of Libration Points

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Abstract : This work is to study an optimized transfer strategy of connecting Earth and Mars via the vicinity of libration points, which have been playing an increasingly important role in trajectory designing on a deep space mission, and can be used as an effective alternative solution for Earth-Mars direct transfer mission in some unusual cases. The use of vicinity of libration points of the sun-planet body system is becoming potential gateways for future interplanetary transfer missions. By adding fuel to cargo spaceships located in spaceports, the interplanetary round-trip exploration shuttle mission of such a system facility can also be a reusable transportation system. In addition, in some cases, when the S/C cruising through invariant manifolds, it can also save a large amount of fuel. Therefore, it is necessary to make an effort on looking for efficient transfer strategies using variant manifold about libration points. It was found that Earth L1/L2 Halo/Lyapunov orbits and Mars L2/L1 Halo/Lyapunov orbits could be connected with reasonable fuel consumption and flight duration with appropriate design. In the paper, the halo hopping method and coplanar circular method are briefly introduced. The former used differential corrections to systematically generate low ΔV transfer trajectories between interplanetary manifolds, while the latter discussed escape and capture trajectories to and from Halo orbits by using impulsive maneuvers at periapsis of the manifolds about libration points. In the following, designs of transfer strategies of the two methods are shown here. A comparative performance analysis of interplanetary transfer strategies of the two methods is carried out accordingly. Comparison of strategies is based on two main criteria: the total fuel consumption required to perform the transfer and the time of flight, as mentioned above. The numeric results showed that the coplanar circular method procedure has certain advantages in cost or duration. Finally, optimized transfer strategy with engineering constraints is searched out and examined to be an effective alternative solution for a given direct transfer mission. This paper investigated main methods and gave out an optimized solution in interplanetary transfer via the vicinity of libration points. Although most of Earth-Mars mission planners prefer to build up a direct transfer strategy for the mission due to its advantage in relatively short time of flight, the strategies given in the paper could still be regard as effective alternative solutions since the advantages mentioned above and longer departure window than direct transfer.

Keywords : circular restricted three-body problem, halo/Lyapunov orbit, invariant manifolds, libration points
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