

LA-UR-23-25634

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Intended for: Web

Issued: 2023-05-24



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Cold Plasma Seminar Series Presentation: May 17th 2023

Title:

Plasma Imaging, Local measurement, and Tomographic experiment (PILOT), a Mission Concept Enabling Transformational Multi-scale Observations of Cold Plasma Dynamics in Earth's Magnetosphere

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Abstract:

Magnetospheric physics has a massive problem: we have not yet determined the fundamental processes that govern plasma mass and energy flow through the terrestrial magnetosphere, nor the degree to which these flows regulate key magnetospheric subsystems. Knowledge of these processes is critical to understanding the mass loss rate of Earth's atmosphere, as well as for determining the role that a planetary magnetic field plays in atmospheric retention, and therefore habitability, for Earth-like planets beyond the solar system. Mass and energy flow processes are challenging to determine at Earth in part because Earth's planetary magnetic field creates a complex 'system of systems' composed of interdependent plasma populations and overlapping spatial regions that perpetually exchange mass and energy across a broad range of temporal and spatial scales. Further, the primary mass carrier in the magnetosphere is cold plasma (as cold as 0.1 eV), which is invisible to many space-borne instruments that operate in the inner magnetosphere.

The PILOT mission concept uses a constellation of 34 spacecraft to provide the transformational multi-scale observations required to answer fundamental open questions about the dynamic distribution of plasma mass in Earth's magnetosphere. 30 of the PILOT spacecraft use radio signals to create a mesh of total electron content (TEC) line-of-sight measurements. The data from this mesh are inverted to create a rapidly refreshing (~15 s), high resolution (~0.5 Earth radii pixel size) radio tomographic image of total plasma density over a broad region of the inner magnetosphere (~3 hours in magnetic local time, ~3 Earth radii in L-shell). These data are combined with extreme ultraviolet imaging of light (He⁺) and heavy (O⁺) ion flows in the meridional plane, and four points of in-situ observation (including plasma waves and cold ion distribution functions) embedded within the imaged regions.

Together, the measurements made by this constellation fully capture the cold plasma mass dynamics of the inner magnetosphere over an unprecedented range of spatial and temporal scales. In this talk, we present the scientific motivation for the PILOT mission concept and describe a fully feasible implementation developed through a funded mission concept study. The mission concept study results were recently delivered to the 2024 Heliophysics Decadal Survey for consideration as a potential future NASA mission.