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PRACTICAL STABLE REGION OF ORBITAL MOTION IN THE VICINITY OF ASTEROID 2016 HO3-CANDIDATE TARGET OF CHINA'S ASTEROID EXPLORATION MISSION

Abstract

This study investigates the practical stable region of orbital motion around the asteroid 2016 HO3 by applying the automatic domain splitting (ADS) algorithm. HO3 is currently the smallest and closest quasi-satellite of Earth [1] and is the candidate target of China's Asteroid Exploration mission. Due to its weak gravity, the perturbations of solar radiation pressure (SRP) and solar gravitation are strong and should be considered. The uncertainties of its central gravity and the SRP are considered due to the limitations of ground observations and the non-complete understanding of the spacecraft's reflection property, respectively.

To propagate the uncertainties, we apply the ADS algorithm [3], which is based on the differential algebra (DA) method that approximates the dynamics with an arbitrary order Taylor expansion. Nevertheless, DA fails when the non-linearity of the dynamics prohibits good convergence of the Taylor expansion. Then ADS was generated to solve this issue by automatically splitting the initial uncertain domain into two equal sub-domains whenever its truncation error reaches a predefined threshold.

Firstly, the relationship among the expansion order, the accuracy of the Taylor expansion and the computation time is investigated, and a proper expansion order is selected. Then, the sensitivities of orbital geometry to the uncertainties of the central gravity and the SRP are investigated, by evaluating their first split time. The region robust to the model uncertainties is identified and is tested against pure numerical integrations. In addition, the bounds of the state flow are also available along the propagation of ADS. Specifically, for small body missions, if the bounds do not exceed a predefined limit within a specific duration that are determined by the mission requirements, the motion is recognized as practically stable. Therefore, we also evaluate the bounds of the state flow for different orbital geometry, and characterize the region of practical stability and its variations with mission requirements. Therefore, by applying ADS, this study contributes to discriminating the stable and unstable region around 2016 HO3 in the phase space with model uncertainties, from the practical perspective.

References

[1] de la Fuente Marcos, C., de la Fuente Marcos, R., Asteroid (469219) 2016 HO3, the smallest and closest Earth quasi-satellite, Monthly Notices of the Royal Astronomical Society, 462(4), (2016) 3441-3456.

[2] A. Wittig, P. Di Lizia, F. Bernelli-Zazzera, R. Armellin, K. Makino, M. Berz, Propagation of large uncertainty sets in orbital dynamics by automatic domain splitting, Celestial Mechanics and Dynamical

Astronomy, 122(3) (2015) 239-261.