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TRANSFERS AROUND PHOBOS USING INVARIANT MANIFOLDS OF UNSTABLE QUASI-SATELLITE ORBITS

Abstract

Quasi-satellite orbits (QSOs) are stable retrograde orbits in the restricted three-body problem that have gained attention as viable candidate for future deep-space missions towards remote planetary satellites. JAXA's robotic sample return mission MMX will utilize QSOs to perform scientific observations of the Martian moon Phobos prior to landing on its surface and attempt sample retrieval (Kawakatsu et al, 2019).The complex dynamical environment around Phobos makes the proximity operations of MMX quite challenging and requires novel and sophisticated techniques for maintaining and transferring between different quasi-satellite orbits.

Previous work on transfers between planar QSOs was carried out by Ichinomiya et al (2019) and Pushparaj et al (2019) using bifurcated multi-revolutional periodic quasi-satellite orbits and impulsive manoeuvres. More recently, Pushparaj et al (2020) extended these analyses by considering injection into unstable, spatial, retrograde orbits known as 3D QSOs via invariant manifolds. Preliminary analyses have shown that transfer between planar and unstable 3D-QSOs can be performed with as less as 8.25 m/s.

The present paper proposes new transfer design methods via dynamical systems theory and invariant manifolds of unstable QSOs. We use Circular Hills Problem with ellipsoidal secondary Phobos model throughout the study. We firstly compute the Multi-Revolutional Periodic QSOs (MP-QSOs) using the in-plane bifurcations from the stable planar QSO family continuation solution curve. Secondly, we select unstable solutions as transfer/staging orbits to enable transfers between two stable planar QSOs. Finally, we compute the three-dimensional QSOs (3D-QSOs) using the out-of-plane bifurcations from the planar QSO family and utilize the weakly unstable 3D-QSOs as an intermediate orbit to design transfer between two stable planar or spatial QSOs.

References

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