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Interstellar Probe: Our Heliosphere as a Habitable Astrosphere

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The global nature of our heliosphere is one of the most outstanding questions of space physics today. Given that our own habitable astrosphere is unlike any of the multiple other astrospheres that have been observed, it has become of particular importance to understand the boundary to the local interstellar medium (LISM).

Nearing their end of life at less than 150 Astronomical Units (AU) from the Sun, Voyager 1 and 2 have revealed several surprises including the importance of the non-thermal particle component in the heliosheath never measured before, a lack of the anticipated source of the anomalous cosmic rays (ACR), and heliopause distances indicating an unexpected shape of our global heliosphere. The Interstellar Boundary Explorer (IBEX) mission and the Ion and Neutral Camera (INCA) on Cassini have given us the first glimpse of the global structure of the heliospheric boundary from within. Building on these missions, the newly selected Interstellar Mapping and Acceleration Probe (IMAP) mission will provide remote observations from its internal vantage point at 1 AU, offering unprecedented understanding of the physical processes at the interstellar boundary. At the same time, the New Horizons mission has explored in situ the farthest object from the Sun to date, taking leaps in our understanding of the evolutionary history of our solar system.

All these missions have placed heliospheric and planetary science at the doorstep of interstellar space with an expanding list of compelling questions. An Interstellar Probe on an escaping trajectory to the pristine local interstellar medium with a dedicated science payload has been discussed since at least 1960 in multiple NASA and international studies. Here, we present the results of a study of a Pragmatic Interstellar Probe currently underway, funded by NASA, and led by The Johns Hopkins University Applied Physics Laboratory with active participation from a large international team of scientists and engineers. The study targets a goal to reach out to 1000 AU distance from the Sun in 50 years with a spacecraft. Current mission scenarios include a launch in 2030 enabled by a Space Launch System (SLS) Block 1B rocket, assuming a New Horizons-like spacecraft using a powered Jupiter Gravity Assist or an Oberth Maneuver close to the Sun and building on the flight experience of the Parker Solar Probe. Science targets bridge heliospheric physics, planetary science, and astrophysics:
• Global heliosphere shaped by the LISM: a dedicated suite of fields-and-particles instrumentation would probe in situ the detailed physical processes in the heliosheath and LISM. Energetic neutral atom (ENA) and far ultraviolet (FUV) cameras would offer the first decisive image of our own astrosphere from outside.
• The circum-solar debris disk: in situ and infrared observations of the large-scale dust distribution enshrouded by the Zodiacal cloud would provide insights into planetary formation processes in both our and other planetary systems.
• Kuiper Belt Object (KBO) and Planetary Science: flyby imaging of a KBO such as the intriguing dwarf planet Quaoar, which may host crystalline ice and may be in its stage of losing its atmosphere, and its moon Weywot.