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

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ADVANCED PROPULSION TECHNOLOGIES FOR RAPID IMPLEMENTATION OF INTERSTELLAR PRECURSOR MISSIONS

Abstract

Today, Voyager 1 has travelled farther from Earth than any other manmade object, collecting data just beyond the heliopause in the Very Local Interstellar Medium (VLISM), 47 years after its launch. This first interstellar mission is however strongly limited by a final speed of 3.6 AU/year. To go beyond this achievement, two challenging missions are currently being designed: the Johns Hopkins Applied Physics Laboratory's Interstellar Probe (ISP) and the Jet Propulsion Laboratory's Solar Gravity Lens (SGL) mission. In order to design a technically feasible mission with minimum development risk, The ISP uses traditional chemical propulsion technology; the baseline launch would be in 2036 using the SLS launcher with additional Centaur and Star 48BV boosters. This launch would put the probe on a direct trajectory to Jupiter, and after a passive gravity assist it would speed out at about 7AU/year, two times the speed of Voyager 1. The SGL mission is far more ambitious than ISP; it begins its primary science mission at the Sun's gravitational lens distance of 650 AU. Reaching the SGL focal region at 650 AU in less than 30 years implies a hyperbolic escape velocity in excess of 20 AU/year. Currently, solar sailing in combination with a very close (0.1AU) perihelion represents the only method of propulsion for a realistic mission to reach solar system exit velocities of 20+ AU/year. However, this propulsion technology needs to be matured and is probably not compatible with a launch before 2050. However, there are other propulsion technologies which could enable challenging near-term interstellar precursor missions by either increasing the achievable delta V, or reducing the required flight time, or mitigating the necessity of very expensive launches, or allowing for higher payload mass ratios, or a combination of these improvements. Of particular interest are electric propulsion systems powered by solar (SEP), nuclear (NEP) or laser (LEP) power sources, nuclear and laser thermal propulsion, solar and electric sails. This paper gives an update on the status of these advanced propulsion concepts and compares them with the ISP and SGL propulsive approaches. Furthermore, it provides examples of other interstellar precursor missions which could be launched before 2050.