Remote Sensing in the Inner Heliosphere
Aberystwyth, 05 - 08 May 2009

Abstracts

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A common format IPS database

Abstract
A consensus about the desirability of a common data format for IPS observatories world wide was reached at the Oct 2007 IPS Workshop at Toyokawa. The availability of IPS data from observatories worldwide in a single database with a common format and interface will make it easier for IPS users to collaborate and use data from different instruments. We expect that this will also help in bringing IPS into the mainstream of heliospheric and space weather physics and analysis.

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The Interplanetary Scintillation (IPS) Data Format: a Brief Summary Following the Toyokawa IPS Workshop

Abstract
At the interplanetary scintillation (IPS) workshop in Toyokawa, Japan, late-October 2007, initial discussion took place on a fixed common format for IPS data. The discussion ranged from what the programming structure of a common format should be (including the choice of coordinate systems etc...) to what data products should be included in this format. The driving goal was to allow these data to be more-easily shared among those directly-related to IPS work as well as to those not in the field, and eventually for multiple-analysis IPS methods. Here, I give a brief summary and agreed-upon aims/goals of the discussions which took place at the Toyokawa IPS workshop and through relevant follow-up communications. These are intended to serve as a starting point for the newly-re-opened topic at Aberystwyth.

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Where next for heliospheric physics?

Abstract
Heliospheric remote sensing has been extraordinarily successful in revealing solar wind structure, but where do we want to go in the post-STEREO era? What should our science drivers be and what facilities will we need to address them? What is the best way to exploit the new generation of array radio telescopes (including SKA?). How do we maximise benefit from upcoming space missions? This talk is meant as a starting point for discussion in the community, though the author will undoubtedly discuss some ideas for directions to explore.

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Removal of background light from SMEI white-light all-sky maps, and an all-sky imager design suitable for future deep-space missions

Abstract
White-light near-all-sky maps from the Solar Mass Ejection Imager (SMEI) have demonstrated this instrument's capability for detecting coronal mass ejections (CMEs) and tracking them from near-Sun elongations/distances to beyond Earth. Moreover, three-dimensional reconstruction using the time series of these maps enables an unfolding of heliospheric density along the line of sight; this in turn permits separation of individual CME structures and determination of their masses and densities. Velocities can also be obtained when combined with interplanetary scintillation (IPS) observations of solar-wind velocity. Comparison of results with *in situ* measurements certifies this reconstruction process. However, for successful reconstruction the white-light maps must have non-Thomson-scattered background light, typically 100-times larger, removed. This can be done approximately by viewing difference maps in which an earlier sky map is subtracted from a present one. However, this method tends to erase heliospheric structures that change more slowly than the time difference between the two maps. Our method preserves even large-scale heliospheric structures, but removes most background which repeats from year to year. Its success depends critically upon SMEI's nearly full-sky coverage. We also present a hemispheric imager whose robust, lightweight design is suitable for future deep-space missions.

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Radio Sounding of the Near-Sun Plasma Using Polarized Pulsar Pulses

Abstract
The results are presented of radio sounding observations probing the inner solar wind near the minimum of solar activity cycle using polarized pulsar pulses from PRS B0525+21 and PSR B0531+21 received when the lines of sight toward these pulsars was close to the Sun. The observations were obtained in June 2005 and June 2007 on the Large Phased Array of Lebedev Physical Institute at 111 MHz. An upper limit for the scattering of giant pulses from PSR B0531+21 due to their passage through the turbulent solar wind plasma is determined. The arrival-time delays for pulses from PSR B0531+21 are used to derive the radial dependence of the mean density of the circumsolar plasma. The resulting density distribution indicates that the acceleration of fast high latitude solar wind outflows continues to heliocentric distances of 5-10 RS, where RS is the solar radius. The mean plasma density at heliocentric distances of about 5 RS is 1.4×10^4 cm^{-3}, substantially lower than at solar activity maximum. This is associated with the presence of polar coronal holes. The Faraday rotation measure at heliocentric distances of 6-7 RS is estimated. Deviation of the spatial distribution of the magnetic field from spherical symmetry are comparatively modest in the studied range of heliocentric distances.

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Measurements of White-Light Images of Cometary Plasma as a Proxy for Solar Wind Speed

Abstract
The high temporal and spatial resolution of heliospheric white-light imagers enables us to measure the changes in the plasma tails of bright comets. Plasma tails of comets have been recognized as natural probes of the solar wind and thus using the technique developed at the University of California, San Diego to measure the changes in the plasma tails of comets, we obtain measurements for the speed of the solar wind in-situ. We present the technique used successfully on multiple comets observed by the Solar Mass Ejection Imager (SMEI) and discuss its future application.

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Joint Interplanetary Scintillation and Heliospheric Imager observations of CMEs and CIRs

Abstract
Results are presented from simultaneous Interplanetary Scintillation (IPS) and white light Heliospheric Imager (HI) observations made in 2007 of a coronal mass ejection and a co-rotating interaction region at interplanetary distances. Significant signatures suggestive of such phenomena are observed in EISCAT IPS observations and are found to coincide temporally and spatially with CME and CIR features observed by HI on the STEREO spacecraft. These studies demonstrate the capability of these two techniques to extract useful information on solar wind phenomena in interplanetary space.

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Solar Wind Forecast by using Interplanetary Scintillation Observation

Abstract
Radio waves from a compact radio source such as a quasar are scattered by irregularities of electron density in the interplanetary medium. The scattered waves interfere with each other as they propagate toward the Earth producing amplitude scintillations which are then seen as diffraction patterns at Earth. This phenomenon is called interplanetary scintillation (IPS). The IPS pattern contains the information of solar wind velocities and density fluctuations passing across a line of sight (LOS) from an observer to a radio source. We determine solar wind velocity and density structures by employing computer assisted tomography (CAT) to reduce the LOS integration effect which degrades the accuracy determination of these structures. This technique can be applied to forecast the solar wind for a few days prior to its reaching Earth. This is because our IPS observations from the Solar-Terrestrial Environment Laboratory (STELab) radio arrays at an observing frequency of 327 MHz are sensitive to a region of from 0.2-1 AU distance from the Sun. However, the CAT algorithm assumes that a three-dimensional solar wind structure is stable and requires a redundancy of LOS numbers. Therefore, the accuracy of the solar wind forecast depends on solar activity as well as the number of IPS data for the period of interest. In this study, we

focused on the accuracy which depends on the number of IPS data and simulated real-time analyses of a forecast procedure using IPS data obtained near solar minimum when a solar wind structure is assumable to be co-rotational. In this procedure, a few tens of IPS observations are included in the CAT algorithm to update the solar wind structure inside of Earth's orbit each day. Then, forecast plots, that is, time profiles of the solar wind velocity at the Earth position for several future days, are drawn. These results are compared with *in situ* measurements to evaluate the accuracy of the solar wind forecast by using STELab IPS observations. We will present the forecast process and discuss dependencies of the accuracy on observing conditions.

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First catalogue of IPS sources detected at the Mexican Array Radio telescope (MEXART)

Abstract
The Mexican Array Radio Telescope (MEXART) consists of a 64x64 (4096) full wavelength dipole antenna array, operating at 140 MHz, occupying about 9,500 square meters (70 m x 140 m) (http://www.mexart.unam.mx). This is a dedicated radio array for IPS observations located at: latitude 19º 48' N, longitude 101º 41' W and 1964 m above sea level. We present the results of the first sky surveys at the MEXART employing a Butler Matrix (BM) of 16x16 ports, fed by 16 East-West lines of 64 dipoles (1/4 of the total array). The BM displays a radiation pattern of 16 beams at different declinations (from -48, to +88 degrees). We have identified (having at least 4 sigmas in power gain) the transit of about 20 radio sources which belong to the 3C, Ooty and/or STEL IPS sources catalogues. We discuss the calculations of the m-values and solar wind speeds.

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Faraday Rotation: Expected Possible Heliospheric Analyses from Polarized Radio Sources

Abstract
We report on recent progress in simulating the Faraday Rotation (FR) response from realistic 3-component magnetic fields from heliospheric data. At the University of California, San Diego (UCSD) we have provided the community with the computer programs allowing us to visualize heliospheric data sets in FR. Our IDL SolarSoft (SSW) programs required to provide these visualizations will be reviewed, and current progress in simulating expected signals described. Recent high-frequency radio observation results using UCSD 3D reconstruction techniques imply that these procedures can be used successfully for some aspects of FR 3-component magnetic-field reconstructions.

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A Summary of UCSD work since the Toyokawa IPS Workshop

Abstract
Data from the Solar Mass Ejection Imager (SMEI) continues throughout the last years, with several steps taken to better provide these data to colleagues and interested parties. We now present both direct and 3D-reconstructed higher-level data products on the USCD Website http://smei.ucsd.edu for the entire SMEI period from February 2003 for use by others. A Web-based scheme allows animations of these images; single heliospheric views can be downloaded from this site. The removal of the zodiacal light signal to better refine SMEI observations continues, and has included measurement of the Gegenschein and its temporal variation. STELab IPS velocity data are used with the SMEI analysis when available in order to refine the overall 3D structure of events and this is now better-detailed in examples that both do and do not include these data. Since 2007 several enhancements to the UCSD 3D reconstruction code allow somewhat higher resolutions for existing data, and these better en able the reconstruction of density enhancements in the SMEI data behind heliospheric shocks for some large CME events. In addition, we have used the 3D-reconstruction technique to provide Ooty data reconstructions in both velocity and density. These analyses, especially from a complex series of events in November 2004, show the importance of using more lines of sight and highlight the potential analysis capabilities from a single-site IPS array. As an aside, the UCSD time-dependent 3D reconstruction code has now successfully used test Faraday-rotation inputs to reconstruct 3-component magnetic fields.

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Review of Columnar Density Changes with Differential Doppler

Abstract
The changes in the index of refraction along the line of sight from a radio source occulted by the solar corona and heliosphere are due to fluctuations in electron density. These fluctuations are proportional to the frequency shift in the radio frequency signal from the source as measured by the observing antenna. Bertotti and Giampieri (1997) improved the calculations for measuring the change in Total Electron Content (TEC) using the frequency shifts in two separate frequencies. Jensen (2007) demonstrated the successful application of these calculations using the Cassini spacecraft X-band and Ka-band radio frequency carriers (8 and 32 GHz) by comparison to DRVID TEC measurements. This technique will be reviewed for its relevance to natural radio sources and various types of antennas.

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Faraday Rotation Response to CME Structure

Abstract
The magnetic field of the heliosphere outside of active regions can only be measured remotely

using the technique of Faraday rotation. Faraday rotation is the rotation of the plane of polarization of an electromagnetic wave as it traverses a birefringent medium such as the plasma of the heliosphere. It is proportional to the integration of the component of the magnetic field parallel to the wave vector of the EM wave weighted by the electron density. Magnetic clouds are a subset of CMEs consisting of a magnetic flux rope with anti-correlated distributions of density and magnetic field strength in their structure. Some CMEs drive a magnetosheath downstream as they expand outward in the solar wind; the sheath region exhibits both enhanced magnetic field strength and density. We will discuss these two CME structures and their predicted effects on Faraday rotation observations.

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Interplanetary Scintillation Measurements at Ooty

Abstract
This talk will review the interplanetary scintillation (IPS) observations obtained from the Ooty Radio Telescope, operating at 327 MHz. At Ooty, a large number of radio sources are observed everyday and it provides an excellent data base for the three-dimensional tomographic reconstruction. This paper discusses the characteristics and evolution of solar wind structures in the inner heliosphere and their association with small and large coronal mass ejections.

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Revealing CMEs in white light coronagraph images

Abstract
A new method for isolating the signal of CMEs in white light coronagraph images is introduced. Whilst removing the background light of the F-corona (and other unwanted signals like instrumental stray light) is an established part of analysing coronal images, removing the background quiescent K-corona to enhance the signal of dynamic events is difficult. We show that above 3 solar radii (and probably below 30Rs), the structure in white light K corona images is almost completely radial. This fact can be exploited to remove the background quiescent corona in a simple and robust manner. Since CMEs are not radial structures, their signal is isolated effectively with this method.

D. Oberoi (1), L. Benkevitch (1) and the MWA Team

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The Murchison Widefield Array : Status, preliminary results and plans

Abstract
The Murchison Widefield Array (MWA) is a new generation low frequency interferometer currently under construction in the radio quiet Western Australian Outback. This presentation will include a

brief overview of the solar and heliospheric science objectives of the MWA. It will provide an update on the current status of the MWA and our immediate plans. We will also share some initial results from the 32 element prototype system which has been deployed on site.

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Upgrade of STEL Multi-Station Interplanetary Scintillation System and Recent Observations of the Solar Wind

Abstract
Observations of interplanetary scintillation (IPS) serve as a useful tool for studying the 3-dimensional (3D) structure of the solar wind and its evolution. We have carried out IPS measurements of the solar wind since early 1980s using the STEL multi-station 327-MHz system. We have been collaborating with the UCSD group on the 3D reconstruction of the solar wind from IPS observations for more than 10 years. Through this collaboration, we successfully developed an analysis method to deconvolve the line-of-sight integration of IPS data using the computer assisted tomography (CAT). Various unprecedented features of the 3D solar wind were revealed from the CAT analysis of our IPS observations. In order to improve the quality of our IPS observations and to optimize the resolution of the CAT analysis further, we initiated an upgrade project of the STEL multi-station IPS system in 2006. Construction of a new IPS antenna at Toyokawa, was completed in 2008, and IPS observations using this antenna are going on now. In this workshop, we report the current status of the upgrade project of our IPS system. In addition, we report some interesting results obtained from our recent IPS observations.

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Monitoring of interplanetary and ionosphere scintillation at the frequency 111 MHz

Abstract
Results are presented of everyday monitoring of interplanetary (IPS) and ionosphere (ISS) scintillation for the years 2006-2008. Observations were obtained on the Large Phased Array of Lebedev Physical institute at the frequency 111 MHz simultaneously in 16 antenna beams. All the sources with scintillating flux densities greater than 0.5 Jy were registered in the sky area with sizes about 8o in declination and 24 hours in right ascension. Interplanetary and ionosphere scintillation are distinguished using their different typical temporal scales: about 1 s for IPS and about 10 s for ISS. The average scintillation index mIPS of the statistical ensemble of scintillating sources is considered as a characteristic of turbulent interplanetary plasma. The maximal value of mIPS of about 0.3 was observed during the day time while mIPS minimal value of about 0.1 was reached during the night time. Weak day-to-day variations of mIPS were observed for both, day and night times. Ionosphere scintillation indexes mISS are considerably lower in comparison with mIPS for day time, and, in average, mIPS » mIPS for the night time. As a whole, interplanetary plasma and mid-latitude ionosphere were in a quiet state during the observation period. Distinct decrease of day time maximal mIPS value was observed in autumn of the year 2008 that can be explained by the dominant influence of the heliospheric current sheet.