Project Details

ROSES ID: NNH21ZDA001N
Selection Year: 2021
Program Element: Focused Science Topic

Topic: Understanding the Large-Scale Evolution of the Solar Wind

Project Title:
A Holistic Solar Cycle Approach to Heliospheric Evolution from UCSD 3-D Reconstructions Using Thomson Scattering Data from STEREO HI and SMEI Imagery, and Interplanetary Scintillation Observations

PI Name: Bernard Jackson
PI Email: bjackson@cass01.ucsd.edu
Affiliation: University of California San Diego
Project Member(s):
- Buffington, Andrew;Co-I;University Of California, San Diego
- Bisi, Mario Mark;Collaborator;UK RESEARCH & INNOVATION
- Tokumaru, Munetoshi;Collaborator;NAGOYA UNIVERSITY, NATIONAL UNIVERSITY CORP.
- Davies, Jackie A;Collaborator;UK RESEARCH & INNOVATION
- Odstrcil, Dusan;Co-I;George Mason University

Summary:
From the year 2000, UCSD's time dependent three dimensional (3-D) reconstruction program has characterized the topology throughout the inner heliosphere based on interplanetary scintillation (IPS) observations. Now also incorporating Solar Mass Ejection Imager (SMEI), and STEREO Heliospheric Imager (HI), imagery and available in-situ measurements from any spacecraft, we have worked to combine all of these observations into a super-program" analysis system. This takes advantage of the benefits of each data source to provide plasma densities, velocities, and extrapolations of solar surface magnetic fields. Our Japanese colleagues have gathered much information about background global solar wind properties in the inner heliosphere using IPS analyses over two solar cycles. However, until now there has not been an attempt to reconstruct the propagation of rapid time variations much beyond Earth's orbit. Here we propose to rectify this and use our comprehensive 3-D reconstruction program to map structures globally to extend the recent science from Mars out to Jupiter. This effort is enhanced by ingesting these tomographic inputs into 3-D MHD modeling using ENLIL, so that now more of the known plasma physical properties are included to this solar distance.

From the UCSD Thomson-scattering SMEI and STEREO HI 3-D reconstructions of densities with about one hour cadence and few-degree latitude and longitude spatial resolutions near Earth and at STEREO, we have found that the heliosphere at 1 AU is not as simple as many modeling efforts imply. Our analyses show that CME fronts at 1 AU are highly corrugated and patchy; some have wavy fronts, and inhomogeneous structure. In-situ measurements can be adequately reproduced at a one-hour cadence, but nearby densities can be greatly different. This feature of the heliosphere, and the science of the small-scale propagation of switchback" fields and plasma, has become more evident from recent Parker Solar Probe (PSP) analyses. We do not know if such corrugation is a ubiquitous feature in all solar wind features - solar interaction regions (SIRs), shock processes, or the background solar wind. We assume that some smoothing occurs, and that the solar wind in general becomes more homogeneous at the distances probed by Ulysses; this proposed effort will clarify this using our highest resolution data sets.

For this FST #3 effort, we will use archival SMEI, STEREO, and IPS data (from the year 2000) and will employ all extant NASA in-situ plasma monitors as input, and verification checks to beyond Jupiter's orbit. This will allow better scientific comparisons all the inner planets to Jupiter, and at the asteroids in between. We note that most members of our group are Co-investigators on NASA's Polarimeter to Unify the Corona and Heliosphere (PUNCH) Small Explorer (SMEX) mission; when remote-sensing data from PUNCH becomes available, and with agreement from NASA and members of the FST, we will incorporate these additional data into the tomography. Our analysis goals set out below will:

1) Assess the 3-D tomography data sets over time to determine the best IPS, SMEI, and STEREO HI imagery sets to use at different times. These optimal data combinations throughout the solar cycle will then be used as inputs to the ENLIL 3-D MHD model to augment the solar wind interaction science out to the distances of the two nearest planets beyond Earth's orbit.
2) With our new understanding that CMEs and presumably most solar wind structures are spotty or at least corrugated from near the Sun to Earth, we will refine the scale of this variability, and its change with solar distance, in our most highly-resolved data sets.
3) Where CMEs are first observed in the LASCO or STEREO coronagraph images by FST members, we will track them until they are measured in situ at Earth, Ulysses, STEREO, and more recently at PSP, Solar Orbiter, and BepiColombo, out as far as Mars, and Jupiter.

Publication References:

no references