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Author: Mr. JianChao Zheng
Beijing Institute of Technology, China

OPTIMIZATION OF CORRECTION MANEUVER IN TRANSFER OF HELIOCENTRIC GRAVITATIONAL-WAVE OBSERVATORY

Abstract

Recently, the heliocentric space-based gravitational-wave observatories (SGWO) have become an increased interest due to their less influences from disturbances such as the Earth's magnetic field. However, the launch error can be enlarged by the dynamics and navigation uncertainties during the transfer phase. For better stability of the SGWO, it is necessary to design the trajectory correction maneuvers (TCMs), which are expected to be less-cost and robust. In general, these two metrics are contradictory with each other, as small terminal error of the spacecrafts can be achieved by performing multiple TCMs. To solve this problem, this paper investigates the multi-objective design optimization problem of the TCMs in transfer of the heliocentric SGWO. First, a multi-objective model considering the total velocity increment of TCMs and the configuration stability uncertainties is established. The maneuver epochs are chosen as the decision variables, and the unscented transformation (UT) method and the state transition tensor (STT)-based method are used to propagate maneuver uncertainty of the TCM and the insertion uncertainties of the configuration, respectively. Then, an adaptive surrogate-based optimization framework is developed to design the TCMs strategy. The adaptive surrogate model is employed to approximate the two objectives to reduce the computational cost of the optimization, and the solution is obtained using a fast and elitist multi-objective genetic algorithm: NSGA-II. Simulations are performed on the example of the lunar flyby transfer of the LISA mission. Numerical results show that the TCM strategies along the pareto frontier can well balance the performances of fuel cost and robustness.