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)

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near Earth. This requires modeling the non-uniform, ambient solar wind and tracking the propagation of interplanetary shocks and coronal mass ejections through the heliosphere. The mapping the IMF lines connecting the traveling shock region to the Earth is also required for predictions of solar energetic particles (SEP) and predictions based upon SEPs. Our group is developing an observation-driven, hybrid, kinematic/3D-MHD solar wind modeling system (H3DM) in order to simulate realistic solar wind conditions, including the time-dependent IMF vector (including Bz) direction and magnitude at Earth. This system couples two mature solar wind codes: the Hakamada-Akasofu-Fry (HAF) model and the Interplanetary Global Model, Vectorized (IGMV). Scientifically, this effort seeks to improve the understanding of the role various drivers of interplanetary disturbances play throughout the solar cycle. Operationally, we are working toward providing a capability to predict, shortly after the launch of large-scale structures at the Sun, their evolution and propagation to Earth. We will describe the H3DM modeling system and provide a project status report.

SH51A-05 0905h INVITED

Cosmic Rays, Solar Energetic Particles, and Climate: Where are the Links?

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The correlation of Earth's climate with the 11 year solar sunspot cycle is difficult to explain with variations of the solar radiative output alone. Recently it has been argued that such climate variations may be due to a modulation of the galactic cosmic ray flux impinging on Earth or due to a modulation of the less energetic solar energetic particles. Such mechanisms are suggested by the surprisingly strong correlation between sunspot numbers and climatic parameters, such as cloudiness. Correlations are of course no proof of causality as long as the detailed mechanisms are not understood. Several mechanisms have been proposed, for example the modulation of the global electric circuit and the modulation of the generation of cloud condensation nuclei (CCNs). Such mechanisms require a sequence of processes to occur, from the modulation of the cosmic ray flux, through the air showers of the atmospheric interaction, the formation of ion pairs, the formation of CCNs, and to the formation of cloud droplets. We are far from understanding these processes, let alone how they interact with each other. In this talk we will outline the beginnings of a interdisciplinary research program that addresses these processes and some initial results.

SH51A-06 0925h

Ion Mediated Nucleation: how is it Influenced by Changes in the Solar Activity?

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Recently it has been pointed out that tropospheric cloudiness can be correlated with the galactic cosmic rays (GCRs) intensity [*Svensmark and Friis-Christensen*, 1997]. A possible explanation for such a correlation relies on the fact that GCRs are the main ionization source in the upper troposphere, hence, throughout ionic mediated nucleation, they could possibly influence the global cloud condensation nuclei (CCN) formation [*e.g.*, *Yu*, 2001; *Dickinson*, 1975]. Because the GCRs are modulated by the interaction between the solar wind and the Earth's magnetosphere and their intensity generally decreases with increasing solar activity, subtle changes in the solar activity could indirectly affect the Earth's climate. We have been studying the very first steps of ionic nucleation considering the molecular species of atmospheric interest (*e.g.*,water, nitric acid, sulfuric acid, ammonia *etc.*). In our approach the formation and evolution of ionic clusters is followed by resolving the time dependent kinetic aggregation process and considering the ions sources (ultimately the atmospheric ionization of neutral species) and sinks. We show how in typical atmospheric conditions stable populations of molecular ions forms. The novelty of our work consists in the determination of the kinetic parameters that govern the molecular ions growth (*i.e.*, the forward and reverse clustering reaction constants for each cluster type and size) at a microscopic level. In fact a thermochemistry data base is built for the species of interest by integrating laboratory measurements, quantum mechanical calculations and, when appropriate, results from the macroscopic liquid droplet model [*Thomson*, 1928]. Such database is than used to retrieve the reverse clustering reaction coefficients for the molecular ion type and size and for the environmental conditions (pressure and temperature) of interest. The forward reaction is instead determined by calculating the ionic-neutral collisional rate or is assumed from laboratory determinations. Here we discuss the methodology and some of the results from sensitivity tests in which the ionization rate is changed so to reflect natural variation of the GCRs as modulated by the Sun. References: Dickinson, R. E., Solar variability and the lower atmosphere, *Bull. Am. Meterol. Soc., 56*, 1240-1248, 1975. Svensmark, H., and E. Friis-Christensen, Variation of cosmic ray flux and global cloud coverage A missing link in solar-climate relationships, *J. Atmos. Sol. Terr. Phys., 59*, 1225-1232, 1997. Thomson, J. J and G. P. Thomson, Conduction of electricity through gases, *Cambridge University Press*, 1928. Yu, F., Altitude variations of cosmic ray induced production of aerosols: Implications for global cloudiness and climate, *J. Geophys. Res., 107*, 10.1029/2001JA000248, 2001.

SH51A-07 0940h

Simulated Radial and Azimuthal Structure of Proton Ring-Current Field

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We simulate the radial and azimuthal structure of the proton ring-current magnetic field by tracing the guiding centers of representative ions from the plasma sheet as they drift within a model magnetosphere. The ambient magnetic field model we use for this study is the Dungey model, which consists of a dipole field plus a uniform southward "tail" field. We map a spatially analytical expansion of the AMIE ionospheric electric potential, expressed as a function of magnetic latitude and magnetic local time, along magnetic field lines (for $L \geq 2$) throughout this model magnetosphere. We trace the bounce-averaged drift for ions conserving the first two adiabatic invariants μ and J (with values that correspond to energies of $\sim 10 - 300$ keV at $L = 3$). Using these simulation results, we map proton phase space densities according to Liouville's theorem but taking into account losses due to charge exchange. We specify an "initial" proton ring current distribution by solving the steady-state transport equation that balances quiescent radial diffusion against charge exchange. To obtain MLT-dependent and UT-dependent boundary values for our phase space density distribution, we map geosynchronous LANL ion data to the boundary of our model magnetosphere as boundary conditions. From the simulated phase-space density, we calculate the proton pressure and energy density distributions. From the pressure distributions, we compute the separate contributions of the magnetic field perturbation from the gradient-curvature drift currents, magnetization currents, and field-aligned currents needed to satisfy Ampere's law. We add these contributions together to obtain the total ring current magnetic field. We perform simulations for a few storm events including the 19 October 1998 storm. We find that during the 19 October 1998 storm the large AMIE electric field in the evening sector would have led to rapid (~ 20 minutes) inward transport of ions from the plasma sheet to the dusk meridian at $L \sim 3$. We can thus account for the observed rapid formation of the partial ring current there and its subsequent symmetrization to a wider range of MLT. In regions where the ring current is especially intense, the ring current magnetic field can be a significant fraction of the Earth's magnetic field. This suggests a need for eventually calculating the particle transport in a magnetically self-consistent model in the future.

SH51B MCC: 2008 Friday 1020h

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

Presiding: **V Papitashvili,** Space Physics Research Laboratory, University of Michigan**; J Foster,** Millstone Hill Observatory

SH51B-01 1020h

Space as Humanosphere: Role of space physics for human activities in the near-Earth Space

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We are entering a new era of utilization of space as Human territory (Humanosphere) for sustainable human society. From this point of view, a comprehensive academic study of the space environment could provide fundamental knowledge for developing space infrastructure such as huge power station (Solar Power Satellite :SPS). Such study should cover not only the solar terrestrial relations but also possible nonlinear effects of space plasma onto large space structures. Since we have reached a state of understanding the framework of solar-terrestrial relations, we need to proceed our research for more practical objectives, which are directly related to the human activity in space. In the preset paper, we review the state of art of our knowledge of the space as Humanosphere from a view point of space plasma physics. I will then discuss the trend and perspectives of the role of space plasma physics, especially space plasma simulations in the coming new era of space civilization (utilization and beyond). The International Space Station is one of the human space activities at the ionospheric altitude level in the very near future. However, beyond the ISS era, much higher space activities will follow towards higher space civilization based on a very large structure such as Solar Power Station (SPS). I will discuss first the need of large scale space development such as the SPS to avoid a possible catastrophe of human life on Earth by the end of this century. Then I will touch upon possible plasma physics problems emerging from such large scale space development. The huge structure and the high voltage power supply for the microwave power transmission from the SPS definitely electromagnetically interact with space plasmas. Also much higher level artificial ion injection from the electric propulsion engine to carry such large structure into the GEO will create a large modification of the natural magnetosphere. These issues will demand the contribution by space physicists and simulationists.

SH51B-02 1035h

The Three Modes of Magnetospheric Behavior Observed During Magnetic Storms

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Understanding geomagnetic storms is a paramount space weather problem as well as a fundamental scientific challenge. The processes that operate during magnetic storms have been areas of active investigation and significant discussion for many years. We believe that it is possible now to identify three distinct modes of magnetospheric operation during various geomagnetic storms. One mode consists of periods of enhanced steady magnetospheric convection (SMC)