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

Author: Mr. Angelo Genovese
Initiative for Interstellar Studies, Germany

Mr. Nadim Maraqtan
Initiative for Interstellar Studies, Germany

ADVANCED ELECTRIC PROPULSION CONCEPTS FOR FAST MISSIONS TO THE OUTER SOLAR
SYSTEM AND BEYOND

Abstract

Electric Propulsion (EP) comprises all types of space propulsion in which a certain amount of propellant is ionized and then accelerated by electric or magnetic fields, or both. This propulsion technology allows for much higher specific impulses than conventional chemical propulsion ($I_{sp} < 2000$ s), resulting in a major reduction of the propellant mass or a considerably higher final speed for a certain space mission. Hence, EP can enable very challenging space missions as DAWN has clearly shown. Furthermore, an EP system coupled with an advanced nuclear reactor could enable fast manned missions to Mars (one-way travel times less than 4 months). This propulsion technology can be scaled up to even higher specific impulses ($I_{sp} > 5000$ s). However, the power needed for the same thrust is also increasing. An Oberth maneuver performed very close to the Sun could provide the additional power to a high- I_{sp} Solar Electric Propulsion (SEP) system in order to reach the needed delta- v for challenging interstellar precursor missions. A breakthrough in power source specific mass is needed in order to enable missions with ultra-high specific impulses ($> 10,000$ s) ; this breakthrough could be realized having the power source not on-board, as with Laser-powered Electric Propulsion (LEP), where the needed power is beamed to the spacecraft from an external laser source. In this case the on-board power source is limited to a light-weight photovoltaic receiver/converter. The development of ultra-high I_{sp} ion thrusters powered by an external laser source could enable the most challenging interstellar precursor missions up to the Oort Cloud and beyond. This paper gives an update on the status of these advanced propulsion concepts, and provides some examples of interstellar precursor missions enabled by advanced EP systems which could be launched before 2040.