Project Details

ROSES ID: NNH14ZDA001N
Selection Year: 2014
Program Element: Physics of the Inner Heliosphere

Topic: Physics-based methods to predict connectivity of SEP sources to points in the inner heliosphere, tested by location, timing, and longitudinal separation of SEPs

Project Title:
Analysis of Plumes to Predict Their Signatures in the Inner Heliosphere and Solar Wind: Laying the Groundwork for Solar Orbiter and Solar Probe Plus

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Summary:
A major unsolved problem in solar physics is determining the source regions of the solar wind. We propose to develop new composition diagnostics for in situ solar wind measurements that will enable Solar Orbiter, Solar Probe Plus, and other missions to identify the sources of the fast wind. This work addresses the science element ``Physics of the Inner Heliosphere'' in the Living With a Star program.

The fast solar wind originates in coronal holes. Within coronal holes two major structures are observed: plumes and interplume regions. Whether plumes or interplumes are the source of the fast solar wind is the subject of much debate. Some have argued that plumes are a major contributor to the solar wind, while others question whether plumes are present in the solar wind at all.

In order to resolve this issue, it is necessary to determine the coronal sources of the observed in situ solar wind. Such measurements, mainly by Ulysses, have found structures in fast solar wind streams, notably the microstreams and pressure balanced structures. These might be the remnants of plumes, but their connection remains ambiguous.

One challenge for relating these observations to coronal hole structure is that existing observations were made far from the Sun, where mixing of plume and interplume properties might have occured. Solar Orbiter and Solar Probe Plus are designed to address this problem by going much closer to the Sun.

The other major challenge has been that observations focussed on plasma properties, such as pressure and magnetic field, which are not uniquely related to solar structures. That is, the structures observed in situ could have formed in interplanetary space rather than originating at the Sun. To unambiguously connect observed solar wind material to plumes and interplumes, it is necessary to identify signatures that persist from the corona into the heliosphere.

The objective of our proposed work is to provide definitive composition diagnostics that will identify the coronal sources of the fast solar wind. The solar wind composition is fixed at low heights in the corona and thereby provides a clear link between the solar wind and the source region.

Ion abundances are one such diagnostic. The charge state distribution becomes frozen-in as the plasma flows away from the Sun. Thus, the charge balance reflects the temperature and density structure of the corona. Because plumes and interplumes have substantial differences in temperature, density, and outflow velocity, it is expected that their frozen-in charge states will also differ in solar wind.

We will calculate the time-dependent ionization balance and predict frozen-in ion abundances based on various plume and interplume models and observations. In preparation for analyzing Solar Orbiter and Solar Probe Plus data, we will apply our results to published in situ data from Ulysses and other missions.

Elemental abundances are also fixed at the Sun. In interplume material, the abundances are similar to the photosphere. But in plumes there are indications of a first ionization potential (FIP) effect, in which elements with a low FIP have elemental abundances that are enhanced relative to their photospheric values.

We will infer elemental abundances in plumes and interplumes using largely archival spectroscopic observations. It is likely that the elemental abundances of plumes vary as a function of the age of the plume. We will determine whether there is a time-dependent FIP effect in plumes. Our inferred elemental abundances will be compared with to existing published in situ measurements.

The outcome of this work will be a set of derived ion abundances and measured elemental abundances, which will be available to analyze in situ measurements from Solar Orbiter and Solar Probe Plus, as well as other in situ data. These data will enable determining whether structures seen in the fast wind are due to plumes or not.

Publication References:

no references