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NUMERICAL CONTINUATION AND STATIONKEEPING OF QUASI-PERIODIC QUASI-SATELLITE ORBITS AROUND PHOBOS

Abstract

Quasi-satellite orbits (QSOs), also known as distant retrograde orbits (DROs), have been under the research spotlight due to their linear stability and close proximity to the secondary body in a restricted three-body system. QSOs have been listed as candidate science orbits for multiple deep-space missions with close operations to a celestial body, including ESA's DePhine mission, NASA's JIMO mission, and JAXA's MMX mission. It is noteworthy that, the quasi-periodic counterparts of QSOs are also of great research interest. With mature numerical algorithms to specify the parameter of a quasi-periodic orbit, researchers proposed to replace purely periodic orbits with families of quasi-periodic orbits which are capable of providing higher accuracy and insight into the elliptic Hill three-body problem.

In this research, the numerical continuation and stationkeeping method of quasi-periodic QSOs is investigated based on the concept of Poincaré sections. By means of the Differential Algebra (DA) techniques, a DA-enhanced numerical method to compute quasi-periodic orbits is proposed. This method is formulated to solve for the invariant curve on a Poincaré section of the quasi-periodic orbit of interest. An enhanced Poincaré map, which is established with DA techniques, plays a pivotal role to reduce the problem dimensionality and promote computation efficiency. A family of quasi-periodic QSOs around Phobos are continued to validate the proposed method.

A Target Phase Approach (TPhA) is proposed and further adapted for the stationkeeping of the quasi-periodic QSOs. The TPhA method is devised with the concept of Poincaré sections and the asscociated phase-angle Poincaré map is established with the DA techniques. Using truncated Fourier series, the invariant curves on different Poincaré sections can be accurately represented and the reference target points on an invariant curve can be properly determined. A stochastic optimization scheme for the adapted TPhA method is formulated in search for fuel-optimal and error-robust stationkeeping parameters. Stationkeeping simulations for the achieved quasi-periodic QSO family are provided to showcase the effectiveness of the adapted TPhA method.