[2]New Jersey Inst. Technology, Physics Dept., NIJT, Newark, NJ 07102-1982, United States

[3]Naval Research laboraroty, 4555 Overlook Ave SW, Washington DC 20375, United States

[4]NASA Goddard Space Flight Center, Code 682.3 Bldg 26, Room G-1, Greenbelt, MD 20771, United States

The space-based SIRA (Solar Imaging Radio Array) will provide a powerful capability to track high energy particles from solar flare and CME sites through interplanetary/heliospheric space all the way to Earth. Together with two other overlapping planned radio interferometers, i.e., FASR (Frequency-Agile Solar Radiotelescope) and LOFAR (Low-Frequency Array) the entire plasma frequency range from 30 GHz all the way down to the plasma frequency cutoff of 30 kHz at 1 AU will be covered. These instruments will track the magnetic trajectory of high energy particles, beam-driven radio emission, and localize the acceleration sites in the corona or interplanetary shocks. We simulate some CME and type III events, as they will be mapped with these instruments, using realistic scattering functions of radio waves on coronal and heliospheric density inhomogeneities.

SH42C-0556 1330h POSTER

Type II Radio Bursts and Energetic Solar Eruptions

N Gopalswamy[1] (301-286-5885; gopals@fugee.gsfc.nasa.gov)

S Nunes[1,2] (snunes@antique.gsfc.nasa.gov)

S Yashiro[1,2] (yashiro@cdaw.gsfc.nasa.gov)

R A Howard[3] (howard@cronus.nrl.navy.mil)

Michael L Kaiser[1]

[1]NASA/GSFC, Building 21, Room 260, Code 695, Greenbelt, MD 20771, United States

[2]The Catholic University of America, 620 Michigan Ave. NE, Washington, DC 20064, United States

[3]Naval Research Laboratory, Solar Physics Division, Washington, DC 20375, United States

Type II radio bursts at decameter-hectometric (DH) and kilometric wavelengths are indicative of CME-driven shocks in the interplanetary medium. Only a subset of these type II bursts continue from the DH to the km regimes. We report on a study of these long-lasting type II bursts using data from the Wind/WAVES experiment in conjunction with white-light coronal mass ejection (CME) data from SOHO. We find the majority of these events (80 percent) are also associated with metric Type II bursts. We also studied the properties of the associated CMEs and found them to be the most energetic when compared to CMEs associated with bursts in any single wavelength regime.

SH42C-0557 1330h POSTER

The Potential for Characterizing the Heliosphere and Disturbances with LOFAR Faraday Rotation Observations

Joseph E. Salah[2] ((978) 692-4764; jsalah@haystack.mit.edu); Justin C. Kasper[1] (617 253 7611; jck@space.mit.edu); Divya Oberoi[2] (doberoi@haystack.mit.edu); Colin Lonsdale[2] (clonsdale@haystack.mit.edu); Alan J. Lazarus[1] (ajl@space.mit.edu); Michael K. Bird[3] (mbird@astro.uni-bonn.de)

[1]MIT Center for Space Research, Massachusetts Institute of Technology 77 Massachusetts Avenue, Cambridge, MA 02139, United States

[2]MIT Haystack Observatory, Route 40, Westford, MA 01886, United States

[3]University of Bonn, Radioastron Inst Auf dem Huegel 71, Bonn 53121, Germany

A linearly polarized radio wave propagating along a magnetic field line may be represented as a combination of two components with right and left-hand circular polarizations. In a magnetized plasma such as the heliosphere these two circular polarizations experience different indices of refraction, leading to a phase lag between the two components. This phase lag results in Faraday Rotation - an overall rotation of the angle of the original linearly polarized wave. The extent of Faraday Rotation is proportional to the component of the magnetic field along the direction of propagation, the electron number density, and the square of the wavelength of the radiation. Faraday Rotation may be used to probe the three-dimensional electron number density and magnetic field topology of both the background heliosphere and of transients such as coronal mass ejections (CMEs). It is particularly interesting to note that the rotation is proportional to the total electron number density, in contrast to the signals from Interplanetary Scintillation (IPS), which are only a function of density fluctuations. Prior work in this topic typically involves monitoring variation in the polarization of either extragalactic sources or of transmitted telemetry from spacecraft such as Helios. These observations have been successfully used to study turbulence and propagating transients in the inner heliosphere. We have begun a study of the potential for the Low Frequency Array (LOFAR) to characterize both the background heliosphere and transients. LOFAR is a possible aperture synthesis radio interferometer for the 10-240 MHz range consisting of hundreds of thousands of individual receivers. The array will operate as a fully digitally steered instrument, in which the signals from the antennae may be combined to simultaneously image multiple regions in the sky. Among the factors which make LOFAR appealing to Faraday Rotation studies are the large wavelengths of the observations, the high sensitivity of the instrument, and the ability to track multiple objects. We will present our initial work on simulations of the ability of LOFAR to observe both the background heliosphere and simple transient structures such as flux ropes. For the background heliosphere we will demonstrate how various models for extrapolating photospheric magnetic fields produce different signatures. In the case of transients we examine how clearly we can extract fundamental properties such as helicity and field strength. This work is sponsored by NSF grant ATM-0317957

SH42C-0558 1330h POSTER

Radio and hard X-ray signatures of flare accelerated electrons

Nicole R Vilmer (33-1-45077806; nicole.vilmer@obspm.fr)

LESIA- Observatoire de Paris, 5 Place Janssen, Meudon 92195, France

While imaging and spectral radio observations in the decimetric-dekametric domain provide signatures of non-thermal electrons in the middle and upper corona , hard X-rays as well as microwaves trace flare accelerated electrons in the low corona and the chromosphere. Radio observations combined with hard X-ray observations thus allow to analyse the signature of energetic electrons in a whole range of coronal heights. We shall present here the results of multiwavelength studies primarily based on the analysis of HXR and decimetric/metric spatially resolved observations from RHESSI and the Nançay Radioheliograph. We shall outline how these combined observations provide information on the magnetic structures at different spatial scales in which energetic electrons are accelerated and injected as well as on the link between the production of energetic electrons interacting at the Sun and the injection of escaping electrons giving rise to the radio emissions at the lowest frequencies.

SH42C-0559 1330h POSTER

Coronal Mass Ejections, Flares and Type II Radio Bursts

Ana M Rosas[1,2] (301-286-3045; arosas@cspsw1.gsfc.nasa.gov)

Nat Gopalswamy[2] (gopals@fugee.gsfc.nasa.gov)

Mike L. Kaiser[2] (Michael.Kaiser@nasa.gov)

Seiji Yahsiro[1,2] (yashiro@cdaw.gsfc.nasa.gov)

Steve Nunes[1,2] (snunes@antique.gsfc.nasa.gov)

[1]Catholic University of America, Physics Dept. 200 Hannan Hall, Washington, DC 20064, United States

[2]NASA/GSFC, Mail Code 695.0, Greenbelt, MD 20771, United States

An investigation of 210 interplanetary type II radio bursts and the associated white-light coronal mass ejections (CMEs) is presented. The radio bursts were detected by the Wind/WAVES experiment in the 1-14 MHz (decameter-hectometric, DH) range, while the CMEs were observed by the Solar and Heliospheric Observatory (SOHO). The study period, 1997-2002, encompasses the current solar cycle (23) between minimum and beyond maximum. We could only find 108 solar flares associated with DH type IIs. We obtained the difference onset times (solar flare - DH type II) and found that DH type IIs start at the same time as the flares. On the other hand the difference between CME and DH type II onset times is indicates that the type II bursts occur well after the CME onset. The present study suggests that the CMEs are more likely to be the source of the shocks responsible for the type II bursts. We extend the study to metric type II bursts and obtained similar results.

SH42D MCC: 2010 Thursday 1340h

Coronal Magnetic Fields: Models to Measurements III

Presiding: **T H Zurbuchen,** University of Michigan**; G Fisher,** University of California, Berkeley

SH42D-01 1340h INVITED

Diagnostics of the Solar Coronal Magnetic Field: 1878 - 2010

John Harvey (jharvey@nso.edu)

National Solar Observatory, P.O. Box 26732, Tucson, AZ 85726, United States

The solar corona is today a subject of intense scientific scrutiny as the birthplace of space weather and the location of the largest explosions in the solar system. The dynamics and structure of the lower solar corona are controlled by its magnetic field. Diagnosing the magnetic field is a difficult task of astrophysics that has been pursued for 125 years. This brief review will examine optical and radio methods used to study the inner coronal magnetic field. The National Solar Observatory is operated by AURA, Inc. under a cooperative agreement with the National Science Foundation.

SH42D-02 1400h

Measuring Coronal Magnetic Fields with Coronal Emission Line Polarimetry

Hao-Sheng Lin (808-876-7600-110; lin@ifa.hawaii.edu)

Institute for Astronomy University of Hawaii, 4761 Lower Kula Road P.O.Box 209, Kula, HI 96790, United States

Magnetic field is the dominating field in the solar corona, responsible for the majestic coronal structures and dynamic events. However, no direct measurements of the coronal magnetic fields are routinely available and we can only infer the coronal magnetic field structures from observed intensity images. Although several methods for the diagnostics of coronal magnetic fields have been demonstrated, measurement of the coronal magnetic fields remains a very challenging observational task. This paper reports on a concerted effort at the Institute for Astronomy (IfA) to establish routine vector coronal magnetic field measurement capabilities using spectropolarimetric observation of the near infrared Fe XIII 1074.7 nm coronal emission line. The IfA effort includes observations of two-dimensional circular polarization maps of the emission line which carry information about the coronal magnetic field strength. High resolution observation of the linear polarization maps which yield the projected direction of the coronal magnetic field in the plane of the sky will also be obtained. The latest results from these experiments will be presented.

SH42D-03 1415h INVITED

Multi-Channel Polarimeter for Coronal Magnetic Filed Measurements

Steven Tomczyk (303-497-1579; tomczyk@ucar.edu)

HAO/NCAR, 1850 Table Mesa Dr., Boulder, CO 80307, United States

We are currently building a filter-based polarimeter optimized for the measurement of magnetic fileds in the solar corona through observations of the coronal emission lines of Fe XIII at 1074.7 and 1079.8 nm. The instrument consists of a polarimeter allowing complete Stokes I,Q,U,V measurement followed by a Lyot birefringent filter with dual passbands of 0.14 nm width. Both the polarimeter and filter employ liquid crystals for rapid electro-optical tuning. This instrument will be deployed at the One Shot coronagraph at NSO Sac Peak. Measurement of the longitudinal Zeeman effect will yield information on the strength of the line-of-sight component of the magnetic field while the observation of resonance scattering will constrain the plane-of-sky field direction. Precise measurement of plasma velocity will also be possible. Such measurements are critical for addressing many outstanding problems in coronal physics. The operation and performance of the instrument will be described. We will also describe the methodology for the coronal magnetic field measurement. Preliminary measurements with the instrument at the One Shot coronagraph will be presented.

SH42D-04 1430h INVITED

Coronal Magnetic Diagnostics With FASR

Stephen M White[1] (301 405 1547; white@astro.umd.edu)

Dale E Gary[2] (dgary@njit.edu)

Jeongwoo Lee[2] (jlee@njit.edu)

Gerardo Giordano[2] (giordano@njit.edu)

[1]Department of Astronomy, University of Maryland, College Park, MD 20742

[2]Dept. of Physics, New Jersey Inst. of Technology 323 King Blvd, Newark, NJ 07102

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

roberto casini[1] (casini@ucar.edu)

Arturo Lopez Ariste[1] (alopez@ucar.edu)

steve tomczyk[1] (tomczyk@ucar.edu)

bruce lites[1] (lites@ucar.edu)

[1]HAO/NCAR, P.O. Box 3000, Boulder, CO 80307-3000, United States

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

Roberto Lionello[1] (Roberto.Lionello@saic.com)

Yung Mok[2] (ymok@uci.edu)

Jon A. Linker[1] (Jon.A.Linker@saic.com)

Zoran Mikić[1] (Zoran.Mikic@saic.com)

[1]Science Applications International Corporation, 10260 Campus Point Dr., San Diego, CA 92121-1578, United States

[2]University of California, Irvine, Department of Physics and Astronomy, 4129 Frederick Reines Hall, Irvine, CA 92697-4575, United States

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

Edward C. Sittler[1] (301-286-9215; edward.c.sittler@nasa.gov); Leon Ofman[2] (301-286-9913); Sarah Gibson[3]; Tom Holzer[3] (tom.holzer@ncar.edu); Joseph Davila[1]; Madhulika Guhathakurta[4] (202-358-1992)

[1]Goddard Space Flight Center, Greenbelt Road, Greenbelt, MD 20771, United States

[2]The Catholic University of America, 620 Michigan Avenue N.E., Washington, DC 20064, United States

[3]High Altitude Observatory/NCAR, P.O. Box 3000, Boulder, CO 80307-3000, United States

[4]NASA Headquarters, Code S 300 E Street SW, Washington, DC 20546-0001, United States

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

Jean-Louis Bougeret (33145077704; jean-louis.bougeret@obspm.fr)

LESIA-CNRS-Observatoire de Paris, 5, place Jules Janssen, Meudon 92195, France

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

Dale E. Gary[1] ((973) 642-7878; dgary@njit.edu)

Namir Kassim[2] (Namir.Kassim@nrl.navy.mil)

Nat Gopalswamy[3] (gopals@fugee.gsfc.nasa.gov)

Markus J. Aschwanden[4] (aschwanden@lmsal.com)

[1]Center for Solar-Terrestrial Research, NJIT, 323 M L King Blvd, Newark, NJ 07102-1982, United States

[2]Naval Research Laboratory, 4555 Overlook Avenue, SW, Washington, DC 20375-5351, United States

[3]Goddard Space Flight Center, Code 682.3/Bldg. 26, Rm. G-1, Greenbelt, MD 20771, United States

[4]Lockheed Martin, SAL - Dept. L9-41, Bldg. 252 3251 Hanover St., Palo Alto, CA 94304, United States

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

Edward W. Cliver (781-377-3975; edward.cliver@hanscom.af.mil)

AFRL/Space Vehicles Directorate, 29 Randolph Rd., Hanscom AFB, MA 01731-3010, United States

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

Robert P. Lin (510-642-1149; rlin@ssl.berkeley.edu)

Physics Dept and Space Sciences Laboratory, University of California, Berkeley., University of California, Space Sciences Laboratory, Berkeley, CA 94720-7450, United States

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