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STATION-KEEPING OF SUN-VENUS L2 LIBRATION POINT ORBITS FOR A PROSPECTIVE SPACE OBSERVATORY MISSION

Abstract

This research is devoted to the problem of station-keeping near the L2 libration point of the Sun-Venus system. Recent studies show that this location can potentially be exploited by space observatories in detecting hazardous asteroids and investigating their physical and chemical characteristics. On the one hand, this kind of missions has a strong requirement on the minimum duration of time intervals when a spacecraft is in the shadow of Venus. On the other hand, sufficient time is needed to recharge the on-board batteries. These conflicting restrictions limit the choice of a feasible operational libration point orbit. We analyze several different classes of libration point orbits (halo, Lissajous, axial, etc.) and describe the most promising options.

During the last 30 years, many effective methods of station-keeping based on the impulsive and continuous control have been designed and verified; among them are the targeting strategies and the unstable mode elimination methods. The targeting strategies (e.g., the target point approach, multiple shooting) are proved to be robust and simple in implementation, though they depend on weight parameters. Therefore, parameter tuning is sometimes needed. The unstable mode elimination methods (e.g., the Floquet mode approach, methods based on the characteristic exponent) usually do not require parameter tuning. However, they are more difficult in implementation due to the unstable nature of the three-body dynamical system. In practice, the orbit and attitude control system architecture and spacecraft pointing requirements may restrict the thrust direction, so simple strategies such as maneuvering towards the Sun (the x-axis control) are used in these cases. Note that almost all of the previous investigations related to the station-keeping problem are focused on the Sun-Earth and Earth-Moon systems.

In this work, we calculate the annual station-keeping costs for different types of libration point orbits around the Sun-Venus L2 point. Two methods are considered: the robust target point approach and the simple x-axis control. To obtain the results, both the expected value and the variance of the yearly costs are estimated in series of the Monte Carlo trials. The numerical simulation is made directly in the ephemeris model. Performance sensitivity to the navigational accuracy, the methods' weight parameters, the time interval between the maneuvers, and the minimum possible delta-v value per a maneuver is analyzed.