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TRAJECTORY OPTIMIZATION FOR SUN-EARTH L5 POINT MISSIONS

Abstract

Sun-Earth L5 point is an ideal location to observe the Sun. Spacecraft in the vicinity of Sun-Earth L5 point can provide different perspectives of the Sun than that of near Earth observatories. One satellite of NASA's STEREO mission passed the vicinity of the Sun-Earth L5 point. However, none satellite has been launched into periodic orbit about the Sun-Earth L4/L5 point. China's Sun observation project KuaFu is now under study. Scientist prefers to launch KuaFu satellite into periodic orbit of Sun-Earth L5 point to study the evolution of Coronal Mass Ejection (CME).

This paper studies trajectory optimization for Sun-Earth L5 point missions. Three novel approaches, the multi-revolution phasing, the invariant manifolds and the lunar flyby, are used to optimize the transfer trajectory to L5 point.

In the multi-revolution phasing approach, satellite is first launched into heliocentric transfer trajectory with semi-major axis a little larger than that of the Earth. Because of the inequality of angular velocity, the phase angle between the Earth and the satellite increases with time. When the phase angle achieves 60 degree after several revolutions, the satellite is injected into the L5 periodic orbit with a tangent maneuver. The tradeoff between transfer time and maneuver velocity is studied. Numerical simulation shows that maneuver is most efficient when the satellite is near perigee of the Earth and most inefficient when the satellite is near apogee. Multi-impulse transfer trajectory is proposed to optimize the maneuver velocity and the amplitude of the L5 periodic orbits.

In the invariant manifolds approach, satellite is first transferred to the Sun-Earth L2 point using stable manifolds of Lissajous trajectory. Then the satellite flies to the L5 point to using the unstable manifolds. A maneuver is carried out when the satellite arrives at the L5 regions. Three-body transit orbits are used to optimize to the flight time of transfer trajectory.

In the Lunar flyby approach, lunar gravity assist is implemented before escape the Earth. The launch C3 can be saved. The work is under study, the results will be presented later.

Finally, mission scenarios using all three approaches are simulated in high precision dynamical model considering perturbations of planets and the DE 405 ephemeris. This paper demonstrates practical application of advanced astrodynamic concepts to optimize trajectory of triangular libration point missions.