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DEPARTURE / SWINGBY WINDOW EXPANSION FOR GRAVITY CAPTURE AROUND THE MOON VIA THE COMBINATION OF THE SOLAR TIDAL FORCE WITH THE LOW THRUST PROPULSION

Abstract

Recent Space Exploration demands have sought for the low delta-V transfer schemes to the Moon. They sometimes assume an apparent gravity capture around the Moon, using the solar tidal force effect accumulated while flying in the far boundary region of the Earth gravity field. The technique is very efficient and can save so much delta-V utilizing perturbation effect. Therefore, the technique is sometimes assumed adopted for future applications. To analyze the earth moon transfer trajectory leading to gravitational capture, the trajectory is divided into 3 segments. The first segment is the trajectory from the earth departure to the lunar swing-by, the second is from the lunar swing-by to the re-approach to the moon, and the third is in the vicinity of the moon. The length of each segment is arbitrary selected. In this study the trajectories after lunar swing-by (including the lunar gravity capture) is particularly paid attention to. However, when/where the capture occurs strongly depends on where the spacecraft swings by the moon and also approaches. In other words, the Moon age of the lunar swing-by/re-approach date is almost uniquely and instantaneously determined, since the flight must receive the prescribed solar tidal effect very precisely. Therefore, such spontaneous capture is hardly applicable to the flexible and practical transportation systems to the Moon. This study presents how the lunar swing-by/re-approach conditions are relaxed taking the advantage of the artificial acceleration, electric propulsion means. First, this study shows how the second segment of the trajectory is changed by the low thrust propulsion. After lunar swing-by S/C goes the far boundary region of the Earth gravity field and the solar tidal force has powerful effects on the behavior of S/C in this region. So Sun-Earth-S/C three-body problem is adopted as a model. The optimization is performed by DCNLP method which approximates the continuous problem with parameter optimization problem. The power of the low thrust propulsion is assumed the power to achieve in several years. Second, the behavior of the S/C in the vicinity of the moon is focused on. It is showed that how S/C approaches the moon from outside the sphere of influence and is captured by the lunar gravity at last. The trajectory near the moon is analyzed in earth-moon-S/C three-body system because the lunar gravity gives more influence on S/C than the sun gravity. The optimization method and is the same as the second segment.