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PRELIMINARY DESIGN OF THE RENDEZVOUS AND INTERCEPTION TRAJECTORIES TO ASTEROID 2015 XF261

Abstract

The Asteroid 2015 XF261 has been selected as one of the potential target of the Near-Earth Asteroid Defense Mission of China. As a typical co-orbital object on the quasi-coplanar orbits with the Earth, this asteroid has a small diameter of 26.5 m and the Earth Minimum Orbit Intersection Distance (MOID) of 0.0024 AU. The mission aims at the high-speed impact and observation, using an impactor and an orbiter launched together. These two probes will perform maneuvers independently, such that the orbiter first rendezvous with the asteroid and the high-speed impact is then achieved by the impactor. Difficulties arisen in designing the coupled trajectories for the rendezvous and interception.

First, compared with the previous asteroid missions, the tradeoff of the departure time and hyperbolic excess velocity with respect to the Earth should be made for the impactor and orbiter because of their rather different trajectories. It is found that the rendezvous trajectory needs larger hyperbolic excess velocity and possible gravity assists (GAs), while the high-speed impact may be achieved by the trajectory design within the multi-body system of the Sun, Earth, and Moon. Second, the trajectories are sensitive to the departure time and orbit, for which the joint optimization is required. Proper dynamics models should be meticulously selected to improve both the fidelity and computational efficiency. Finally, the possible asteroid flybys and the specific periodic orbits around Earth should be searched based on the preliminary design results.

This work systematically investigates the joint optimization problem of the rendezvous and interception trajectories to the Asteroid 2015 XF261. The epochs of the departure, rendezvous, and impact are searched to satisfy the constraints of the observation and impact. By testing two types of departure orbits (highly elliptical orbit and escape orbit), the performances in transfer time and propellant consumption are analyzed. The patched two-body dynamics and high-fidelity dynamics are employed to design the rendezvous and interception trajectories, respectively. The global search is performed using the particle swarm optimization with given GA and impulse sequence, and the local optimization uses the NLopt library subject to the high-fidelity dynamics. The optimal velocity increments are 1.63 and 0.17 km/s for the orbiter and impactor, respectively. Several alternative choices are designed in combination with

the distance retrograde orbit of Earth or multiple flybys by the impactor. The optimization results can provide theoretical support and reference scheme for the future implement of the asteroid defense mission.