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Technology

Ikaros^2: Paving the Way for Interstellar Precursor Missions

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ABSTRACT

One of the biggest technological challenges in making interstellar precursor missions feasible is developing an efficient propulsion system. Although several innovative propulsion concepts have been proposed, none have yet provided a conclusive, near-term solution. Therefore, it is realistic to assume that such solutions, if they exist, will likely not be implemented for several decades. As a result, it is sensible to consider missions to the outer reaches of the solar system that use extensions of existing technologies.

A crucial parameter for propulsion in interstellar precursor missions is the specific impulse. To reduce the propellant mass and, consequently, the spacecraft mass to manageable levels, the specific impulse needs to be significantly higher than what current high-efficiency ion thrusters can achieve.

Field Emission Electric Propulsion (FEEP) presents several unique advantages: it offers very high specific impulse (> 4,000 seconds), is the most efficient method for carrying propellant in solid form (as Indium, which is used, melts at around 157°C), it has very low thermal losses because the emitter electrode is kept just above Indium's melting point, and it has a negligible electrode erosion.

Over the past two decades, Fotec GmbH and Enpulsion GmbH have developed and refined FEEP technology using porous tungsten emitter crowns, establishing it as a reliable space propulsion solution. More than 150 thrusters have been successfully deployed and are currently operational in space. Ground tests have shown that these thrusters can operate continuously for over 50,000 hours with minimal performance degradation. This exceptional longevity is crucial for the viability of interstellar precursor missions.

This paper proposes a short-term interstellar demonstration mission, Ikaros^2; it is a NanoSat Spacecraft with Off-the-Shelf Indium FEEP Technology and a deployable solar array in order to increase the maximum power available for propulsion.

The mission main goal is the exploitation of increased solar radiation flux by first going towards the Sun and building up momentum thanks to the so called Oberth-effect. After launch, the FEEP propulsion system is used to lower the perihelion by thrusting in anti-flight direction, but not lower than 0.7 AU thus avoiding the need for a heavy thermal shield. Close to perihelion, when the solar panels provide maximum electrical power to the propulsion system, the probe is accelerated with maximum thrust.

This mission can demonstrate the Oberth maneuver using Electric Propulsion for the first time, paving the way for more challenging interstellar precursor missions similar to the one proposed by Loeb et al in 2011.

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