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ORBITAL TRANSFER DESIGN BETWEEN LIBRATION POINTS AROUND JOVIAN SATELLITES

Abstract

This study analyzes the gravity field of Jovian system and attempts to construct fuel effective transfer trajectories between Jovian satellites by the combination of the tidal force with artificial acceleration owing to impulsive and low thrust propulsion.

The scientific interest in the Jupiter system has been growing for these years. The Europa, a major Jovian Moon, has active internal core and ice on the surface, which may leave the possibility of life entity. In addition, the Jupiter has many moons unlike our Earth and this makes synthesis of spacecraft trajectories hard. Here, numerical and analytical approaches are presented for synthesizing fuel effective trajectories.

Gravity capture around the moons enable a spacecraft to rendezvous from one to another with small delta-V. Invariant manifolds of periodic orbits are applied and used to design auto-capture trajectories. Koon, Lo, Marsden, Ross (2001) proposed the "Multi-Moon Orbiter" scheme to make a spacecraft transfer and stay around the Jovian moons in sequential manner using the invariant-manifolds. Their approach utilized explicit ballistic captures and succeeded in reducing delta-V about 50% in comparison with the Hohmann transfer strategies. Furthermore, they showed the delta-V can be reduced down to 20 m/s via the repetition of synchronized swing-bys. But this method takes several years in transfer, and the delta-V has to be traded-off with transfer time.

Their study mentioned above tried to make a sole and full use of the moons' gravity with one single-impulse acceleration placed at a connecting point between two invariant manifolds. However, neither the multi-impulse transfers nor low-thrust transfers have been hardly studied so far. In general, a delta-V applied at the peri-apsis significantly affects the spacecraft trajectory, much more effectively than any delta-V applied at other points. And low-thrust propulsion represented by electric propulsion has so high-specific impulse that the required fuel amount is much less than that via impulsive chemical propulsion in order to acquire the same velocity increment. Few investigations have been made for low-thrust trajectory in this field, since invariant-manifolds are themselves the energy surfaces associated with the three-body problem, and the energy integral property keeps changing when accelerated continuously.

In this paper, the authors developed a successful trajectory synthesis strategy and will present how multi-burn or low-thrust continuous-burn trajectories can be well incorporated in the invariant-manifolds approach. The strategy obtained is applied not only to Jovian system but also to the other systems with multiple satellites like the Jovian system.