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STABILITY ANALYSIS OF THREE-DIMENSIONAL QUASI-SATELLITE ORBITS AROUND PHOBOS

Abstract

The exploration to Martian moons is of growing interest with several space missions proposed to return samples from these bodies. The proximity operation planning needs to consider the complex dynamical environment. The purpose of the present work is to identify three-dimensional quasi-satellite orbits (3D QSO) around Phobos that are suitable for global mapping and bounded in the realistic model for a permissible period (i.e. 7 days).

Linear stability and divergence indices are defined to indicate the safety of the orbit for operations. Periodic resonant 3D QSO are first computed in the circular-restricted three-body problem (CR3BP) based on the approach of bifurcation and continuation, which provide both a database of initial guesses for bounded orbits in the realistic model and picture of linear-stability region. Stable solutions with high z-amplitudes (e.g. up to 40 km at x-amplitude = 30 km) are found in this stage. As the CR3BP is a simplified model, the eccentricity and higher-order gravitational terms, and navigation errors can strongly perturb the orbits in the realistic model. The validity of the CR3BP is accessed by a validation model. The validation model takes into account the elliptic J2-perturbed orbit of Phobos and Phobos non-spherical gravity field. With the validation model a picture about the orbit divergence as a function of the initial phase can be quickly obtained. The CR3BP model is shown suitable for analyzing the QSO around Phobos in the preliminary stage. Orbits that are bounded regardless of the initial phase are identified. Those promising orbits are then verified in the realistic model starting at varied epochs. Two safe and favorable initial conditions are identified at x-amplitudes of 24 and 30 km with an inclination of 40 degrees.