SH42D-04 1430h INVITED

Coronal Magnetic Diagnostics With FASR

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Coronal magnetography is one of the main scientific drivers for the proposed Frequency Agile Solar Radiotelescope (FASR). Radio emission is particularly valuable as a diagnostic of coronal magnetic fields because (a) the emission mechanisms all depend on magnetic field, and (b) typical values of the electron gyroresonance frequency f_B for coronal field strengths lie in the radio domain. The microwave emission from active regions is dominated by thermal gyroresonance emission at low harmonics of f_B and this provides a well-understood diagnostic. Since f_B is proportional to magnetic field strength, there is a simple mapping between frequency and magnetic field. A wide range of coronal magnetic field strengths can be sampled by observing across a wide range of radio frequencies simultaneously, and FASR is designed to do this quickly enough to follow changes in coronal fields. We demonstrate the ability to measure coronal fields with this technique by simulating a FASR observation of a realistic three-dimensional model of an active region and then determining the coronal magnetic field at the base of the corona from the simulated images. Comparison with radio images of gyroresonance emission from active regions is also a valuable tool for assessing extrapolations of surface magnetic field measurements into the corona, and we discuss several applications of this comparison. Gyrosynchrotron radio emission from nonthermal electrons accelerated by solar flares also can reveal the magnetic topology of the flare source and we discuss this briefly.

SH42D-05 1445h

Magnetic maps of prominences

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We present the first magnetic maps of a prominence obtained by applying our PCA inversion approach to prominence spectropolarimetric data in the He I D3 line. Our results indicate the presence of organized structures in the prominence plasma embedded in magnetic field that are significantly larger than average (50 G and higher). We reaffirm the need for a Hanle-based diagnostics of prominence magnetism using full Stokes spectropolarimetry, and the importance of improved, multi-line observations, ideally involving both He I D3 and 10830.

SH42D-06 1500h

Comparison of Observed Coronal EUV and X-Ray Emission with that from Heating Models

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The problem of finding the physical mechanism that heats the solar corona is still unsolved. Many theoretical and observational models have been proposed in the literature. In order to understand which model better reproduces the observations, we present a quantitative comparison between the emission calculated from different heating models and the observed images of an active region. This investigation uses our 3D MHD model in Cartesian coordinates, which calculates the magnetic configuration of Active Region 7986 (August, 1996) starting from a photospheric magnetogram, and another algorithm that solves the 3D fluid equations along magnetic field lines, and that includes thermal conduction, radiation losses, and the heating mechanism under investigation. Once the plasma properties are found, the emission in different wavelengths can be calculated using the Solarsoft package and can be compared with the photon counts recorded by the EIT instrument aboard the SOHO spacecraft, and the SXT instrument aboard the Yohkoh satellite.

SH42D-07 1515h

Development of 2D MHD Self-Consistent Empirical Model of the Corona and Solar Wind

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We are developing a 2D MHD self-consistent empirical model of the solar corona and solar wind. We constrain the solution using empirically determined estimates of the effective pressure for the momentum equation and effective heat flux for the energy equation provided from coronagraph data and Ulysses plasma and magnetic field data. Our solutions are steady state and do not use a polytrope which we know is not valid in the solar corona. We have been able to achieve preliminary convergence. We will present the results of an error analysis. Our results are presently only valid during solar minimum, but are generalizing so it can be used during the transition toward solar maximum (i.e., three current sheets). We will also present some preliminary results which will allow us to apply our solutions to solar maximum conditions.

SH42E MCC: 2010 Thursday 1600h

Radio Remote Sensing of the Corona and Heliosphere II

Presiding: **B Lin,** University of California, Berkeley**; N Gopalswamy,** NASA Goddard Space Flight Center

SH42E-01 1600h INVITED

Radio Investigations of the Inner Heliosphere

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We review recent observations of the thermal and non-thermal radio radiation in the inner heliosphere. The thermal radiation can yield information on both quiescent and transient structures, while non-thermal radiation traces populations of energetic electrons associated with high energy phenomena, such as beams of energetic electrons and shock waves. Results very much depend on the type of instrument which is used: spectrograph or imager, ground-based or space-borne. The frequency range of radio sources in the inner heliosphere corresponds to the metric, decametric, hectometric, and kilometric bands. Only the metric and a small part of the decametric range can be accessed from the ground. The longer wavelengths are blocked by the terrestrial ionosphere and observations from space are required. Long wavelength require extremely long baseline interferometers in order to produce images. This has never been done from space as yet. There are some techniques, however, to determine the direction of the source centroid. We will try to provide an integrated view of the different approaches, focusing on the physical nature of the phenomena which are observed. Finally we will mention future programs in this field: Stereo, FASR, LOFAR, SIRA, LWS/Sentinels among others.

SH42E-02 1615h INVITED

Radio Coverage from Chromosphere to Earth: FASR-LOFAR-SIRA Synergy

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Radio emission is uniquely sensitive to a number of key plasma parameters (magnetic field, temperature, density, high-energy electrons, and various plasma waves) over heights ranging without gaps from the chromosphere, throughout the corona and heliosphere, to the Earth. Two ground-based radio arrays, the Frequency Agile Solar Radiotelescope (FASR) and the Low Frequency Array (LOFAR), together with the space-based Solar Imaging Radio Array (SIRA) are planned that will for the first time provide direct imaging of disturbances over this vast height range through interferometric imaging over their equally impressive frequency range of 24 GHz to 30 kHz. We describe the science goals of these instruments, focusing especially on the science addressed jointly by all three instruments. Among the examples are (1) simultaneous imaging of CMEs, flaring loops, and shock-associated (type II) emission and (2) imaging the propagation of electrons on open field lines (type III), from their acceleration point through the corona and heliosphere to the point where they are measured in situ by near-Earth spacecraft. In addition to spatially relating the different phenomena, the spectral information is rich in quantitative diagnostics. We give some examples of the revolutionary results we can expect from the combined instruments.

URL: http://www.ovsa.njit.edu/fasr

SH42E-03 1630h INVITED

Origins of Coronal Shock Waves Revisited

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The origins of coronal shock waves manifested by metric type II radio bursts has been, and remains, a controversial topic. Type II shocks have been attributed to flare blast waves or identified as waves driven by flare ejecta or coronal mass ejections (leading edge or flanks). It has also been suggested that a type II shock occurs when a blast wave moves through a preceding coronal mass ejection. I focus on a few key events to highlight points of contention in the debate such as the association of metric IIs with flares and CMEs, timing relationships between the various phenomena, and the connectivity of metric and decametric-hectometric type II bursts.

SH42E-04 1645h INVITED

Solar Hard X-ray Bursts and Type III Radio Bursts

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Observations of solar type III radio bursts provided the first evidence for accelerated electrons of a few to a few tens of keV energy escaping the Sun. These escaping electrons have been detected in situ by spacecraft in the interplanetary medium (IPM) near 1 AU. Near the Sun, the electrons must produce hard X-rays (HXRs) through bremsstrahlung collisions with the relatively dense corona. In the past, HXR bursts (usually associated with a solar flare) were sometimes detected in close temporal coincidence with type III radio burst, but most type III bursts were unaccompanied by HXR bursts and vice versa. The Ramaty High Energy Solar Spectroscopic Imager (RHESSI) mission launched Feb. 2002 provides uniquely high sensitivity imaging and spectroscopy of HXRs down to 3 keV. RHESSI observations suggest that type III bursts are a phenomenon separate from flares, although often closely associated. The HXR emission from type III bursts alone has been detected for the first time, providing quantitative numbers and spectra for the radio-emitting electrons. The

HXR imaging, together with radio and in situ electron observations from the Wind spacecraft, allow unambiguous tracing of the magnetic connection of the IPM back to the Sun, and also allow the physics of the escape, propagation, and radio emission processes to be studied in detail.

SH42E-05 1700h INVITED

Type III Radio Bursts and the Structure of the Inner Heliosphere

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Type III solar radio bursts provide important information on the origin, acceleration, and propagation of particles associated with solar flares and coronal shocks. Since these radio emissions are generated by the plasma emission mechanism, observations of these solar radio transients also provide remote sensing of the plasma conditions in the corona and of the magnetic and plasma structure of the inner heliosphere. In this talk I will review the progress of type III research from their discovery in the late 40s to the most recent advances from low-frequency spacecraft observations, primarily from ISEE-3, Wind and Ulysses.

SH42E-06 1715h INVITED

Scientific Goals of the Solar Imaging Radio Array

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The Solar Imaging Radio Array (SIRA) will be a constellation of about 16 microsatellites designed to image radio sources in the solar corona and heliosphere using aperture synthesis techniques. These images will permit the mapping and tracking of CME-driven shocks (type II radio bursts) and solar flare electrons (type III radio bursts) as a function of time from near the sun to 1 AU. Two dimensional imaging of the CME-driven shock front is important for determination of space weather effects of CMEs. Imaging of the more frequent type III bursts will permit the derivation of density maps in the outer corona and solar wind. Certain intense type III bursts provide valuable information about particle acceleration and SEP events. SIRA will be the first mission to image the heliosphere (and the celestial sphere) with good angular resolution at frequencies below the ionospheric cutoff (10 MHz). The radio images are intrinsically complementary to white-light coronagraph data, such as those of SDO, and can play a valuable role in the NASA Living with a Star program. In this presentation, I will present the scientific goals of SIRA with attention to the new results that will be possible.

SH42E-07 1730h INVITED

Density Structure of the Solar Corona From Radio Occultation Measurements

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Starting with angular broadening measurements five decades ago, a wide variety of radio propagation and scattering phenomena have been observed when natural radio sources or spacecraft radio signals happened to pass behind or were occulted by the solar corona. While yielding information on density, velocity and magnetic fields, these unique measurements probe density most directly, and with unprecedented sensitivity, spatial and temporal resolution. Coronal density takes on added importance because it provides insight into magnetic field topology at a time when few measurements of the coronal magnetic field are available. While complexity of the corona and paucity of measurements have certainly contributed, lack of understanding of the nature of the inferred density variations is the main reason why it has taken so long for radio occultation measurements of density to finally realize their perennial potential. The purpose of this paper is to summarize the salient features and highlights of radio occultation measurements of density that include: propagation of shock waves driven by coronal mass ejections, origin and evolution of the solar wind, coronal magnetic field topology, and fine-scale filamentary structures that are more than two orders of magnitude smaller than those observed in highest spatial resolution images of the solar corona.

SH42E-08 1745h INVITED

Radio Astronomy and the Structure of the Interplanetary Medium

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Radioastronomical remote sensing measurements provide one of the few ways of diagnosing the coronal and solar wind plasma from the inner corona to the limit of in-situ measurements (0.28 a.u.). This talk concentrates on results from observations of extragalactic radio sources (radio galaxies and quasars) viewed through the corona and solar wind. Measurements have been made of the fluctuations in brightness of these sources (intensity scintillations), blurring due to plasma turbulence (angular broadening), and turbulence-induced fluctuations in the phase of an interferometer. Depending on the instrument used and the frequency of observation, the heliosphere can be probed from heliocentric distances of about 2 solar radii to greater than 0.5 a.u. Results of such observations have been determination of the flow speed of the solar wind for both fast and slow streams in regions of the heliosphere not accessible to direct measurement, the evolution of the intensity of the turbulence with heliocentric distance, limits on the speed with which the turbulence propagates with respect to the solar wind fluid, enhancements of turbulence in the vicinity of coronal mass ejections, the magnitude of plasma velocity fluctuations (and therefore magnetic field fluctuations) as a function of heliocentric distance, the magnitude of the large scale coronal magnetic field, and properties of irregularities in that field. In my opinion, the most important future contribution of this type of measurement will be to determine the level and spectral characteristics of magnetic field and velocity fluctuations in the inner heliosphere (within a heliocentric distance of 0.3 astronomical units) and the relationship of those fluctuations to the large scale solar wind stream structure.

SH51A MCC: 2008 Friday 0800h

Space Science Research With Societal Consequences II *(joint with SA, SM, AE)*

Presiding: **D F Webb,** Boston College; **V Pizzo,** NOAA

SH51A-01 0800h INVITED

The Solar MURI Project: Understanding Magnetic Eruptions on the Sun and their Interplanetary Consequences

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The MURI-funded project, “Understanding Magnetic Eruptions on the Sun and their Interplantary Consequences”, is a program of basic research into how the Sun’s magnetic field can evolve in such a way as to result in coronal mass ejections and eruptive solar flares. The project involves roughly 25 scientists at 9 Universities. Activities funded through our MURI effort include: bhasic theoretical research on eruption mechanisms, the development of numerical MHD models, data analysis, the incorporation of real vector magnetic field measurements into solar MHD models, and the development of new instrumentation to measure magnetic fields in the solar corona. I will describe these activities in more detail, and show how efforts such as this MURI can be used to conduct focused, basic research in Solar Physics in such a way that the research is made clearly relevant to societal needs.

URL: http://solarmuri.ssl.berkeley.edu

SH51A-02 0820h

Measuring Magnetic Helicity Transport in Solar Active Regions: a Practical Implementation

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The causes of solar eruptions are not well understood, but it is clear that the emergence of magnetic flux and the accumulation of twisted (helical) magnetic fields in the solar atmosphere are preconditions for eruption. It has been very difficult to study these indicators because the magnetic data were unreliable due to varying seeing’ conditions. However, SOHO produces reliable magnetograms every 95 minutes. Chae (Astrophys. J. 560, L95, 2001) showed how SOHO (Solar and Heliospheric Observatory) data can yield reliable estimates of magnetic flux and magnetic helicity accumulation in the solar atmosphere. Chae’s results suggest that regular time-series analyses of magnetograms could provide a useful early indicator of the build up of energy in the solar corona. Our objective has been to develop simple quantitative indicators of pre-eruption build-up and thereby warn of potential space weather related disturbances in space systems. We use the SOHO data, but in the near future the Solar B and SDO missions will provide much better magnetograms. So far, we have used Chae’s method to map helicity transport in several regions with solar flares. We will show how advective helicity transport influences flare rate. We will also compare our results with analyses of vector magnetograms, which show both advective and convective helicity transport.

SH51A-03 0835h

Calculation of a Minimum Total Magnetic Helicity in Solar Active Regions

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Despite its extreme importance, the calculation of the total magnetic helicity in solar active regions remains an unresolved problem in solar physics. On the other hand, the helicity variations in an active region can be calculated partially, for longitudinal magnetograms, or in full, for vector magnetograms, but only by using coarse, uncertain velocity field maps, calculated by means of correlation tracking techniques. Whether one should apply correlation tracking to magnetograms or white-light continuum images is also unclear, as the two inputs do not yield identical outputs. We present a technique that provides a lower limit of the total magnetic helicity in active regions, without using any velocity fields. The temporal variation of the total helicity can also be calculated in full if a series of vector magnetograms is available. The method relies on a comparison between the best linear force-free approximation and the potential approximation for a given photospheric boundary and begins by demonstrating that a commonly used formula for the magnetic helicity density in the linear force-free approximation is, in fact, erroneous. We have tested our method on vector magnetograms acquired by the Imaging Vector Magnetograph (IVM) of the University of Hawaii. We discuss the pros and cons of our approach and we compare our results for the magnetic helicity variations with results obtained when classical methods are employed.

SH51A-04 0850h

An observation-based, hybrid 3D-MHD solar wind modeling system, H3DM

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A major space weather challenge is to characterize and predict solar wind conditions, and in particular the evolution of the interplanetary magnetic field (IMF)