Connecting a multi-wavelength view of the corona with multi-spacecraft sampling of the solar wind in the era of PUNCH

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Abstract

A unified theory of the energy and mass flow across the Sun-Heliospheric system requires detailed observations of plasma state and the magnetic field to constrain models of the corona and solar wind. This presentation will briefly summarize the necessary diagnostics to probe the transfer of energy across the corona and inner heliosphere. In particular, highlighting the critical role of PUNCH observations in capturing the extended solar wind evolution to couple with in situ observations of Parker Solar Probe and Solar Orbiter.

Motivation

The solar wind is a continuous flow of plasma that fills the heliosphere. However, the connection between its formation, development, and local, ongoing plasma dynamics as it streams from the Sun is known partially or in segments. A full theory of the solar wind requires extended coronal remote observations that track its birth in the corona and as it escapes into the inner heliopshere.

A key to bridging coronal and heliospheric physics lies in our ability to continue tracing the newly formed solar wind stream beyond the solar atmosphere to address important solar wind questions that pertain to:

- **What are the conditions of solar wind solar sources that drive its distinct evolution?**
- **Are the physical heating mechanisms in the solar wind distinct from those that produce coronal heating?**
- **What is the role that Alfven waves/turbulence play in producing the non-adiabatic ion and electron temperature profile observed between the corona and heliosphere?**

Figures 1-5: To quantify the mass and energy flow we require tracing state variables (density, temperature, velocity), magnetic field, and non-thermal diagnostics between the corona and heliosphere are shown in the Figures below.

We note that integrating these measurements are limited to when the remote observations are taken in quadrature with in situ observations of the inner heliosphere as well as restricted to overlapping operation. Caveats and details of the different missions can be found in Rivera and Badman (2025).

Generally, there can be excellent coverage of density and velocity diagnostics between the low corona and the inner heliosphere when observations can be coupled. However, temperature, magnetic field and non-thermal diagnostics are much more limited to the low corona, below $2R_{\odot}$, leaving a large observational gap between their in situ counterparts.

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Fig.1: Density diagnostics (extended corona)

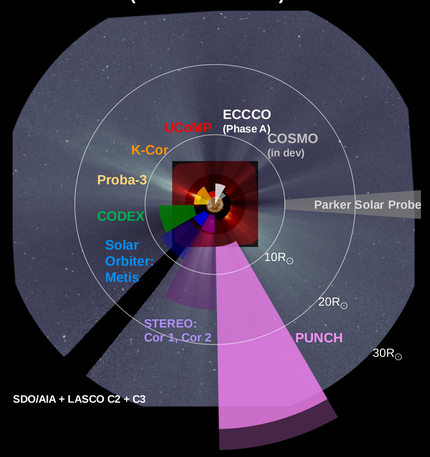


Fig 2: Density diagnostics (inner heliosphere)

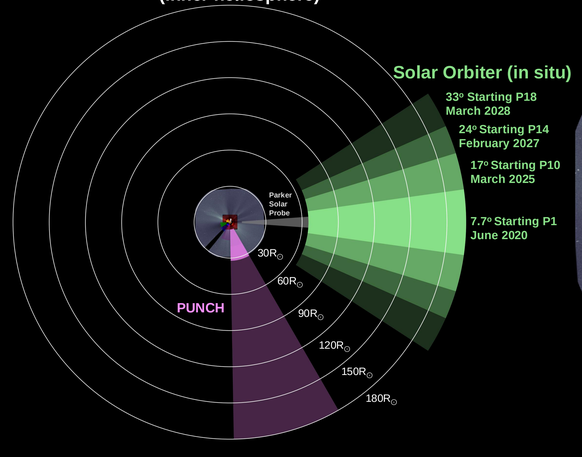


Fig 3: Temperature diagnostics

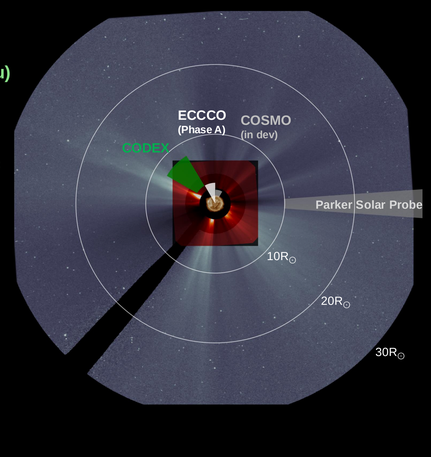


Fig 4: Velocity diagnostics

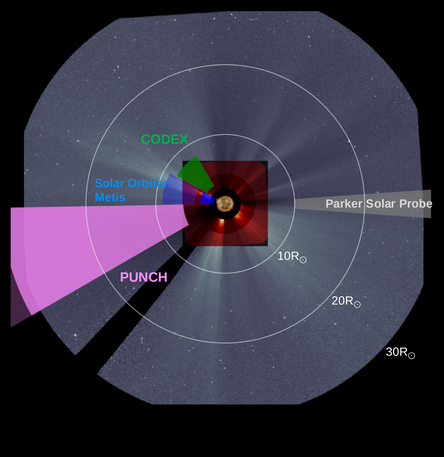
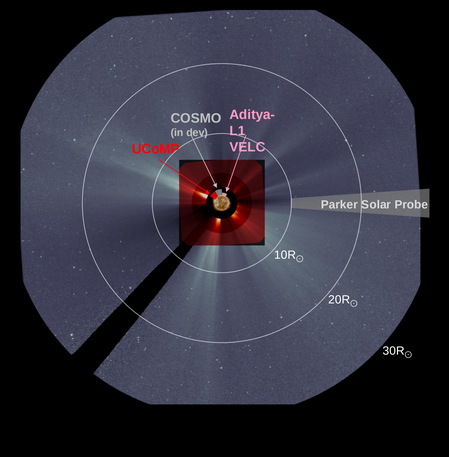
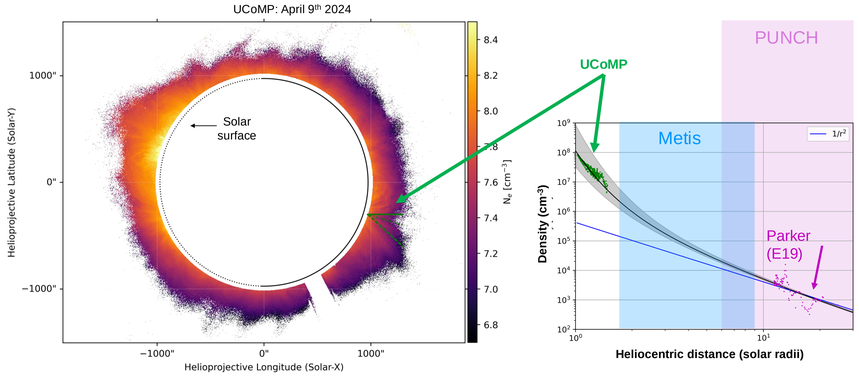


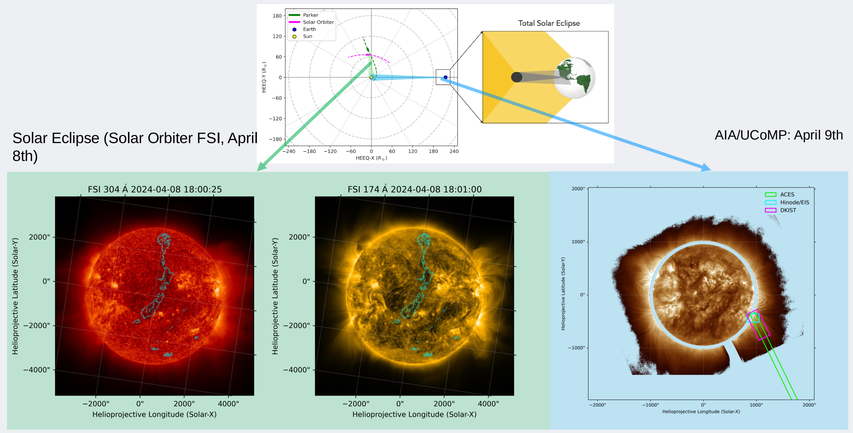
Fig 5: Magnetic field and non-thermal diagnostics



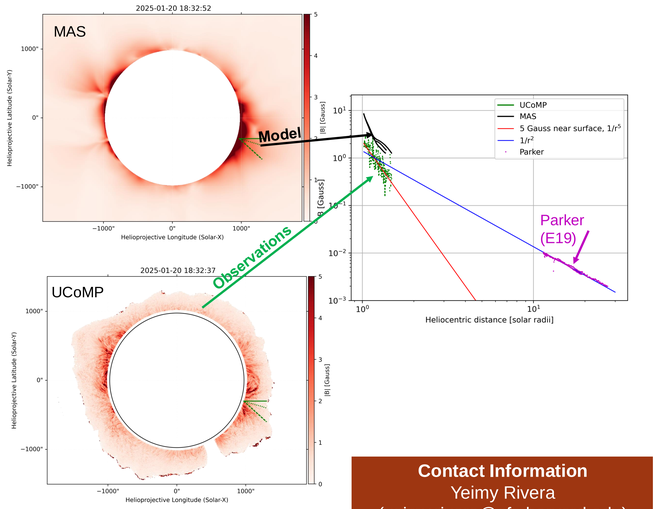
Connecting solar wind density



Spacecraft configuration in quadrature with Earth during total Solar Eclipse (Rivera+, *in prep*)



Connecting coronal magnetic field



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