ABSTRACT: Mission Design for the FIRE and PSI Missions

Martin W. Lo
Jet Propulsion Laboratory
California Institute of Technology

B.T. Barden and Kathleen C. Howell
School of Aeronautics and Astronautics
Purdue University

Sun-Earth L2 libration point orbits have become extremely popular for many NASA astrophysics missions due to the constant cold observation environment and low energy required for access. The Primordial Structures Investigation (PSI) and Far Infrared Explorer (FIRE) missions are currently proposed, as NASA Midex missions to study the cosmic microwave background (CMB) radiation, following in the footstep of the highly successful COBY Mission.

Both PSI and FIRE have selected a relatively small amplitude lissajous orbit about L2. The Delta-Lite class launch vehicle will place the spacecraft into an 11-day highly elliptical phasing orbit with apogee just beyond the moon. Two to four revolutions in the phasing orbits were considered to optimize mission performance. Near the last apogee, gravity assist from a lunar swingby transfers the spacecraft to a small amplitude (120,000 km Y, Z radius) lissajous orbit about the Sun-Earth L2 point. Lissajous orbits are smaller versions of the halo orbits used successfully by the ISEE3, SOHO, and ACE missions.

The lunar swingby transfer to L2 provides greater performance and less risk than a direct launch. The single maneuver to correct the launch error is broken into several smaller maneuvers, the first of which is 11 days after launch (vs. 1 day for direct launch). Many recovery scenarios exist within our propellant budget, even if one of these correction burns were missed, For a 2.5 rev phasing orbit mission, a 5-10 day contiguous launch period is possible each month, with a 2 minute launch window daily. For a 4.5 rev phasing orbit mission, this can be extended to 15 days.

Once on orbit, the spacecraft rotates slowly about an axis pointed at the Sun. The optical axis of the instrument is perpendicular to this axis. The rotation sweeps out a great circle of the sky and maps the entire sky in 6 months. The mission duration is around 2 years which provides a maximum of four all-sky surveys.

The mission design is forgiving and robust. In compassion to a direct launch trajectory, the lunar swingby trajectory to L2 provides many more opportunities for launch error recovery. Maneuvers are spaced no less than 2 days apart to give ample time for orbit determination and operations planning. Whether the problem is a larger launch period, degraded launch vehicle performance, or a missed critical perigee maneuver, recovery is still possible to achieve the lissajous orbit and complete the mission. The flexibility of the mission design and the simplicity of the observational strategy make these robust and cost effective.