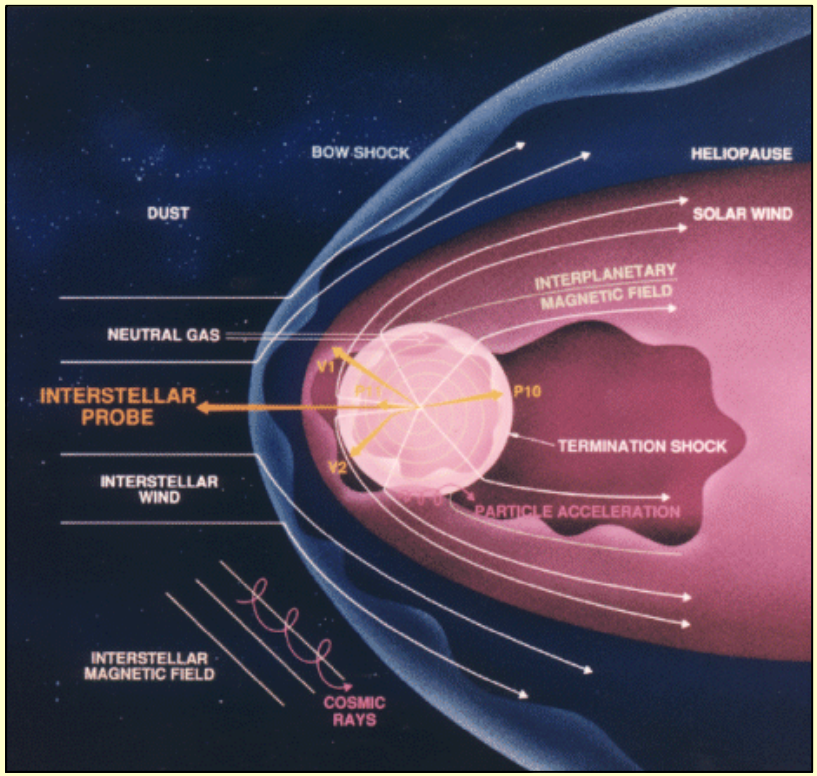
INTERSTELLAR PROBE



Interstellar Probe would pass through the boundaries of the heliosphere and begin exploring nearby interstellar space.

Technology Requirements

- Solar sail propulsion
- Low-mass/power optimized instrumentation
- Advanced Ka-band telecommunications
- Light-weight, low-cost spacecraft
- Integral design of structure and electronics

Fundamental Question:

What is the nature of the interstellar medium and its interaction with the solar system?

Science Objectives:

- Explore the interstellar medium and determine the properties of plasma, neutrals, dust, magnetic fields, and cosmic rays.
- Determine the structure and dynamics of the heliosphere as an example of the interaction of a star with its environment
- Study, in situ, the structure of the solar wind termination shock and the acceleration of pickup ions and other species
- Investigate the origin and distribution of solar system matter beyond the orbit of Neptune

Mission Description:

- Send a spacecraft to =200 AU in 15 yr. with solar sail propulsion
- Use sail to decelerate and drop in to 0.25 AU where photon pressure accelerates the spacecraft towards the upwind direction
- Jettison the sail at ~5 AU and coast to >200 AU, exploring the Kuiper Belt, heliospheric boundaries, and interstellar medium

Measurement Strategy:

- Measure in situ, the properties and composition of interstellar plasma, neutrals, dust, and low-energy cosmic rays
- Determine heliospheric structure and dynamics with in situ measurements and global imaging
- Map IR emission of the zodiacal dust cloud and measure

Interstellar Probe: Further Explanation

First mission to cross the heliopause and begin exploring the interstellar medium.

In our present view of the heliosphere, the solar wind flows outward to a termination shock, surrounded at somewhat greater distance by a contact surface called the heliopause, which is the boundary between solar wind and interstellar plasma. A bubble of solar wind therefore shields the inner heliosphere from the plasma, energetic particles, dust, and fields of the interstellar medium (ISM). To observe these directly, it is necessary to get outside the heliopause. Recent estimates place the distance to the termination shock at ~80 to 100 AU, with the heliopause at ~120 to 150 AU.

First Penetration into Interstellar Space

The Interstellar Probe mission would be designed to cross the termination shock and heliopause and make a significant penetration into nearby interstellar space. The principal objectives of the mission would be to: (1) Explore the nature of the ISM and its implications for the origin and evolution of matter in our Galaxy and the Universe; (2) Explore the influence of the ISM on the solar system and its dynamics and evolution; (3) Explore the impact of the solar system on the ISM as an example of the interaction of a stellar system with its environment; and, (4) Explore the outer solar system in search of clues to its origin and to the nature of other planetary systems.

Comprehensive In-situ and Imaging Instrumentation

To achieve these broad, interdisciplinary objectives, the strawman payload includes an advanced set of miniaturized, low-power instruments specifically designed to make comprehensive, in-situ studies of plasma, neutrals, energetic particles, fields, and dust in the outer heliosphere and ISM. Included would be studies of solar wind, neutrals, and pickup ions in the interplanetary medium, in-situ studies of particle acceleration at the termination shock (a model for other astrophysical shocks), studies of the penetration of interstellar gas and dust into the heliosphere, and exploration of the hydrogen wall and of the source of 2-3 kHz radio emission observed by Voyager. Infrared and in situ studies of the zodiacal dust cloud would have important implications for the evolution of the solar system, for studies of planets around other stars, and for studies of the cosmic infrared background radiation. The large-scale structure and dynamics of the heliosphere would be studied in-situ and with energetic-neutral-particle imaging. The interaction of our heliosphere with the ISM is a model for similar interactions occurring around other stellar systems.

Solar Sail Propels Spacecraft to Beyond 200 AU

Once beyond the heliopause Interstellar Probe would measure the properties of interstellar gas, dust, magnetic fields, and of low-energy cosmic rays unaffected by "solar modulation" processes that shield the inner heliosphere. Measurements would be made of the dust composition and of the elemental and isotopic composition of the ionized and neutral interstellar gas and low-energy particles, including ^{2}H, ^{3}He, ^{13}C, and heavier species. It may also be possible to identify organic matter in the outer solar system and ISM.

To accomplish its objectives, data should be acquired out to at least 200 AU, with a goal of continuing to ~400 AU. A spacecraft velocity of 14 AU/year (4 times that of Voyager 1) can be achieved with solar sail propulsion (sail radius of ~200 m), also beneficial for many other missions. Sending a spacecraft to nearby interstellar space ranks as one of the last great frontiers in space exploration and one of the grand scientific enterprises of the next century.