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PRELIMINARY TRAJECTORY DESIGN OF A MULTIPLE NEO RENDEZVOUS MISSION THROUGH SOLAR SAILING

Abstract

Because of its potentially infinite specific impulse, solar sail propulsion is an attractive solution to reach interplanetary mission goals otherwise not achievable, or very expensive in terms of propellant mass. Furthermore, the scientific interest for the Near-Earth Objects (NEOs) and the categorization of some of those as Potentially Hazardous Objects (PHOs) led several researchers to focus their work on NEOs' related problems. The DLR/ESA Gossamer roadmap aims to push the boundaries of solar sailing technology by establishing three steps of increasing complexity, aimed to demonstrate the feasibility and reliability of the solar sail technology. A preliminary result in a recent study showed the possibility to rendezvous three NEOs in less than 10 years, according to the constraints of the DLR/ESA Gossamer technology. Considering the same technology constraints, this work presents a methodology for preliminary design of a mission to visit a number of NEOs through solar sailing. The criteria that guide the selection of the possible encounters are: the reduction of total mission duration, the reduction of the required characteristic acceleration (therefore, the reduction of the sail size or the increase of the payload mass) and the priority with respect to PHOs. According to the NASA's NEO database, more than 10,000 asteroids are orbiting around the Earth, of which more than 1,000 are classified as PHO. Therefore, the selection of the candidates for a multiple rendezvous is firstly a combinatorial problem, with more than a trillion of possible sequences of three different encounters. Moreover, for each sequence a problem of trajectory optimisation should be solved. This is a mixed combinatorial/optimisation problem, notoriously complex to tackle all at once. This study proposes two sequential steps: the first searches for the sequence, initially pruning the whole list of objects with heuristic rules, then using simplified trajectory models. In the second step, an optimisation solver, based on a pseudospectral method, is used to solve the subsequent solar sail optimal control problem. The best solutions found by the described method of selection/optimisation, with respect to the criteria listed above, are shown.