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Strategies for Rapid Implementation of Interstellar Missions: Precursors and Beyond (4)

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DUAL JUPITER SWING-BY TRAJECTORY FOR INTERSTELLAR PROBE

Abstract

One main objective of the Interstellar Probe mission is to accelerate a spacecraft to an escape velocity of 95 km/s and reach a distance from the Sun of 1000 AU within 50 years with a launch date between 2030 and 2040. In a preliminary trajectory analysis, different options have been analyzed in order to achieve such a high solar system escape velocity. A basic constraint in this analysis is that the resulting trajectory is achievable with existing technologies. E.g. the escape velocity from Earth is constrained to the expected capabilities of the SLS. This results in trajectories that can reach out to Jupiter or Saturn. An outbound trajectory with a Jupiter or Saturn swing-by does not result in a sufficiently high escape velocity. The planetary constellation between 2030 and 2040 does not allow for multiple gravity assist maneuvers at the outer large planets as it was done e.g. in the Voyager mission. Therefore, a dive back to the Sun is considered, in combination with a powered Sun fly-by at a very close distance of around 5 Solar radii. Initially, the Sun fly-by is constrained to a ΔV of 8 km/s. This results in the requirement of a powered Jupiter gravity assist which leads to extremely high overall ΔV's that do not appear to be feasible with current technology. However, the shape of the trajectory indicates, that it may be possible to perform two Jupiter gravity assists: a first one which re-directs the probe towards the sun, and a second one on the way out of the solar system. Using a patched conics method, different scenarios are analyzed, and different fly-by sequences are combined. All scenarios are analyzed and constrained to technically challenging but not entirely unrealistic minimum distances from Jupiter and the Sun. The results are presented in classical porkchop plots, showing that solutions exist that yield overall ΔV's which are not far from being technically feasible. Further analysis is required in order to refine the trajectories by including deep-space maneuvers and potentially additional swing-by maneuver at the smaller planets. Technically, a staging solution which combines bi-propellant stage(s) and potentially electrical propulsion for the trajectory from Earth to Jupiter and back on the way to the Sun appears to be a very promising candidate for a realization of this mission.