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SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 2 (2B)

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LUNAR MISSION ORBITS WITH LONG LIFE-TIME AND GLOBAL COVERAGE

Abstract

Key factors of the motion of spacecraft around the Moon are perturbations from third bodies and lunar non-spherical mass distribution. These external forces might make the lunar orbits unstable, leading to escape from or impact on the Moon. It is necessary to find stable orbits with long life-time in the proximity to Moon for long-term science missions. Firstly, this paper identifies the dominating forces for different orbit ranges with increasing orbit altitude, through numerical simulations. Then, focusing on orbit ranges where the Earth gravitation and lunar non-spherical mass are dominant, the model of the circular restricted three-body problem (CRTBP) is applied for the third-body perturbation from Earth. Further, the high-order lunar non-spherical gravity field is added to the CRTBP. Differential corrector (DC) algorithm is used to find periodic orbits in the Moon-centered synodic coordinate system, and two kinds of orbits are found: near polar, circular orbits and elliptical, inclined orbits. Due to the rotation period of the Moon being equal to its orbital period around Earth, the periodic orbits are in fact repeat ground track orbits with different cycles in the Moon body-fixed system. Finally, long-term propagations are performed for these orbits to verify their stability. Including detailed lunar gravity from the LP165P model, gravities of Earth and the Sun, as well as the RK7(8) integrator and DE405 ephemeris, it is found that the eccentricity vector of orbits with low altitudes varies within small ranges for ten years' propagation time, which demonstrates long-term stability, while others at higher altitude crashed on the moon after decades or even months. Therefore, the combination of the CRTBP model and the DC algorithm is more feasible for the search of long life-time lunar periodic orbits at low altitudes, which can serve as parking orbits for science missions and global coverage missions.