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SOLAR PHYSICS DIVISION
New Mexico's distinctive insignia is the Zia Sun, which originated with the Indians of Zia Pueblo in ancient times. Its design reflects their tribal philosophy, with its wealth of pantheistic spiritualism teaching the basic harmony of all things in the universe.
2011
Meeting
June 12-16
Las Cruces, New Mexico, USA
astronomy.nmsu.edu/SPD2011
NM STATE UNIVERSITY
Photos of Las Cruces and the Organ Mountains courtesy of Mike Groves (mikegrovesphotography.com).

Schedule

Abstracts

Monday, June 13, 2011, 7:30 AM – Thursday, June 16, 2011, 8:30 AM

P15

Instrumentation and Techniques

Poster

Exhibit Hall 1 - Las Cruces Convention Center

P15.01

Solar Hard X-ray Observations with NuSTAR

David M. Smith[1], S. Krucker[2], H. S. Hudson[2], G. J. Hurford[2], S. M. White[3], R. A. Mewaldt[4], D. Stern[5], B. W. Grefenstette[4], F. A. Harrison[4]

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High-sensitivity imaging of coronal hard X-rays allows detection of freshly accelerated nonthermal electrons at the acceleration site. A few such observations have been made with Yohkoh and RHESSI, but a leap in sensitivity could help pin down the time, place, and manner of reconnection.

In 2012, the Nuclear Spectroscopic Telescope Array (NuSTAR), a NASA Small Explorer for high energy astrophysics that uses grazing-incidence optics to focus X-rays up to 80 keV, will be launched. NuSTAR is capable of solar pointing, and three weeks will be dedicated to solar observing during the baseline two-year mission. NuSTAR will be 200 times more sensitive than RHESSI in the hard X-ray band. This will allow the following new observations, among others:

1) Extrapolation of the micro/nanoflare distribution by two orders of magnitude down in flux;

2) Search for hard X-rays from network nanoflares (soft X-ray bright points) and evaluation of their role in coronal heating;

3) Discovery of hard X-ray bremsstrahlung from the electron beams driving type III radio bursts, and measurement of their electron spectrum;

4) Hard X-ray studies of polar soft X-ray jets and impulsive solar energetic particle events at the edge of coronal holes, and comparison of these events with observations of 3He and other particles in interplanetary space;

5) Study of coronal bremsstrahlung from particles accelerated by coronal mass ejections as they are first launched;

6) Study of particles at the coronal reconnection site when flare footpoints are occulted; and

7) Search for hypothetical axion particles created in the solar core via the hard X-ray signal from their conversion to X-rays in the coronal magnetic field.

NuSTAR will also serve as a pathfinder for a future dedicated space mission with enhanced capabilities, such as a satellite version of the FOXSI sounding rocket.

P15.02

New Capabilities of the EUNIS Sounding Rocket Instrument

Adrian N. Daw[1], J. Brosius[2], E. Criscuolo[3], J. Davila[1], J. P. Haas[1], G. Hilton[4], D. Linard[1], T. Plummer[1], D. Rabin[1], R. Thomas[5], D. Varney[6], T. Wang[2]

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7:30 AM Monday - 8:30 AM Thursday

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The upcoming flight of the Extreme Ultraviolet Normal Incidence Spectrograph (EUNIS) sounding rocket instrument, a two-channel imaging spectrograph that observes the solar corona and transition region with high spectral resolution and a rapid cadence made possible by unprecedented sensitivity, will incorporate a new wavelength channel and cooling of the active pixel sensor (APS) arrays. The new 52.4-63.0 nm channel incorporates a Toroidal Varied Line Space (TVLS) grating coated with B_4C/Ir, providing broad spectral coverage and a wide temperature range of 0.025 to 10 MK. The APS arrays for both the 52-63 nm and 30-37 nm channels will be cooled to -20 C to reduce dark current noise. With the resulting read-noise limited performance, over a dozen new diagnostic line pairs become available in the two wavelength channels. To our knowledge, this will be the first flight demonstration of cooled APS arrays. EUNIS will co-observe dynamic coronal phenomena with SDO/AIA and Hinode/EIS and will contribute to the absolute radiometric calibrations of these instruments.
EUNIS is supported by NASA through the Low Cost Access to Space Program in Solar and Heliospheric Physics.

P15.03

Solar Orbiter Core Science With the SPICE Spectral Imager

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SPICE is a novel spectral imager designed for deployment on Solar Orbiter, and directly addresses the core science using high level science data products including Dopplergrams, "FIPograms" and "QMograms" to correlate solar wind source regions at the surface of the Sun with in situ measurements made simultaneously on board Solar Orbiter.
SPICE data are critical to the key motivating questions for the Solar Orbiter mission, and the data products and observing plans draw heavily from lessons learned in the SOHO mission to yield accessible data products that can be compared easily with other types of solar data. We describe key questions that Solar Orbiter will address, and how SPICE data products enable answering them.

P15.04

Accounting for the Albedo Flux in RHESSI Image Reconstructions

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7:30 AM Monday - 8:30 AM Thursday

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Solar flare hard x-ray emission over the disk of the Sun must be accompanied by a high percentage of back-scattered x-rays from the photosphere. This albedo flux is an inevitable result of the high ratio of Compton scattering to photoelectric absorption. While we know that a substantial fraction of the emission should be albedo we have been unable to separate this flux in images made with RHESSI because the albedo may be more diffuse or very closely aligned with the direct flux.
In this study we will take a fresh approach where we include the contribution of the albedo flux for a point source where we have assumed the height of the source above the photosphere as well as its up/down directivity. For this we use a Green’s function approach to modify the expected count rates of the point source or alternatively determine the true visibilities from the measured x-ray visibilities. We will examine how this affects images obtained for two solar flares, one on 20 Feb. 2002 at 11:06 UT and the other on 20 Aug. 2002 at 8:24 UT. Both flares are observed in energies above 100 keV with footpoints above the visible solar disk. We will make images assuming several different combinations of the height and directivity to see how the spectrum and image have changed.

This activity has been supported by NASA and the European Community FrameworkProgramme 7, 'High Energy Solar Physics Data in Europe (HESPE).'

P15.05

Imaging and Aspect Systems Development for the Gamma-Ray Imager/Polarimeter for Solar Flares (GRIPS) Instrument.

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7:30 AM Monday - 8:30 AM Thursday

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The Solar System's most powerful explosions occur as solar flares capable of releasing ~10^{33} ergs of power and accelerating particles to 10s of GeV. Moving particles emit spectra which encode key information about acceleration processes and ambient plasma parameters, providing a powerful tool to study particle dynamics. Currently, the most detailed solar imaging and spectroscopy comes from the Reuven Ramaty High-Energy Solar Spectroscopic Imager (RHESSI) satellite. For the two best-observed flares, RHESSI found the location of ion emission sources were significantly displaced from electron sources in the flare footpoints. This result is surprising; the standard flare model predicts that ions and electrons are accelerated along the same field lines, implying that they would enter the chromosphere together and have similar emission source locations. Current acceleration models cannot account for the separate ion and electron footpoints. To explain this discrepancy and enhance understanding of particle acceleration and energy release in flares, enhanced spectroscopy and imaging of the gamma/HXR spectrum over wide ranges of energy and resolutions is required; the Gamma-Ray Imager/Polarimeter for Solar Flares (GRIPS) instrument is designed to address this need. GRIPS is optimized to provide high-resolution imaging, spectroscopy and polarimetry of gamma/HXR flare emissions from ~20 keV to >~10MeV. GRIPS' novel three dimensional germanium detector (3D-GeD) enables the use of a single grid imaging system, the multi-pitch rotating modulator (MPRM), that creates a nearly ideal point response function with quasi-continuous resolution from 12.5-162 arcsecs and a two-fold increased sensitivity over a bi-grid design like RHESSI. We present the design, capabilities, and recent progress on the GRIPS imaging and aspect systems.

P15.06

Lyman Alpha Spicule Observatory (LASO)

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The Lyman Alpha Spicule Observatory (LASO) sounding rocket will observe small-scale eruptive events called "Rapid Blue-shifted Events" (RBEs), the on-disk equivalent of Type-II spicules, and extend observations that explore their role in the solar coronal heating problem. LASO utilizes a new and novel optical design to simultaneously observe two spatial dimensions at 4.2" spatial resolution (2.1" pixels) over a 2'x2' field of view with high spectral resolution of 66mÅ (33mÅ pixels) across a broad 20Å spectral window. This spectral window contains three strong chromospheric and transition region emissions and is centered on the strong Hydrogen Lyman-α emission at 1216Å. This instrument makes it possible to obtain new data crucial to the physical understanding of these phenomena and their role in the overall energy and momentum balance from the upper chromosphere to lower corona. LASO was submitted March 2011 in response to the ROSES SHP-LCAS call.

P15.07

ROSA: A High-cadence, Synchronized Multi-camera Solar Imaging System

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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Rapid Oscillations in the Solar Atmosphere (ROSA) instrument is a synchronized, six-camera high-cadence solar imaging instrument developed by Queen's University Belfast and recently commissioned at the Dunn Solar Telescope at the National Solar Observatory in Sunspot, New Mexico, USA, as a common-user instrument. Consisting of six 1k x 1k Peltier-cooled frame-transfer CCD cameras with very low noise (0.02 - 15 e/pixel/s), each ROSA camera is capable of full-chip readout speeds in excess of 30 Hz, and up to 200 Hz when the CCD is windowed. ROSA will allow for multi-wavelength studies of the solar atmosphere at a high temporal resolution. We will present the current instrument set-up and parameters, observing modes, and future plans, including a new high QE camera allowing 15 Hz for Halpha. Interested parties should see
https://habu.pst.qub.ac.uk/groups/arcresearch/wiki/de502/ROSA.html

P15.08
Deconvolution of Spatial and Spectral Information in Slitless Spectrometer Images
Shaela I. Jones[1], J. M. Davila[1]
[1]NASA GSFC.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Observation of coronal emission has greatly enhanced our understanding of the solar corona. However, to date solar scientists have been forced to choose between the large fields of view offered by imaging telescopes and the detailed spectral information offered by imaging spectrometers. In order to measure spectral characteristics over large portions of the corona, imaging spectrometers must raster over the area, a time-consuming process that lowers the effective time cadence of the resulting observations and causes confusion between spatial and temporal variation. Slitless spectrometers, which produce images with convolved spatial and spectral information from a relatively large field of view, offer the opportunity to study the emission line profiles of large regions of the corona without rastering, if the spatial and spectral information can be reliably deconvolved. Here we present a study of the potential capabilities of such an instrument, including examples showing deconvolution of artificial slitless spectrometer images based on Hinode EIS spectral measurements. We compare the expected accuracy of intensities, linewidths, and doppler shifts measured using our deconvolution technique to those derived from fitting of EIS spectral data.

P15.09
Solar Limb AO:
Seeing the Hidden Detail in Solar Prominences
Gregory Taylor[1], T. Rimmele[2], J. Marino[2], J. McAteer[1]
[1]NMSU Department of Astronomy, [2]National Solar Observatory.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
In order to understand Solar Prominences, we need to observe them at sub-arcsecond resolution, with a sub-second cadence. Present image reconstruction techniques, such as Speckle Interferometry, are capable of delivering high resolution images, but at a slow cadence. We propose the design for a Solar Limb Adaptive Optics system that would allow images to be captured at sub-second cadence with sub-arcsecond resolution. The challenge, with Solar Limb AO, is the use of faint Hα prominence structure near the limb, to derive wavefront mea-

surements at hight speed. Regular, on-disk Solar Adaptive Optics have su[[Unsupported Character - ﬃ]]cient photon [[Unsupported Character - ﬂ]]ux
available, for the subaperture based wavefront sensor. In contrast, a Shack Hartmann wavefront sensor, which uses faint Hα prominence structure as its reference, is photon starved. Full aperture sensor concepts, such as Phase Diversity, may have to be considered. It is hoped that such a system, if successful, would be implemented on the upcoming Advanced Technology Solar Telescope.

P15.10

Evaluation of Diffraction by a Rounded Surface

Douglas M. Rabin[1]

[1]NASA Goddard Space Flight Center.

7:30 AM Monday - 8:30 AM Thursday

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Wide-angle heliospheric imagers such as those carried on the SMEI and STEREO spacecraft require highly effective baffle systems to exclude diffracted light from the solar disk as well as other sources of stray light. Buffington (2000, Appl. Opt. 39, 2683-2686) has proposed replacing multi-vane baffle systems with a curved surface that can be thought of as the limiting case of closely spaced vanes. Buffington’s experimental data showed that the diffractive performance of a continuous baffle is consistent with the limiting form expected from multi-vane diffraction on dimensional grounds, but a detailed prediction was not possible because multi-vane diffraction calculations assume that the diffractive edges act independently, an assumption that breaks down for a continuous surface. I describe analytic calculations of diffraction from a smooth rounded surface based on the approach of Vogler (1985, Radio Sci. 20, 582-590).

P15.11

The Focusing Optics X-ray Solar Imager

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The Focusing Optics X-ray Solar Imager (FOXSI) is a NASA Low Cost Access to Space sounding rocket payload that will launch in late 2011. A larger sensitivity and dynamic range than currently available are needed in order to image faint X-rays from electron beams in the tenuous corona, particularly those near any coronal acceleration region and those that escape into interplanetary space. FOXSI combines fast-replication, nested, grazing-incidence optics with double-sided silicon strip detectors to achieve a dynamic range of >100 and a sensitivity 100 times that of RHESSI. Advances in the fabrication and assembly of the optics at the NASA Marshall Space Flight Center provide a spatial resolution of 8 arcseconds, while the silicon detectors, developed by the Astro-H team at ISAS/JAXA, offer an energy resolution of 0.5 keV. FOXSI's first flight will be used to conduct a search for X-ray emission from nonthermal electron beams in quiet Sun nanoflares. In addition, FOXSI will serve as a pathfinder for future space-based solar hard X-ray spectroscopic imagers, which will be able to image nonthermal electrons in flare acceleration sites and provide quantitative measurements such as energy spectra, densities, and energy content in accelerated electrons.

P15.12

The Interface Region Imaging Spectrograph (IRIS) NASA SMEX

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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The solar chromosphere and transition region (TR) is highly structured, dynamic, and intimately connected to the corona. It requires more than ten times the energy required to heat the corona, and yet it has received far less interest because of the complexity of the required observational and analytical tools. In the TR the density drops by six orders of magnitude and the temperature increases by three orders of magnitude. Hinode observations reveal the importance the magnetic field has on this region of the solar atmosphere that acts as the interface between the photosphere and the corona. The Interface Region Imaging Spectrograph (IRIS) was selected for a NASA SMEX mission in 2009 and is scheduled to launch in December 2012. IRIS addresses critical questions in order to understand the flow of energy and mass through the chromosphere and TR, namely: (1) Which types of non-thermal energy dominate in the chromosphere and beyond? (2) How does the chromosphere regulate mass and energy supply to the corona and heliosphere? (3) How do magnetic flux and matter rise through the lower atmosphere, and what roles dos flux emergence play in flares and mass ejections? These questions are addressed with a high-resolution imaging spectrometer that observes Near- and Far-VU emissions that are formed at temperatures between 5,000K and 1.5 x 10^6 K. IRIS has a field-of-view of 120 arcsec, a spatial resolution of 0.4 arcsec, and velocity resolution of 0.5 km/s. Members of the IRIS investigation team are developing advanced radiative MHD codes to facilitate comparison with and interpretation of observations. We present the status of the IRIS observatory development, which completed its Critical Design Review in December 2010.

P15.13
STEREO COR1-A/B Intercalibration at 180 Degrees Seperation
William T. Thompson[1]
[1]*NASA/GSFC.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The two STEREO spacecraft achieved 180 degree separation on 6 February 2011. This allows the first-ever view of the entire Sun. Another advantage of being at 180 degree separation is that it serves as a unique opportunity to check the cross-calibration of the STEREO telescopes. At 180 degrees, both spacecraft see the same corona from opposite sides. Where the corona is optically thin, the images from the two spacecraft should appear as mirror images of each other. We analyze the COR1 data from the time of opposition, and show that the COR1-A and COR1-B images agree with each other to a high degree of accuracy, thus validating both the radiometric intercalibration, and the background subtraction methodology. We also show from stellar observations that the COR1 radiometric calibrations have not changed since launch.

P15.14
An Advanced EUV Multi-Order Spectral Imager For The Solar Atmosphere
Charles Kankelborg[1], C. Chen[1], P. Lokken[1]
[1]*Montana State Univ..*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We describe an EUV imager capable of measuring spectral line profiles at high spatial resolution over a wide field of view in a single snapshot. The instrument follows in the footsteps of the Multi-Order Solar EUV Specrtrograph (MOSES) sounding rocket instrument, and could fly simultaneously within the same

experiment section. The design provides higher moments of the spectral line profile and higher sensitivity that MOSES, but with a more compact optical configuration.

P15.15

Reduction of SOLIS/VSM Intensity, Line Depth, and Equivalent Width Images

Harrison P. Jones[1]

[1]*National Solar Observatory.*

7:30 AM Monday - 8:30 AM Thursday

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Most user interest in the SOLIS Vector Spectromagnetograph (VSM) centers on full-disk vector and longitudinal magnetograms which are used for many purposes including flare prediction, field extrapolation, and studies of the solar cycle. However, pseudo-continuum intensity, line-depth, and equivalent-width images, which are perfectly registered both in time and space with their corresponding magnetograms, are carried with the standard SOLIS data analysis to Level 1 (flat-fielding and sorting of individual scan lines into "raw" images). These quantities potentially provide important thermodynamic information which improve feature identification and inform models of photospheric and chromospheric structures, but the raw images contain many defects which prevent their direct use. Least-squares spline and polynomial algorithms are presented for compputing contrast images which are free of both these defects and center-to-limb variation.

P15.16

Virtual Solar Observatory: Web Interface Updates

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7:30 AM Monday - 8:30 AM Thursday

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The Virtual Solar Observatory (VSO) enables scientists to query and download a wide range of solar data sets using a web interface, IDL or programmatically via an API. Because of the complex nature of the queries that are possible using the VSO, we have had to re-work the web client to enable complex searches without creating an overly cluttered or complex interface. The new interface is modular to allow us to more easily add new search parameters while allowing users to set defaults for their preferred search and download settings, minimizing the amount of complexity exposed. We describe the advantages of the new search interface, including the ability to bookmark searches, a streamlined query process, customized search interfaces for instruments with special needs, and improved performance.

P15.17

The Helioviewer Project: Solar Data Visualization and Exploration

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SDO has only been operating a little over a year, but in that short time it has already transmitted hundreds of terabytes of data, making it impossible for data providers to maintain a complete archive of data online. By storing an extremely efficiently compressed subset of the data, however, the Helioviewer project has been able to maintain a continuous record of high-quality SDO images starting from soon after the commissioning phase. The Helioviewer project was not designed to deal with SDO alone, however, and continues to add support for new types of data, the most recent of which are STEREO EUVI and COR1/COR2 images. In addition to adding support for new types of data, improvements have been made to both the server-side and client-side products that are part of the project. A new open-source JPEG2000 (JPIP) streaming server has been developed offering a vastly more flexible and reliable backend for the Java/OpenGL application JHelioviewer. Meanwhile the web front-end, Helioviewer.org, has also made great strides both in improving reliability, and also in adding new features such as the ability to create and share movies on YouTube. Helioviewer users are creating nearly two thousand movies a day from the over six million images that are available to them, and that number continues to grow each day. We provide an overview of recent progress with the various Helioviewer Project components and discuss plans for future development.

P15.18

Earth-Affecting Solar Causes Observatory (EASCO): Results of the Mission Concept Study

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7:30 AM Monday - 8:30 AM Thursday

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Coronal mass ejections (CMEs) corotating interaction regions (CIRs) are two large-scale structures that originate from the Sun and affect the heliosphere in general and Earth in particular. While CIRs are generally detected by in-situ plasma signatures, CMEs are remote-sensed when they are still close to the Sun. The current understanding of CMEs primarily come from the SOHO and STEREO missions. In spite of the enormous progress made, there are some serious deficiencies in these missions. For example, these missions did not carry all the necessary instruments (STEREO did not have a magnetograph; SOHO did not have in-situ magnetometer). From the Sun-Earth line, SOHO was not well-suited for observing Earth-directed CMEs because of the occulting disk. STEREO’s angle with the Sun-Earth line is changing constantly, so only a limited number of Earth-directed CMEs were observed in profile. In order to overcome these difficulties, we proposed a news L5 mission concept known as the Earth-Affecting Solar Causes Observatory (EASCO). The mission concept was recently studied at the Mission Design Laboratory (MDL), NASA Goddard Space Flight Center. The aim of the MDL study was to see how the scientific payload consisting of ten instruments can be accommodated in the spacecraft bus, what propulsion system can transfer the payload to the Sun-Earth L5, and what launch vehicles are appropriate. The study found that all the ten instruments can be readily accommodated and can be launched using an intermediate size vehicle such as Taurus II with enhanced faring. The study also found that a hybrid propulsion system consisting of an ion thruster (using ~55 kg of Xenon) and hydrazine (~10 kg) is adequate to place the payload at L5. The transfer will take about 2 years and the science mission will last for 4 years around the next solar maximum in 2025.

P15.19

The Coronal Suprathermal Particle Explorer (C-SPEX)

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The primary science objective of the Coronal Suprathermal Particle Explorer (C-SPEX) is to investigate the spatial and temporal variations of coronal suprathermal particle populations that are seeds for

acceleration to solar energetic particles (SEPs). It is understood that such seed particle populations vary with coronal structures and can change responding to solar flare and coronal mass ejection (CME) events. Models have shown that higher densities of suprathermal protons can result in higher rates of acceleration to high energies. Understanding the variations in the suprathermal seed particle population is thus crucial for understanding the variations in SEPs. However, direct measurements are still lacking. C-SPEX will measure the variation in the suprathermal protons across various coronal magnetic structures, before/after the passage of CME shocks, in the post-CME current sheets, and before/after major solar flares. The measurements will not only constrain models of SEP acceleration but also constrain models of the production of suprathermal particles from processes such as magnetic reconnection at the Sun. Understanding the causes for variation in the suprathermal seed particle population and its effect on the variation in SEPs will also help build the predictive capability of SEPs that reach Earth.
The C-SPEX measurements will be obtained from instrumentation on the International Space Station (ISS) employing well-established UV coronal spectroscopy techniques. The unique aspect of C-SPEX is a >100-fold increase of light gathering power over any previous UV coronal spectrometer. It is demonstrated C-SPEX will thus overcome the limitations in signal to noise that have thwarted prior attempts to observe suprathermals in the corona.
The present lack of a means to predict the variability of SEP intensities and the likelihood C-SPEX will help develop such predictions makes the proposed investigation directly relevant to each of the three strategic objectives of the NASA Heliophysics Research Strategic Objectives.

P15.20

Slitless Solar Spectroscopy

Joseph M. Davila[1]
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7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

Spectrographs have traditionally suffered from the inability to obtain line intensities, widths, and Doppler shifts over large spatial regions of the Sun quickly because of the narrow instantaneous field of view. This has limited the spectroscopic analysis of rapidly varying solar features like, flares, CME eruptions, coronal jets, and reconnection regions. Imagers have provided high time resolution images of the full Sun with limited spectral resolution.
In this paper we present recent advances in deconvolving spectrally dispersed images obtained through broad slits. We use this new theoretical formulation to examine the effectiveness of various potential observing scenarios, spatial and spectral resolutions, signal to noise ratio, and other instrument characteristics.
This information will lay the foundation for a new generation of spectral imagers optimized for slitless spectral operation, while retaining the ability to obtain spectral information in transient solar events.

P16
Solar Interior
Poster
Exhibit Hall 1 - Las Cruces Convention Center

P16.01

Subsurface Vorticity of Emerging Active Regions

Rudolph Komm[1], R. Howe[2], F. Hill[1]
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7:30 AM Monday - 8:30 AM Thursday

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We study the temporal variation of subsurface flows associated with emerging active regions. We have analyzed the flows of nearly 1000 active and quiet regions analyzing GONG high-resolution Doppler data with ring-diagram analysis. We determine the change in unsigned magnetic flux during the disk passage of each active region using MDI magnetograms binned to the ring-diagram grid. In a previous study, we have found that emerging flux has a faster rotation than the ambient fluid and pushes it up, as indicated by enhanced vertical velocity and faster-than-average zonal flow. In this study, we are focusing on the vorticity of subsurface flows associated with newly emerging active regions. We will present the latest results.

P16.02

Helioseismic Inversions For Magnetic Field And Sound-speed Perturbations

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7:30 AM Monday - 8:30 AM Thursday

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In local helioseismology, inversion methods that can separate magnetic and thermal perturbations are needed, especially for probing the subsurface structure of sunspots. We present a method for performing linear helioseismic inversions that can infer small-amplitude perturbations to both the magnetic field strength and the sound-speed profile in translation-invariant background models permeated by a 3 kG vertical magnetic field, consistent with expectations for sunspot umbrae. We introduce a novel inversion routine that consists of two parts: first; a traditional regularized least squares inversion is utilized to search regularization-parameter space for inversion coefficients and second; an analysis of these inversion coefficients identifies the sets of coefficients that have the required attributes for a pair of inferred sound-speed and magnetic fields models. We show a case study in which this inversion method is able to accurately recover a sound-speed perturbation and a perturbation in the magnetic field strength simultaneously. We will discuss how these results relate to the local helioseismology of sunspots. This work is supported by NASA contracts NNH09CE41C and NNG07EI51C.

P16.03

Towards Reliable Physics-based Helioseismic Inversions of Sunspot Structure

Douglas Braun[1], A. Birch[1], A. Crouch[1], C. Clack[1], D. Dombroski[1], M. Rempel[2], T. Duvall, Jr.[3]

[1]NorthWest Research Associates, Inc., [2]NCAR/HAO, [3]NASA/GSFC.

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Inversion methods capable of reliably probing the subsurface structure beneath regions of strong magnetic fields, such as sunspots, remain elusive. We will review progress of a SDO Science Center project, funded to (among other goals) develop and evaluate new methods for this problem. Progress to date has included extensive production of magneto-convective sunspot models for the testing and validation of existing methods, for which a 27 hour run of artificial photospheric Dopplergrams is available online to the community. We will also summarize progress on the use of magnetostatic models for the development and testing of novel inversion methods designed to distinguish between magnetic field and thermal perturbations.

This work is supported by NASA contracts NNH09CE41C and NNG07EI51C.

P16.04

Local Helioseismology of Small-Scale Magnetic Elements

Ashley D. Crouch[1], D. C. Braun[1], T. Felipe[1], A. C. Birch[1], T. L. Duvall[2]
[1]*NorthWest Research Associates,* [2]*NASA/GSFC.*
7:30 AM Monday - 8:30 AM Thursday
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We will discuss recent progress in the measurement and modeling of the interaction of helioseismic waves with small-scale magnetic elements. We will present measurements of the Hankel analysis phase shifts and absorption coefficients associated with an average small-scale magnetic element, measured using ensemble-averaging techniques. We will show results from theoretical calculations and the numerical simulations of wave interactions with thin magnetic flux tubes. We will compare the Hankel analysis measurements with the predictions from these theoretical models, and discuss how these results pertain to the local helioseismology of magnetic flux concentrations. This work is supported by NASA contract NNH09CE43C.

P16.05
Extending Global Helioseismic Measurements From MDI to HMI
Jesper Schou[1], T. P. Larson[1]
[1]*Stanford Univ..*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
With the end of regular observations using MDI the question arises if we can provide good continuity between MDI and HMI. In particular MDI has shown intriguing differences in the torsional oscillation between the two most recent 11-year solar cycles. In this poster we will discuss some of the instrumental differences as well as examine the differences in global mode parameters and inferred quantities between the two during the period of overlap of MDI and HMI observations. This work is supported by NASA contract NAS5-02139 to Stanford University.

P16.06
A Comparison Of Solar High-degree p-mode Parameters From HMI And MDI
M. Cristina Rabello-Soares[1], R. Bogart[1], S. Korzennik[2], T. Larson[1], J. Reiter[3], E. Rhodes[4], J. Schou[1]
[1]*Stanford University,* [2]*Harvard-Smithsonian, CfA,* [3]*Zentrum Mathematik, Technische Universitat Munchen, Germany,* [4]*Univ. of Southern California.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Solar acoustic modes have been successfully used to make inferences about the solar interior. The comparison of independent contemporaneous data sets is important to test the reliability of our inferences. Here we compare helioseismic data from the Michelson Doppler Imager (MDI) on board SOHO with Helioseismic and Magnetic Imager (HMI) on board SDO using spherical harmonic decomposition and ring-diagram analysis. We will focus on the analysis of high-degree modes. They propagate through the outer layers of the Sun giving valuable information about this region. This interesting region is the seat of the near-surface shear layer, where the excitation and damping mechanisms are believed to be concentrated and where the effects of the equation of state are felt most strongly.

P16.07
Local Helioseismology of Magnetoconvective Sunspot Simulations and the Reliability of Standard Inversion Methods
Douglas Braun[1], A. Birch[1], M. Rempel[2], T. Duvall, J.[3]
[1]*NorthWest Research Associates, Inc.,* [2]*NCAR/HAO,* [3]*NASA/GSFC.*
7:30 AM Monday - 8:30 AM Thursday

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Controversy exists in the interpretation and modeling of helioseismic signals in and around magnetic regions like sunspots. We show the results of applying local helioseismic inversions to travel-time shift measurements from realistic magnetoconvective sunspot simulations. We compare travel-time maps made from several simulations, using different measurements (helioseismic holography and center-annulus time distance helioseismology), and made on real sunspots observed with the HMI instrument onboard the Solar Dynamics Observatory. We find remarkable similarities in the travel-time perturbations measured between: 1) simulations extending both 8 and 16 Mm deep, 2) the methodology (holography or time-distance) applied, and 3) the simulated and real sunspots. The application of RLS inversions, using Born approximation kernels, to narrow frequency-band travel-time shifts from the simulations demonstrates that standard methods fail to reliably reproduce the true wave speed structure. These findings emphasize the need for new methods for inferring the subsurface structure of active regions. Artificial Dopplergrams from our simulations are available to the community at www.hao.ucar.edu under "Data" and "Sunspot Models." This work is supported by NASA under the SDO Science Center project (contract NNH09CE41C).

P16.08

Comparison of Ring Diagram Fitting Techniques

Charles Baldner[1], S. Basu[1], R. Bogart[2], D. Haber[3], F. Hill[4], R. Howe[5], C. Rabello-Soares[2]
[1]Yale University, [2]Stanford University, [3]JILA, University of Colorado, [4]National Solar Observatory, [5]University of Birmingham, United Kingdom.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Ring diagrams are used to study the structure and dynamics of the near-surface layers of the Sun. The parameters of primary interest are frequencies and velocities in both the zonal and merridional direction as a function of wavenumber and of radial order n. These parameters are recovered by fitting a model of the spectral profile to three-dimensional power spectra of small regions of the Sun. In this work, we examine the systematic differences between fits assuming an asymmetric profile and fits assuming a symmetric profile. We also explore the coupling between the parameters of interest and certain secondary parameters such as amplitude, width, and asymmetry.

P16.09

Medium-l Global Helioseismology with MWO Dopplergrams

Timothy P. Larson[1], J. Schou[1], E. J. Rhodes[2], A. Spinella[2], S. Irish[2]
[1]Stanford University, [2]University of Southern California.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The 60-foot solar tower at Mount Wilson Observatory took high resolution dopplergrams at a cadence of one minute between the summers of 1988 and 2006. Because this instrument overlaps with GONG and MDI, it provides a unique opportunity to extend the inferences of those two projects backwards in time to solar cycle 22. Furthermore, access to the MWO data has been facilitated by its ingestion at the Joint Science Operations Center (JSOC) at Stanford. For this initial study we choose for our analysis a single summer in which MDI was also operating. By running the MWO data through the same processing pipeline and comparing with the results from MDI, we are able to determine how accurately the two datasets can be combined. In future we will be able to use the MWO data to compare the torsional oscillation during solar cycles 22 and 23.

P16.10

Large-scale Zonal Flows During the Solar Minimum -- Where Is Cycle 25?

Frank Hill[1], R. Howe[2], R. Komm[1], J. Christensen-Dalsgaard[3], T. P. Larson[4], J. Schou[4], M. J. Thompson[5]
[1]National Solar Obs., [2]University of Birmingham, United Kingdom, [3]Aarhus University, Denmark, [4]Stanford University, [5]High Altitude Observatory.
7:30 AM Monday - 8:30 AM Thursday
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The so-called torsional oscillation is a pattern of migrating zonal flow bands that move from mid-latitudes towards the equator and poles as the magnetic cycle progresses. Helioseismology allows us to probe these flows below the solar surface. The prolonged solar minimum following Cycle 23 was accompanied by a delay of 1.5 to 2 years in the migration of bands of faster rotation towards the equator. During the rising phase of Cycle 24, while the lower-level bands match those seen in the rising phase of Cycle 23, the rotation rate at middle and higher latitudes remains slower than it was at the corresponding phase in earlier cycles, perhaps reflecting the weakness of the polar fields. In addition, there is no evidence of the poleward flow associated with Cycle 25. We will present the latest results based on nearly sixteen years of global helioseismic observations from GONG and MDI, with recent results from HMI, and discuss the implications for the development of Cycle 25.

P16.11
Helioseismic Measurements Of Meridional Flows In Artificial Data From 3d Numerical Simulations Of Wave Propagation In The Whole Sun
Thomas Hartlep[1], M. Roth[2], H. Doerr[2], J. Zhao[1], A. G. Kosovichev[1]
[1]Stanford University, [2]Kiepenheuer-Institut fuer Sonnenphysik, Germany.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Measuring the structure of the deep solar interior is of considerable interest for understanding how the solar dynamo functions. In particular, the structure of the meridional flow and the depth of its return flow are of significant interest. Detecting such small flows in the deep interior is a challenging problem. Numerical simulations can provide means for testing and calibrating measurement techniques and help increase our confidence in the inferences obtained from observations. We present results from analyzing artificial helioseismology data obtained from numerical simulations of helioseismic wave propagation in the whole 3D solar interior with models of the meridional circulation present in the background state. Two methods - a time-distance helioseismology technique and a Fourier-Legendre decomposition technique - are used in this paper to try to detect and measure this flow from the oscillations at the solar surface.

P16.12
Subsurface Flows Near New Solar Cycle Erupting Filaments
Deborah A. Haber[1], R. S. Bogart[2], N. Featherstone[3]
[1]JILA / University of Colorado Boulder, [2]CSSA-HEPL Stanford University, [3]High Altitude Observatory.
7:30 AM Monday - 8:30 AM Thursday
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In early August 2010, HMI observed two long solar filaments of the new solar cycle that each erupted, yielding large CMEs, within a day of each other. One explanation for the cause of a CME is that the magnetic field of a filament becomes unstable due to twisting of the field by the turbulent convective flows near its footpoints. A CME results when the relatively cool filament gas supported by the field is expelled, along with significant amounts of energy, due to a reconnection event caused by the magnetic instability. It is thus of interest, for theories of coronal mass ejections from otherwise quiescent filaments, to know what the horizontal subsurface flows near the footpoints of the magnetic field are doing. In the work presented here, we extend our earlier ring-diagram analysis of subsurface flows near

the neutral lines of these two filaments to include information from greater depths. This is due, in part, to our ability to measure flows from solar 5-minute oscillations of greater radial order and lower wavenumber through the use of multiple-ridge fitting of the power spectra than with the standard ring analysis technique. It is also due to our further use of our relatively new 3-D inversion code. This code combines information from 2, 4, and 16 degree tiles to determine self-consistent flows; preserving the high spatial resolution information provided by the small tiles with the greater depth information provided by the large tiles. The data used in this analysis were obtained with the HMI and AIA instruments on SDO as well as the H-alpha network. This work is supported by grants from NASA and institutional funding from NSF.

P16.13

F-mode Seismology Of Solar Simulations

Kyle DeGrave[1], J. Jackiewicz[1], D. Braun[2], A. C. Birch[2], NorthWest Research Associates

[1]New Mexico State University, [2]NorthWest Research Associates.

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Time-distance helioseismology using f-mode travel times is used to study near-surface regions of realistic numerical magnetohydrodynamic simulations. A fully-consistent inversion procedure is used to analyze the simulation flow field outside of a sunspot. This approach is carried out to validate the time-distance technique, as well as the sensitivity kernels and the inversion algorithm. This work is supported by NASA under the SDO Science Center project (contract NNH09CE41C) as well as well as a NASA EPSCoR award.

P16.14

Meridional Circulation Measurements From 15 Years Of Gong

Aleksander Serebryanskiy[1], S. Kholikov[2], F. Hill[2], J. Jackiewicz[3]

[1]UBAI, Uzbekistan, [2]NSO, [3]NMSU, Astronomy Department.

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We present results of meridional flow measurements utilizing the GONG spherical harmonic time series for the 1995-2009 time period. Travel-time differences were obtained from cross-correlation measurements in the North-South direction using traditional time-distance helioseismology procedures. The travel times were used as input to an inversion procedure based on ray-path approximation kernels to infer the velocity amplitude of the meridional flow throughout the solar convection zone. Also presented

are studies of well-known projection and systematic errors of these types of measurements.

P16.15

The B0-angle Effect in Local Helioseismology Inferences of Meridional Circulation

Irene Gonzalez-Hernandez[1], T. Hartlep[2], S. Kholikov[1], F. Hill[1]

[1]National Solar Observatory, [2]W.W. Hansen Experimental Physics Laboratory, Stanford University.

7:30 AM Monday - 8:30 AM Thursday

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Meridional circulation has become a key ingredient in flux-transport solar-dynamo models. The development of local-helioseismology methods, combined with medium-high continuous observations from the Global Oscillation Network Group (GONG) and the Michelson Doppler Imager (MDI) has allowed the monitoring of the meridional circulation below the solar surface during the last solar cycle. However, the inferences have been limited in latitude as well as in depth, due mainly to the uncertainties in the analysis methods and the resolution of the observation. Here we investigate the

effect of the B0 angle on the inferences of meridional circulation flows and explore the possibility of modeling such effect by using artificial data, a numerical simulation of helioseismic wave propagation in the whole solar interior.

P16.16

On Measuring Deep Meridional Flows with Time-Distance and Ring-Diagrams

Sudeepto Chakraborty[1], R. S. Bogart[1], T. L. Duvall Jr.[2], M. C. Rabello-Soares[1]
[1]Stanford University, [2]NASA Goddard Space Flight Center.

7:30 AM Monday - 8:30 AM Thursday

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With the launch of the Solar Dynamics Observatory (SDO) we now have access to images of the Sun taken continuously, combining unprecedented spatial and temporal resolution. Meridional circulation, an important component in flux-transport solar-dynamo models, is one of the keys to understanding the solar cycle. In this work we concentrate on preliminary attempts at evaluating the constraints of time-distance helioseismology in measuring meridional flows in the convection zone of the Sun by analyzing data from the Helioseismic and Magnetic Imager (HMI) aboard SDO. We estimate the maximum depth into the convection zone that can be achieved using deep-focus time-distance analysis and compare results with current ring-diagram techniques.

P16.17

First Steps toward Seismic Holography of the Tachocline

Manuel Diaz Alfaro[1], I. González Hernández[2], F. Pérez Hernández[1], C. Lindsey[3]
[1]Instituto de Astrofísica de Canarias, Spain, [2]National Solar Observatory, [3]Northwest Research Associates (CoRA).

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The solar dynamo is thought to be generated at the tachocline and the deepest layers of the convection zone. Yet much about these layers or how this mechanism works remains unknown. In this work we present the first of a series of steps in order to apply helioseismic holography to the study of the tachocline.

Traditionally a plane-parallel approximation has been used for the calculation of the pupil for earthside seismic holography. In this work we have used a spherically symmetric model for the pupil to map an active region in the frontside of the Sun to test its potential. We also present the theoretical background to use a spherical polar expansion to calculate the Green's functions instead of the usual acoustic ray path approximation. These new Green's functions will allow to reach the deepest layers of the convection zone with more accuracy.

P16.18

Deep Meridional Flow Measurements from GONG: Temporal and Depth Variations

Shukur Kholikov[1], J. Leibacher[1], F. Hill[1]
[1]National Solar Observatory.

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We present measurements of meridional flow using time-distance analysis of GONG data. To push the depth profile of the flow deeper, we average time-difference measurements over 15 years. In order to increase the signal-to-noise ratio, and to reduce contamination from other modes, we utilized both phase velocity and low-*m* filtering. This approach seems to be capable of extending the meridional-flow measurements down to 0.7 Rsun. Our preliminary results indicate that the precision achieved is very close to that required to measure the reverse flow down to the base of the solar convection zone where it is expected to be situated. Typical uncertainties for most depths within mid-latitudes are less than 0.02 seconds. At high latitudes, due to projection effects, error bars increase up to 0.06 seconds. There is a significant change in the nature of the time differences at the bottom of the convection zone.

P16.19

The Influence of Rotation on the Pulsation Spectra of B-stars

Bernard J. McNamara[1], J. Jackiewicz[1], C. Lovekin[2], J. McAteer[1], L. Boucheron[1], H. Cao[1], D. Voelz[1], M. Kirk[1], G. Taylor[1], K. DeGrave[1], A. Al-Ghraibah[1], A. Pevtsov[1]

[1]New Mexico State Univ., [2]Los Alamos National Laboratory.

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B stars are known to oscillate in both radial and non-radial modes. Rotation may play an important role in altering the pulsation spectra of these stars. The results of 2D model calculations of rapidly rotating early B-stars is presented and used to examine the frequency spectrum of a Kepler B-star. The reduction procedure to determine stellar pulsation spectra using Kepler data sets is discussed, as well as the need for additional observational data to constrain the B-star spherical harmonic l and m values. This work is supported by the NASA Kepler Guest Observer program.

P16.20

Cyclic Behavior of the Sun's Small-scale Magnetic Elements

Jingxiu Wang[1], C. Jin[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences, China.

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With the unique database from the Michelson Doppler Imager on board the *Solar and Heliospheric Observatory* in an interval embodying solar cycle 23, the cyclic behavior of solar small-scale magnetic elements is studied. More than 13 million small-scale magnetic elements are selected, and their cyclic behavior is analyzed in comparison with the changes of sunspot numbers and active region magnetic flux. From the small to large end of the flux spectrum, the variations of numbers and total flux of the network elements show no correlation, anti-correlation, and correlation with sunspots, respectively. The anti-correlated elements, covering the flux of $(2.9\text{-}32.0)\times10^{18}$ Mx, occupy 77.2% of the total element number and 37.4% of the quiet-Sun flux. Unlike the correlated elements, which follow the sunspot butterfly diagram, the anti-correlated elements cover very broad range of latitude and do not show clear latitude migration during the cycle. These results provide insight for understanding the anti-correlations of small-scale magnetic activity during the solar cycle. The quiet regions dominate the Sun's magnetic flux for about 8 years in the 12.25 year duration of cycle 23, their monthly average magnetic flux is 1.12 times that of the active regions in the cycle. For the 28 continuous months from July 2007 to October 2009, the six-month running average ratio of quiet region flux to that of the total Sun is larger than 90.0%, which characterizes the gram minima in cycles 23 and 24 very well.

P16.21

Universality of the Small-Scale Dynamo Mechanism

Jonathan Pietarila Graham[1], R. Moll[2], J. Pratt[3], R. Cameron[2], W. Mueller[3], M. Schuessler[2]

[1]LANL, [2]Max Planck Institute for Solar System Research, Germany, [3]Max Planck Institute for Plasma Physics, Germany.

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We quantify possible differences between turbulent dynamo action in the Sun and the dynamo action studied in idealized simulation. For this purpose we compare Fourier-space shell-to-shell energy transfer rates of three incrementally more complex dynamo simulations: an incompressible, periodic simulation driven by random flow, a simulation of Boussinesq convection, and a simulation of fully compressible convection that includes physics relevant to the near-surface layers of the Sun. For each of the simulations studied, we find that energy is transferred from the turbulent flow to the magnetic field from length-scales in the inertial range of the energy spectrum. The addition of physical effects relevant to the solar near-surface layers, including stratification, compressibility, partial ionization, and radiative energy transport, does not appear to affect the nature of the dynamo mechanism. The role of inertial-range shear stresses in magnetic field amplification is independent from outer-scale circumstances, including forcing and stratification. Although shell-to-shell energy transfer functions have similar properties in each simulation studied, the saturated states of these simulations are not universal; the flow at the driving scales is a significant source of energy for the magnetic field. The mechanism of energy-transfer in kinematic small-scale dynamo simulations exhibits universal properties.
This work has been supported by the Max-Planck Society in the framework of the Interinstitutional Research Initiative Turbulent transport and ion heating, reconnection and electron acceleration in solar and fusion plasmas of the MPI for Solar System Research, Katlenburg-Lindau, and the Institute for Plasma Physics, Garching (project MIF-IF-A-AERO8047).

P17

Lower Atmosphere

Poster

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P17.01

A Mechanism of the Solar Acoustic Emission

Irina Kitiashvili[1], A. G. Kosovichev[1], S. K. Lele[1], N. N. Mansour[2], A. A. Wray[2]
[1]Stanford University, [2]NASA Ames Research Center.

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Understanding the mechanism of acoustic waves excitation in the turbulent surface layer is very important for the interpretation of helioseismology data and development of new methods of helioseismic diagnostics of the solar interior, as well as for understanding of the role of the acoustic flux in the energy transport. A substantial progress is being made from the analysis of high-resolution observational data, particularly from Hinode, Sunrise, and SDO/HMI, and also from high-resolution realistic numerical simulations. The simulations take into account all essential turbulent and other physical properties of the solar plasma, and allow us to look at the scales that cannot be resolved in observations, and also compare the data and models. We present new results of 3D radiative hydrodynamics simulations of the upper convection zone and atmosphere, and show that one of the possible mechanisms of the acoustic waves generation is a result of interaction two and more vortex tubes. The process of a vortex annihilation, which produces acoustic waves, the properties of these waves and vortices, and comparison with the available observational data will be discussed.

P17.02

Probing the Solar Atmosphere Using Oscillations of Infrared CO Spectral Lines

Matthew J. Penn[1], T. Schad[2], E. Cox[2]
[1]National Solar Obs., [2]University of Arizona.

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Oscillations were observed across the whole solar disk using the Doppler shift and line center intensity of spectral lines from the CO molecule near 4666~nm with the National Solar Observatory's McMath/Pierce solar telescope. Power, coherence, and phase spectra were examined, and diagnostic diagrams reveal power ridges at the solar global mode frequencies to show that these oscillations are solar p-modes. The phase was used to determine the height of formation of the CO lines by comparison with the IR continuum intensity phase shifts as measured in Kopp et al., 1992; we find the CO line formation height varies from 425 < z < 560 km as we move from disk center towards the solar limb 1.0 > mu > 0.5. The velocity power spectra show that while the sum of the background and p-mode power increases with height in the solar atmosphere as seen in previous work, the power in the p-modes only (background subtracted) decreases with height. The CO line depth weakens in regions of stronger magnetic fields, as does the p-mode oscillation power. Across most of the solar surface the phase shift is larger than the expected value of 90 degrees for an adiabatic atmosphere. We fit the phase spectra at different disk positions with a simple atmospheric model to determine that the acoustic cutoff frequency is about 4.5 mHz with only small variations, but that the thermal relaxation frequency drops significantly from 2.7 to 0 mHz at these heights in the solar atmosphere.

P17.03

Solar Cycle Variation of the Ca 854.2 nm Line Bisectors

Anna Pietarila[1], W. Livingston[1]

[1]*National Solar Observatory.*

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The bisector of the strong chromospheric Ca II 854.2 nm line has an inverse-C shape the cause of which is not yet fully understood. We show that the amplitude of the bisector in Sun-as-a-star observations exhibits a solar cycle variation with smaller amplitudes during highest activity. The line core intensity is lower during solar minima while the part of the bisector most sensitive to the line core shows no systematic change with activity. We also show preliminary results of a connection between magnetic shadows and bisector amplitudes. Our results support the use of Ca II 854.2 nm bisectors in studying the relationship between convection and magnetic fields, not only in the Sun but in other stars as well.

P17.04

Conditions for Photospherically Driven Aflvenic Oscillations to Heat the Chromosphere by Pedersen Current Dissipation

Michael L. Goodman[1]

[1]*West Virginia High Technology Foundation.*

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An MHD model that includes a complete electrical conductivity tensor is used to estimate conditions for photospherically driven, linear, non-plane Alfvenic oscillations extending from the photosphere to the lower corona to drive a chromospheric heating rate due to Pedersen current dissipation that is comparable to the observed net chromospheric radiative loss of ~ 10^7 ergs-cm^{-2}-sec^{-1}. The heating rates due to electron current dissipation in the photosphere and corona are also computed. The wave amplitudes are computed self-consistently as functions of an inhomogeneous background atmosphere. The effects of the conductivity tensor are resolved numerically using a resolution of 3.33 m. The oscillations drive a chromospheric heating flux F_{Ch} ~ 10^7-10^8 ergs-cm^{-2}-sec^{-1} at frequencies nu ~ 10^2 - 10^3 mHz for background magnetic field strengths B >~ 700 G, and magnetic field perturbation amplitudes ~ 0.01-0.1 B. The total resistive heating flux increases with nu. Most heating occurs in the photosphere. Thermalization of Poynting flux in the photosphere due to electron current dissipation regulates the Poynting flux into the chromosphere, limiting F_{Ch}. F_{Ch} initially increases with nu, reaches a maximum, and then decreases with increasing nu due to increasing electron current dissipation in the photosphere. The resolution needed to resolve the oscillations increases from ~ 10 m in the photosphere to ~ 10 km in the upper chromosphere, and is proportional to nu^{-1/2}. Estimates suggest these oscillations are normal modes of photospheric flux tubes with diameters ~ 10-20 km, excited by magnetic reconnection in current sheets with thicknesses ~ 0.1 km. This work was supported by the NSF Solar Terrestrial Physics Program. It is described in detail in a paper in submission to ApJ.

P17.05

Meridional Surface Flows and the Recent Extended Solar Minimum

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Nandy, Munoz, \& Martens, have published a kinematic dynamo model that successfully reproduces the main characteristics of the recent extended solar minimum (Nature 2011, 471, 80). The model depends on the solar meridional flow and its return flow along the tachocline determining the period and character of the cycle. In particular Nandy et al.\ found that a meridional flow that is fast in the first half of the cycle and then slows down around solar maximum, can lead to an extended minimum with the characteristics of the recent minimum: an extended period without sunspots and weak polar fields.
It has been pointed out that the observed surface meridional flows over the last cycle do not fit the pattern assumed by Nandy et al. Hathaway \& Rightmire (Science 2010, 327-1350) find that the meridional speed of small magnetic surface elements observed by SoHO/MDI decreased around solar maximum and has not yet recovered. Basu \& Antia (ApJ 2010, 717, 488) find surface plasma meridional flow speeds that are lower at solar maximum 23 than at the surrounding minima, which is different from both Hathaway and Nandy.
While there is no physical reason that solar surface flows -- both differential rotation and meridional flow -- would vary in lockstep with flows at greater depth, as the large radial gradients near the surface clearly indicate, and while Nandy et al.\ have demonstrated that the deeper flows dominate the net meridional mass flow, we find that there is in effect a very satisfying agreement between the observational results of Hathaway \& Rightmire, Basu \& Antia, and the model assumptions of Nandy, Munoz, \& Martens. We present an analytical model that reconciles the first two, followed by a hydrodynamical model that demonstrates the consistency of these observational results with the model assumptions of Nandy et al.

P17.06

A RHESSI And SDO Campaign Measuring Latitude-dependent Limb Profiles And Oblateness Of The Optical Solar Disk

Martin Fivian[1], H. S. Hudson[1], R. P. Lin[1], R. I. Bush[2], M. Emilio[3], J. R. Kuhn[4], I. F. Scholl[4]
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The SDO spacecraft conducted a special roll maneuver, 2011 April 6 05:50-12:30 UT, to enable its HMI instrument to obtain precise observations of the global structure of the limb. Similar maneuvers had been carried out with SOHO for MDI in the past. On this occasion we also successfully obtained RHESSI optical observations at very high cadence, 128 samples per sec for each of the three linear CCDs. The data from the two instrument (RHESSI/SAS and SDO/HMI), give different means for the investigation of the variation of the solar limb properties as a function of position angle (latitude). At the normal RHESSI cadence very long integrations (of order 3 months) are needed to obtain precise limb measurements, but in this case we expect to be able to report results within the exact time frame of the SDO roll maneuver. The special RHESSI data rate was about 10,000 times larger than the standard rate and will achieve high precision in a relatively short time. We will compare these results with our earlier RHESSI observations (Fivian et al., 2008) and those obtained by Kuhn et al. (1998) and Emilio et al. (2007) with the earlier MDI roll maneuvers.

P17.07

MHD Wave Transformation and Radiation Transfer Simulations in Sunspots

Konstantin Parchevsky[1], A. Kosovichev[1]

[1]*Stanford University.*

7:30 AM Monday - 8:30 AM Thursday

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We present results of resonant wave transformation in MHD models of sunspot. Numerical 3D MHD simulations of waves excited by subsurface point sources and traveling through the sunspot models reveal details of the MHD mode conversion, which happens in the regions where the wavefront crosses the level where the plasma parameter β is of the order of unity. In particular, the wave transformation produces slow MHD waves traveling predominantly along the magnetic lines in the central part of sunspot. This process is clearly seen when plotted as a projection of velocity (and magnetic field) variations along and perpendicular to the local direction of the magnetic field lines. Detailed simulations show that the transformed wave appears even in the case where the source is located completely outside the magnetic region, so that when the initial wave is pure acoustic. To investigate the wave amplitude and travel-time corrections due to the variations of thermodynamic properties and magnetic effects in sunspots we apply the 1D LTE radiation transfer code SPINOR/STOPRO to the wave simulation results. This permits us to simulate the profile of the HMI Fe6173A spectral line, and model the HMI observations of the line-of-sight velocity and magnetic field, and also the Stokes profiles. For calculation of the observables we use the same set of 6 narrow-band filters as used in the HMI instrument. Such simulations provide artificial HMI level-1 data for testing helioseismology measurements in sunspots and magnetic active regions.

P17.08

High-resolution 3D Radiative MHD Simulations Of Turbulent Convection And Spectro-polarimetric Properties

Irina Kitiashvili[1], A. G. Kosovichev[1], N. N. Mansour[2], J. O. Stenflo[3], A. A. Wray[2]

[1]*Stanford University,* [2]*NASA Ames Research Center,* [3]*Institute of Astronomy, ETH Zurich, Switzerland.*

7:30 AM Monday - 8:30 AM Thursday

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Realistic numerical simulations of solar magnetoconvection play a key role for our understanding of the basic physical phenomena in the subsurface convective boundary layer and the atmosphere. For the accurate modeling of the turbulent processes on the Sun it is important to perform the simulations with the highest possible resolution. Our results have revealed significant changes in properties of the turbulent motions when the resolution is increased. It is particularly interesting that small-scale vortex motions in the intergranular lanes become ubiquitous and strong, and play a critical role in the large-scale organization of the solar dynamics. For the comparison with observational data it is necessary to investigate relationships between the physical and spectro-polarimetric properties in various conditions of the quiet-Sun and magnetic regions, and model the observed parameters. By using the radiative line formation code, SPINOR/STOPRO, we have calculated the Stokes profiles and other characteristics for the spectral line of the Hinode/SOT and SDO/HMI instruments, and compared the simulation results with the observational data.

P17.09

Velocity Characteristics Of Rotating Sunspots

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7:30 AM Monday - 8:30 AM Thursday

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A statistical study is carried out to investigate the detailed relationship between the rotating sunspots and the emergence of magnetic flux tubes. This paper presents the velocity characteristics of 132 sunspots in 95 solar active regions. The rotational characteristics of the sunspots are calculated from successive SOHO/MDI magnetograms by applying the Differential Affine Veloicty Estimator (DAVE) technique (Schuck, Astrophys. J. 646, 1358, 2006). Among 82 sunspots in active regions exhibiting strong flux emergence, 77% are rotating sunspots with rotational angular velocity larger than 0.4 deg/hr. Among 50 sunspots in active regions without well-defined flux emergence, 28% are rotating, and the sunspot rotation tend to be slower, even ceased, compared to those during the emergence. In addition, we investigated 11 rotating sunspot groups in which both polarities show evidence for contemporary rotation. In seven of these cases the two polarities co-rotate while the other four are found to be counter-rotating. Plausible reasons for the observed characteristics of the rotating sunspots are discussed.

P17.10

A Revisit of Hale's and Joy's Laws of Active Regions Using SOHO MDI Obsevations

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Hale's law of polarity defines the rule of opposite direction of two polarities of solar bipolar Active Regions in the two hemispheres. Another law, Joy's law, governs the tilt of ARs with respect to their heliographic latitudes. Both laws are essential for constraining solar dynamo models. In this study we attempt to examine these laws in great detail using a large sample of ARs. With the help of an automatic AR detection algorithm (based on morphological analysis, Zhang et. al, 2010), we have processed high resolution SOHO/MDI synoptic magnetograms over the entire solar cycle 23, we identified all active regions in a uniform and objective way and determined their physical properties, including locations, fluxes of positive and negative polarities ,as well as the direction angles of these regions. Among 1084 bipolar ARs detected, the majority of them (87%) follow Hale's polarity law, while the other 13% of ARs do not. We attribute this deviation to the complexity of AR emergence from the turbulent convection zone. Regarding the Joy's law, we find that there is only a weak positive trend between AR tilt angles and latitudes. On the other hand, the tilt angle has a broad Gaussian-like distribution, with the peak centered around zero degree, and a width of about 20 degree at half maximum. Implications of these results on solar dynamo theory will be discussed.

P17.11

Magnetic Element Meridional Flow: Dependence on Strength

Lisa Rightmire[1], D. Hathaway[2]
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Meridional Flow (MF) speeds are only on the order of 10-20 m/s. For this reason, MF is the most difficult transport velocity to measure. However, these velocities can be measured by tracking the motion of small magnetic elements on the surface of the sun and averaging over a Carrington Rotation (CR). Magnetograms obtained by the HMI instrument aboard SDO are turned into maps of the magnetic features. Strips from these maps, taken 8 hours apart, are then cross-correlated to determine the distances in latitude and longitude that flux elements have moved, thus producing MF and differential rotation velocities as functions of latitude. Averaging the MFs obtained for every 8 hour separation over a 27-day CR produces a MF profile for that CR. This process was repeated for data with varying magnetic element strength. Results show that the MF is more complex than previously thought. It varies with the strength of the magnetic elements. The MF is slower for the stronger flux elements. This is consistent with stronger flux elements being anchored deeper in the Sun's surface shear layer where the MF is slower. New Surface Flux Transport and Solar Dynamo models should reproduce solar conditions while including these variations.

P17.12
HMI Measurements Of The Solar Magnetic Field
Jon Todd Hoeksema[1], HMI Magnetic Field Team
[1]*Stanford University.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Helioseismic and Magnetic Imager (HMI) on NASA’s Solar Dynamics Observatory (SDO) routinely produces a comprehensive array of magnetic field data products including 45-second line-of-sight magnetograms, synoptic maps and synchronic frames, 12-minute vector field time series in HMI Active Region Patches (HARPs), model calculations of the coronal field and solar wind, and near-real-time parameters for space weather. Other products, such as surface flow maps, can be produced on demand or on request. We present examples of data products generated during the first year of operations and compare some of these with measurements from other observatories, including the now-dormant MDI. The HMI Team is sponsored by NASA.

P17.13
Studying Solar Flux Emergence for High Shear, Low Twist Magnetic Fields
Mark Linton[1], J. Leake[2]
[1]*NRL,* [2]*George Mason University.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Current simulations show that buoyant convection zone flux ropes can emerge a significant fraction of their flux into the corona if they are highly twisted. However, the twist in these flux ropes is significantly higher than the twist observed at the photosphere in most active regions. It also appears to be higher than what is required if emerging flux, rather than surface motions, were to produce highly sheared pre-coronal-mass-ejection prominences. We study, via magnetohydrodynamical simulations, whether it is possible to dynamically emerge convection zone magnetic field in such a way as to reproduce either the low twist photospheric and coronal signatures of average sunspots or the highly sheared structures of prominences.

P17.14

Bright Points In And Around Sunspots

Debi Prasad Choudhary[1], N. Deng[1], T. Shimizu[2]
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We used the flux calibrated images through the Broad Band Filter Imager and Stokes Polarimeter data obtained with the Solar Optical Telescope onboard the Hinode spacecraft to study the properties of sunspot bright points. The isolated bright points were selected and classified as umbral dot, peripheral umbral dot, penumbral grains and G-band bright point depending on their location. Most of the bright points are smaller than about 150 km, and not uniformly distributed over the umbra but preferentially located around the penumbral boundary and in the fast decaying parts of umbra. The color temperature of the bright points, derived using the continuum irradiance, are in the range of 4600 K to 6600 K with cooler ones located in the umbra. The temperature increases as a function of distance from the center to outside. The G-band, CN-band and CaII H flux of the bright points as a function of their blue band brightness increase continuously in a nonlinear fashion unlike their red and green counterpart. The scatter in CaII H irradiance is higher compared to the G-band and CN-band irradiance. The light curve of the bright points show that the enhanced brightness at these locations last for about 15 to 60 minutes. The umbral dots near the penumbral boundary are associated with elongated filamentary structures. The G-band brightness closely follows their magnetic filling factor. Generally, the umbral dots have higher magnetic field and larger Doppler velocity compared to their counterpart outside the spot. These results are consistent with the model in which the upward intruding plasma through the nonmagnetic columns between the fluxtubes of sunspot produce the bright points and heat the matter inside of adjacent tubes. The heated plasma flows in the direction of reduced gas pressure. Similar localized heating of penumbra leads to the origin of penumbral grains.

P17.15

Understanding the Physics of Flux Cancellation

Brian Welsch[1], G. Fisher[1], X. Sun[2]
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center

Cancellation of magnetic flux in magnetograms has been defined in observational terms as "the mutual apparent loss of magnetic flux in closely spaced features of opposite polarity." Physically, this removal of flux could correspond to one of three mechanisms: (i) the emergence of U-shaped magnetic loops, (ii) the submergence of Omega-shaped loops, or (iii) reconnection in the magnetogram layer. Evidence has been reported for all three of these mechanisms, but does one predominate? Does most canceling flux enter the outer solar atmosphere, or submerge into the interior? Answers to these questions will improve our understanding of both the solar-cycle and quiet-Sun dynamos, as well as the origins of structures that erupt in coronal mass ejections (CMEs). We can investigate cancellation mechanisms at work in an active region's magnetic fields using time-averaged Doppler shifts along polarity inversion lines (PILs) of the line-of-sight (LOS) magnetic field near disk center. Along these PILs, the LOS component of the magnetic field vanishes, so LOS flows inferred from Doppler shifts are perpendicular to the magnetic field. If the evolution is ideal, such flows imply the transport of magnetic flux across the atmospheric layer imaged in the magnetogram. As a preliminary step in our study, we present an innovative method to remove biases in the measured Doppler velocities due to offset in the line-center position, which might arise from a well-known correlation between brightness and blueshifts in the convecting photospheric plasma. In cases with significant discrepancies between flux cancellation rates

separately inferred from (1) changes in LOS flux near canceling PILs and (2) combined Doppler velocities and transverse field strengths along PILs, we can characterize departures from ideal evolution in terms of an effective magnetic diffusivity, which can be evaluated from the data.

P17.16

Intrinsic Sunspot Rotations and Energetic Events

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7:30 AM Monday - 8:30 AM Thursday

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The intrinsic rotation of sunspots is considered to play a role in the magnetic energy buildup leading to solar eruptions. Much of sunspot intrinsic rotational measurements are made from photospheric observations via white-light imaging and refers to rotation of the photospheric layers. This paper presents a pilot project to investigate measures of intrinsic sunspot rotations at both the photosphere (true-continuum) and chromosphere (H-alpha) in an effort to understand their coupling in these layers. The data used in this research are obtained from the USAF/AFRL/NSO Improved Solar Observing Optical Network (ISOON) prototype telescope at the National Solar Observatory, Sunspot, New Mexico. ISOON images from 2003 October 27-29 include NOAA active regions 10484, 10486, 10487, 10488, 10490, 10491, and 10492. These active regions, during the mentioned time period, were a source of intensive solar eruptions and include a 4B/X17.2-class solar flare in NOAA Active Region 10486 (Ambastha 2007; Kazachenko et al., 2010).

For each sunspot within an active region, a circular aperture is chosen to enclose the sunspot. The aperture is centered on the umbra and the sunspot is “uncurled” into a two-dimensional plot of radial distance, in pixels, versus angular distance, in degrees. This procedure follows the technique of Balasubramaniam (2002) and Brown et al. (2003) and will yield intrinsic sunspot rotational velocities through time for variable distances from the umbral center. We present our initial comparisons of photospheric and chromospheric rotational characteristics, the extent of coupling between the photosphere and chromosphere, and rotational characteristics as a function of sunspot size, age, solar latitude, and classification. Determining the rotational nature of a large number of sunspots as a function of various sunspot characteristics can lead to a greater understanding of the effects of intrinsic sunspot rotations on the occurrences of solar flares.

P17.17

Can We Determine Electric Fields and Poynting Fluxes from Vector Magnetograms and Doppler Measurements?

George H. Fisher[1], B. T. Welsch[1], W. P. Abbett[1]

[1]UC, Berkeley.

7:30 AM Monday - 8:30 AM Thursday

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The availability of vector-magnetogram sequences with sufficient accuracy and cadence to estimate the temporal derivative of the magnetic field allows us to use Faraday's law to find an approximate solution for the electric field in the photosphere, using a Poloidal--Toroidal Decomposition (PTD) of the magnetic field and its partial time derivative. Without additional information, however, the electric field found from this technique is under-determined -- Faraday's law provides no information about the electric field that can be derived the gradient of a scalar potential. Here, we show how additional information in the form of line-of-sight Doppler-flow measurements, and motions transverse to the line-of-sight determined with ad-hoc methods such as local correlation tracking, can be combined with the PTD solutions to provide much more accurate solutions for the solar electric field, and therefore the

Poynting flux of electromagnetic energy in the solar photosphere. Reliable, accurate maps of the Poynting flux are essential for quantitative studies of the buildup of magnetic energy before flares and coronal mass ejections.

P17.18

The Evolution of Dark Canopies Around Active Regions

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7:30 AM Monday - 8:30 AM Thursday

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As observed in spectral lines originating from the chromosphere, transition region, and low corona, active regions are surrounded by an extensive 'circumfacular' area which is darker than the quiet Sun. We examine the properties of these dark moat- or canopy-like areas using Fe IX 17.1 nm images and line-of-sight magnetograms from the Solar Dynamics Observatory. The 17.1 nm canopies consist of fibrils (horizontal fields containing EUV-absorbing chromospheric material) clumped into featherlike structures. The dark fibrils initially form a quasiradial or vortical pattern as the low-lying field lines fanning out from the emerging active region connect to surrounding network and intranetwork elements of the opposite polarity. The area occupied by the 17.1 nm fibrils expands as supergranular convection causes the active region flux to spread into the background medium; the outer boundary of the dark canopy stabilizes where the diffusing flux encounters a unipolar region of the opposite sign. The dark fibrils tend to accumulate in regions of weak longitudinal field and to become rooted in mixed-polarity flux. To explain the latter observation, we note that the low-lying fibrils are more likely to interact with small loops associated with weak, opposite-polarity flux elements in close proximity, than with high loops anchored inside strong unipolar network flux. As a result, the 17.1 nm fibrils gradually become concentrated around the large-scale polarity inversion lines (PILs), where most of the mixed-polarity flux is located. Systematic flux cancellation, assisted by rotational shearing, removes the field component transverse to the PIL and causes the fibrils to coalesce into long PIL-aligned filaments.

P17.19

Hemispheric Trends In The Current Helicity Of The Large Scale Solar Magnetic Fields : Vsm/solis And Hmi/sdo Observations

Sanjay Gusain[1], A. Pevtsov[1]

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7:30 AM Monday - 8:30 AM Thursday

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The current helicity of the large-scale magnetic fields has been computed in the past by using reconstructed vector magnetograms. Such magnetograms were derived by using sequence of line-of-sight magnetograms (Pevtsov A. A., and Latushko S. M.: 2000) and were used for studying the helicity patterns during cycle 22 and 23. The reconstruction method, however, made several assumptions, and the meridional component could not be reconstructed very well. Full disk vector magnetograms, which are now available from VSM/SOLIS and HMI/SDO are very promising to make a systematic study of large scale helicity patterns during cycle 24, which is in its onset phase. In this paper we shall discuss our preliminary results about the large-scale helicity patterns in the beginning of cycle 24 using VSM/SOLIS and HMI/SDO full disk vector magnetograms.

P17.20

High-frequency Waves in Numerical Simulations of the Solar Atmosphere

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7:30 AM Monday - 8:30 AM Thursday

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We investigate the excitation processes, propagation characteristics, and energy transport of high-frequency waves in the solar atmosphere with the help of high-resolution 3D radiation-hydrodynamics simulations. Time series of synthetic spectra of four photospheric Fraunhofer lines (Fe 6302, Fe 6301, Fe 6173, Ni 6768) from these simulations are analyzed in order to evaluate the diagnostic power of spectroscopic observations.

P17.21

A Decade of Diminishing Sunspot Vigor

W. C. Livingston[1], M. Penn[1], L. Svalgard[2]

[1]National Solar Obs., [2]Stanford University.

7:30 AM Monday - 8:30 AM Thursday

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[1]A Decade of Diminishing Sunspot Vigor

William Livingston[1]

Matt Penn[1]

Leif Svalgard[2]

Sunspots are small dark areas on the solar disk where internal magnetism, 1500 to 3500 Gauss, has been buoyed to the surface. (Spot life times are the order of one day to a couple of weeks or more. They are thought to be dark because convection inhibits the outward transport of energy there). Their “vigor” can be described by spot area, spot brightness intensity, and magnetic field. From 2001 to 2011 we have measured field strength and brightness at the darkest position in umbrae of 1750 spots using the Zeeman splitting of the Fe 1564.8 nm line. Only one observation per spot per day is carried out during our monthly telescope time of 3-4 days average. Over this interval the temporal mean magnetic field has declined about 500 Gauss and mean spot intensity has risen about 20%. We do not understand the physical mechanism behind these changes or the effect, if any, it will have on the Earth environment.

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P17.22

Solar Synoptic Maps from the San Fernando Observatory

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7:30 AM Monday - 8:30 AM Thursday

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We are developing a set of synoptic image maps compiled from daily photometric images taken at the San Fernando Observatory. Our initial maps show the progression of solar features across the central meridian for approximately one solar rotation. The red continuum maps show the photometric contrast of solar features in the photosphere while the Ca II K-line maps show the same in the lower chromosphere. Comparing these maps with each other, and with those of other solar groups, will yield information regarding the evolutionary patterns of solar activity at different heights of the solar atmosphere. This is a first step toward a comprehensive set of synoptic maps covering the period from mid-solar cycle 22 in 1988 to the present.

This work has been supported in part by NSF grant ATM-0848518.

P17.23

Trenches In Granulae
Aleksandra Andic[1]
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
NST resolution of 0.09" showed fine details in granulae. Photometry of granular field performed with spectral line 705.68 nm revealed a small percentage of the granulae with a dark trench that spreads from edge of the granule straight towards the granular centre. Although the magnetic information was not available at the same resolution, the observed behavior of the trenches indicated the possible involvement of the magnetic field. The behavior and statistic of these trenches will be presented in this work.

P17.24
Results and Analysis of the RHESSI/SAS Observations of the Optical Solar Limb
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Solar Aspect System (SAS) of the RHESSI satellite measures the optical solar limb in the red continuum with a cadence typically set at 16 samples/s in each of three linear CCD sensors. RHESSI has observed the Sun continuously now for more than 9 years, and we have acquired a unique data set ranging almost over a full solar cycle and consisting of about 25x10^9 single data points. These measurements have led to the most accurate oblateness measurement to date, 8.01+-0.14 milli arcsec (Fivian et al., 2008), a value consistent with models predicting an oblateness from surface rotation. An excess oblateness term can be attributed to the enhanced network. New measurements of latitude-dependent brightness variations at the limb lead to a quadrupolar term (a pole-to-equator temperature variation) of 0.04+-0.02 K. We present the analysis of these unique data and an overview of some results.

P17.25
Time-Series Analysis of Supergranule Characteristics Derived from SOHO/MDI Dopplergrams.
Peter E. Williams[1], W. D. Pesnell[1]
[1]*NASA/GSFC.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Supergranulation exhibits both radial and horizontal velocity components within Doppler data. The weak, radial flows drag magnetic field lines to the surface while their strong, divergent, horizontal counterparts advect the field to the edges of the supergranulation cells. Field congregation at supergranule boundaries is observed in magnetic filed images and via Ca II K observations of the chromospheric network.
Supergranulation characteristics, such as typical sizes and velocities, have been studied using MDI Doppler data and tracked over 60-days of observations made in 1996 and 2008, relating to periods of solar minimum. Time-series of these characteristics exhibit regular fluctuations on the order of 3-5 days. These time-series are analyzed to extract frequency information and cross-correlated to investigate any temporal link between the characteristics.
Whether the fluctuations are an instrumental artifact is studied by comparing contemporaneous time series produced from SOHO/MDI and SDO/HMI Dopplergrams. There exists a high correlation between the two time-series showing that the fluctuations are solar in origin.

P17.26

Time Variation of the Large-scale Velocity Fields in the Photosphere

Hyewon Jung[1], P. W. Schuck[2]
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7:30 AM Monday - 8:30 AM Thursday

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The photospheric large-scale velocity fields of differential rotation and meridional flow play important roles in solar dynamo models. We measure these flows from 1996 to 2010 using 1-minute cadence vector-weighted Dopplergrams of the Michelson Doppler Imager (MDI) onboard the Solar Heliospheric Observatory (SOHO). After removing observer motion, co-aligning, and averaging over a day, we fit the time-averaged Dopplergram with a two-dimensional function containing the disk-orthogonal expressions for the differential rotation and meridional flow. The time variation of the fitted large-scale flows will be presented.

P17.27

Rapid Oscillations in the Solar Atmosphere: Spectra and Physical Effects

John K. Lawrence[1], D. J. Christian[1], A. C. Cadavid[1], D. B. Jess[2], M. Mathioudakis[2]
[1]California State University Northridge, [2]Queen's University, Belfast, United Kingdom.

7:30 AM Monday - 8:30 AM Thursday

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High-frequency fluctuations are observed with the Rapid Oscillations in the Solar Atmosphere (ROSA) instrument (Jess et al. 2010, *Solar Phys*, 261, 363) at the Dunn Solar Telescope. This can produce simultaneous observations in up to six channels, at different heights in the photosphere and chromosphere, at an unprecedentedly high cadence of ~0.5 seconds, and at a spatial resolution of 100 km after photometrically correct speckle reconstruction.

Here we concentrate on observations at two levels. The first is in the G-band of the CH radical at 4305.5Å, bandpass 9.2Å, with height of formation z < 250 km at a cadence of 0.525 sec corresponding to Nyquist frequency 950 mHz. The second is in the Ca II K-line core at 3933.7Å, bandpass 1.0Å, with height of formation z < 1300 km, and cadence 4.2 sec giving Nyquist frequency 120 mHz. The data span 53 min, and the maximum field of view is 45 Mm. The data were taken on 28 May 2009 in internetwork and network near disk center.

Using both Fourier and Morlet wavelet methods we find evidence in the G-band spectra for intensity fluctuations above noise out to frequencies f >> 100 mHz. The K-line signal is noisier and is seen only for f < 50 mHz. With wavelet techniques we find that G-band spectral power with 20 < f < 100 mHz is clearly concentrated in the intergranular lanes and especially at the locations of magnetic elements indicated by G-band bright points. This wavelet power is highly intermittent in time. By cross-correlating the data we find that pulses of high-frequency G-band power in the photosphere tend to be followed by increases in K-line emission in the chromosphere with a time lag of about 2 min.

P17.28

Properties of Magnetic Neutral Lines and Chromospheric Filaments Formation

Nina Karachik[1], A. A. Pevtsov[1]
[1]National Solar Observatory.

7:30 AM Monday - 8:30 AM Thursday

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Chromospheric filaments - large concentrations of dense and cool material held in place by magnetic fields - form at a boundary (neutral lines) between opposite polarity magnetic fields. However, not all magnetic neutral lines have filaments above them. In present research we compare properties of magnetic polarity inversion lines that have filaments above them and those without filaments, and investigate how these properties change during solar cycle. The results are used to establish the conditions at neutral lines that may lead to formation of the chromospheric filaments.

P17.29

Effect of Magnetic Fields on Wave Propagation in the Solar Atmosphere

John K. Lawrence[1], A. C. Cadavid[1], D. J. Christian[1]

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7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

We studied 1 - 24 mHz intensity fluctuations in 3-hour sequences of high-cadence, high-resolution, broad-band filtergram images taken by the SOT-FG on board the Hinode spacecraft. The observations consist of near simultaneous, co-registered G-band (GB), Ca II H-line (HL) intensity images, and line-of-sight magnetic images calibrated to Gauss with MDI magnetograms. GB is typically used as a proxy for magnetic fields while HL is a diagnostic of chromospheric heating.

We estimate the height z1 of the “magnetic canopy,” where magnetic and gas pressures balance, using potential field extrapolation and the Fontenla 2006 model atmosphere. When z1 is above the height of formation of both signals, the coherence of the GB and HL oscillations is strong for frequencies between 3 mHz and 6 mHz and maximal near 5 mHz, around the acoustic cutoff frequency. Near 3 mHz there is no time delay between the HL and GB signals indicating a pure standing wave. Above 7 mHz the time delay settles near 20 sec indicating an upward propagating acoustic wave. When z1 is below the GB and HL heights of formation the coherence between the signals drops and has a maximum near 4 mHz. The time delay remains zero at 3 mHz, but above 7 mHz it is less than 20 sec and decreases with frequency, suggesting that the original acoustic fluctuations have undergone mode conversion.

A similar analysis of ground-based data acquired with the Rapid Oscillations in the Solar Atmosphere (ROSA) instrument at the Dunn Solar Telescope finds longer time delays of 34 sec when z1 is high and 21 sec when z1 is low. This is consistent with the greater effective formation height of the ROSA narrowband (1 Å) Ca II K-line core compared to the more broadband (3 Å) H-line in the Hinode data.

P17.30

Observations From The Hrts-9 Rocket In The Nuv Passband Of The Iris Mission

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7:30 AM Monday - 8:30 AM Thursday

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The HRTS-9 rocket flew in April 1995 and observed several solar surface features on the western solar disk. The HRTS-9 spectrograph was modified to observe a 180 A wide portion of the solar spectrum near MgII at 2800 A. Also, a slit-jaw camera observed a 400" x 900" region around the 960" long x 1" wide spectrograph slit in five passbands, specifically, 1540A (Si I), 1550A (C IV), 1560A (C I), 1600A, and images of H-alpha.

During the flight, the slit was pointed at various features including the quiet sun near disk center and the limb, active regions, and a sunspot. At the end of the flight, the pointing was fixed and a slit scanning mechanism was used to collect a series of spectra that span about 45". From this data set spectral images at specific wavelengths in the 2765 to 2885A range can be generated and compared to the broadband images at shorter wavelengths. For example, preliminary spectral images in the MgII k line show evidence of loop structures similar to those seen in C IV. Our previous efforts with this data set have focused on the impact these radiance observations near MgII have on solar spectral irradiance studies. These topics include examining the sources of solar irradiance variability, the center-to-limb

variability of the quiet sun, and the relationship between the MgII intensity and the photospheric magnetic field. In light of the upcoming IRIS Explorer mission, we are turning our attention to those science goals in order to anticipate and support potential observations by the IRIS NUV spectrograph channel.
In this presentation we describe the available observations, previous results, as well as discuss our ongoing analysis and preliminary spectral images of features in the region near MgII. Work was sponsored by NASA.

P17.31

Solar Oscillations And Acoustic Power Measured In H-alpha

Jason Jackiewicz[1], K. Balasubramaniam[2], R. McAteer[1], S. M. Jefferies[3]
[1]New Mexico State University, [2]Space Vehicles Directorate, Air Force Research Laboratory, [3]Institute for Astronomy, University of Hawaii.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We present initial studies of the evidence of acoustic power in H alpha data observed with the ISOON telescope. Uninterrupted times series were obtained at 1-minute cadence of the H alpha intensity and Doppler velocity signals of both quiet and active regions on the Sun. Spatial and temporal power maps show enhanced contributions from a flaring active region that is a strong function of frequency. Cross-correlations and wave travel times are computed and give indications of the presence of running waves below the acoustic cut-off frequency.

P17.32

Connecting Ephemeral Chromospheric Brightenings to Coronal Loops

Michael S. Kirk[1], K. S. Balasubramaniam[2], J. Jackiewicz[1], J. McAteer[1], R. Milligan[3]
[1]New Mexico State University, [2]Air Force Research Laboratory, [3]Queens University, United Kingdom.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Sequential chromospheric brightenings (SCBs) flanking solar flares represent chromospheric foot-points of magnetic field lines that extend into the corona. During the eruption of a solar flare related CME, these field lines are considered to be energized in sequence by magnetic re-connection, as coronal fields separate from the solar surface. Using automated procedures to extract physical measurements of chromospheric flares and SCBs, we superpose these features onto coronal EUV images and trace the spatio-temporal relationship between coronal loops and SCBs. We postulate a physical connection for SCBs and their coronal counterparts and estimate an energy budget.

P17.33

Pederson Current Dissipation In Emerging Active Regions

James E. Leake[1], M. G. Linton[2]
[1]George Mason University, [2]Naval Research Laboratory.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Pederson current dissipation in emerging active regions.
Certain regions of the solar atmosphere, such as the photosphere and chromosphere, as well as prominences, contain a significant amount of neutral atoms, and a complete description of the plasma requires including the effects of partial ionization. In the chromosphere the dissipation of Pederson currents is important for the evolution of emerging magnetic fields.
Due to the relatively high number density in the chromosphere, the ion-neutral collision time-scale is much smaller than timescales associated with flux emergence. Hence we use a single-fluid approach to

model the partially ionized plasma. Looking at both the emergence of large-scale sub-surface structures, and the emergence and reconnection of undulatory fields, we investigate the effect of Pederson current dissipation on the state of the emerging field, on magnetic reconnection and on dissipative heating of the atmosphere. Specifically we examine the effect of motions across fieldlines in the partially ionized regions, and how this can increase the free energy supplied to the corona by flux emergence. We also look at reconnection associated with flux emergence in the partially ionized atmosphere, and how this can account for observed small-scale brightenings (Ellerman Bombs).

P17.34

A Standard-to-blowout Jet

Chang Liu[1], N. Deng[2], R. Liu[1], I. Ugarte-Urra[3], S. Wang[1], H. Wang[1]

[1]NJIT, [2]CSUN/NJIT, [3]GMU.

7:30 AM Monday - 8:30 AM Thursday

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The commonly observed jets provide critical information on the small-scale energy release in the solar atmosphere. We report a near disk-center jet on 2010 July 20, observed by the Solar Dynamics Observatory. In this jet, the standard interchange magnetic reconnection between an emerging flux spanning 9x10^3 km and ambient open fields is followed by a blowout-like eruption. In the "standard" stage, as the emerging negative element approached the nearby positive network fields, a jet with a dome-like base in EUV grew for 30 minutes before the jet spire began to migrate laterally with enhanced flux emergence. In the "blowout" stage, the above converging fields collided and the subsequent cancellation produced an A6 microflare visible in 1700 A images. In the latter stage that lasted seven minutes, the dome of the jet seemed to be blown out as (1) the spire swung faster and exhibited an unwinding motion before vanishing, (2) a rising loop and a blob erupted leaving behind cusped structures, with the blob spiraling outward in acceleration after the flare maximum, and (3) ejecting material that formed a curtain-like structure at chromospheric to transition-region temperatures also underwent a transverse motion. It is thus suggested that the flare reconnection rapidly removes the outer fields of the emerging flux to allow its twisted core field to erupt, a scenario favoring the jet-scale magnetic breakout model as recently advocated by Moore et al. in 2010.

P17.35

Chromospheric Response At The Photospheric Dynamic

Aleksandra Andic[1], J. Chae[2], H. Park[3], H. Yang[4]

[1]Big Bear Solar Observatory, [2]Astronomy Program, Department of Physics and Astronomy, Seoul National University, Korea, Republic of, [3]Astronomy Program, Department of Physics and Astronomy, Seoul National University, Korea, Republic of, [4]Astronomy Program, Department of Physics and Astronomy, Seoul National University, Korea, Republic of.

7:30 AM Monday - 8:30 AM Thursday

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We analysed the event in the chromosphere and its connection to the photo- spheric dynamic. The observations were done at New Solar Telescope at the Big Bear Solar Observatory using the photometry in TiO spectral line and FISS spec- trograph scanning Ca II and Hα spectral lines.

The event showed strong plasma flows and propagating oscillations that coin- cided with the photospheric dynamic. The movement of the footprints of the flux tubes in photosphere indicated a possible flux tube entanglement and mag- netic reconnection that caused observed brightening. The waves, originating in the photosphere, were propagating prior the event. The reconnection itself caused additional burst of the oscillations originating at the place of the reconnection. This event are complex and contain both jets and the oscillatory propagation.

P17.36

Modeling of Ca II Absorption Features in the Solar Atmosphere

Alexandra Truebenbach[1]
[1]Wesleyan University.

7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center

The Ca II H and K and infrared triplet lines are important diagnostics of the solar atmosphere. To accurately infer solar atmospheric properties from their observed spectra, we need realistic atomic data. By using a new program that pulls atomic data from the NIST Atomic Spectra Database and TOPbase, we are able to create a variety of Ca II models. These models allow us to evaluate the accuracy of the data obtained from these databases and to determine which aspects of the Ca II model most affect the spectral lines. We found that the number of levels included in the Ca II model does not significantly contribute to the realism of the model but that the photoionization cross sections used can significantly affect the spectral lines. The cross sections provided in TOPbase are larger than those previously used to model Ca II and appear to generate a more physically accurate representation of the Ca II lines. With this knowledge, and the new program, we can efficiently analyze a greater number of atomic models in order to better understand the solar atmosphere.

This work is carried out through the National Solar Observatory's Research Experiences for Undergraduate (REU) site program.

P17.37

Observations of On-Disk Type I and II Spicules

Na Deng[1], C. Denker[2], M. Verma[2], T. Shimizu[3], C. Liu[4], H. Wang[4]
[1]CSUN and NJIT, [2]AIP, Germany, [3]ISAS/JAXA, Japan, [4]NJIT.

7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center

A coordinated observing campaign was carried out during 2010 November 16-30 using German Vacuum Tower Telescope (VTT) and Hinode to investigate properties of small-scale spicules on the solar disk. The high-spectral resolution Echelle spectrograph at the VTT on Tenerife acquired spectra of the chromospheric halpha (656.28 nm) and photospheric Fe I (656.92 nm) lines in a region centered on a small pore. Hinode mission provides high-cadence vector magnetograms, G-band and Ca II H images, EIS and XRT observations of the same region. We present statistical properties of spicules (type I and II), such as spectral characteristics, velocities, spatial distribution and temporal evolution, paying particular attention to type II spicules or chromospheric jets. We investigate the photospheric magnetic structure, flow field and their evolution attempting to find the origin of chromospheric jets. The vertical extent of identified chromospheric jets in the transition region and corona will be studied using EIS and XRT observations in conjunction with SDO observations.

P17.38

Nonpotentiality of Chromospheric Fibrils in the Active Regions NOAA 9661 and NOAA 11092

Ju Jing[1], Y. Yuan[1], K. Reardon[2], T. Wiegelmann[3], N. Deng[1], Y. Xu[1], H. Wang[1]
[1]New Jersey Institute of Technology, [2]Osservatorio Astrofisico di Arcetri, Italy, [3]Max Planck Institut f"ur Sonnensystemforschung (MPS),, Germany.

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We have developed a method to automatically segment chromospheric fibrils from Halpha observations and further identify their orientation. We assume that chromospheric fibrils are magnetic field-aligned. By comparing the orientation of the fibrils with the azimuth of the embedding chromospheric magnetic field extrapolated from the photosphere or chromosphere with the help of a potential field model, the shear angle, a measure of nonpotentiality, along the fibrils is readily deduced. Following this approach, we make a quantitative assessment of the nonpotentiality of fibrils in the active region NOAA 9661 and NOAA 11092. The spatial distribution and the histogram of the shear angle along fibrils are presented.

P17.39

Fine Structure and Optical Depth in the Solar Transition Region

Jacob Plovanic[1], C. C. Kankelborg[1], K. Williamson[1]
[1]*Montana State University.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

Unresolved fine structure in the solar transition region (TR) has long been inferred from measurements of density-sensitive line pairs showing low filling factor (< 0.01). Low filling factor models for the structure of the He II source region, however, have not been well studied. We propose a highly structured model of the lower atmosphere in which He II is formed at low filling factors, leading to high emission measure and an optically thin He II line. This transparent TR material is juxtaposed with absorbing chromospheric structures, leading to the nearly uniform center to limb behavior of the He II line as observed.

P17.40

Blue Shifted Jets in the Transition Region

Thomas Rust[1], C. C. Kankelborg[1]
[1]*Montana State University.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

We report on blue shifted jets observed at ~10 s cadence with the *MOSES* sounding rocket (first flight February 2006). *MOSES* (Multi-Order Solar EUV Spectrograph) employs multicoated diffractive optics to obtain simultaneous images and spectra of He II emission in the solar transition region.

P17.41

Response of a Model Chromosphere to Shock-generated Conduction Fronts

Sean Brannon[1], D. Longcope[1]
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7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

It is currently believed that solar flares result from magnetic reconnection leading to rapidly contracting loops. Plasma trapped on the contracting field lines is compressed and heated at two shocks propagating downward to the footpoints. These shocks, and heat fronts preceding them, drive hard X-ray emission and chromospheric evaporation. We study the response of the chromosphere using both time-dependent non-linear simulations as well as linear analysis. The linear model considers thermally diffusing acoustic pulses reflecting from a region of non-uniform sound speed. We compare results from these two models in the case of small-amplitude linear pulses.

This work is supported by grants from the NSF and DOE.

P17.42

Sunspot Cycle 24 Ascent To Peak Activity

Harjit S. Ahluwalia[1], J. Jackiewicz[2]
[1]*Univ. of New Mexico,* [2]*New Mexico State University.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

Sunspot cycle 23 exhibited two unusual features. First, it lasted too long. Second, the interplanetary magnetic field intensity at earth orbit reached the lowest value since in situ measurements in space began in October 1963. These physical anomalies significantly altered the early forecasts for the sunspot activity for cycle 24; we note that there was a significant change in the behavior of sun during cycle 22. We discuss the observed trends and their effect on our solar activity forecasting technique, leading to our prediction for cycle 24 activity parameters; it will be only half as active as cycle 23, reaching its peak in May 2013. We speculate about the implications of this outcome on the future earth climate change and the ensuing socio-economic-political consequences.

P17.43

Understanding the Origin of the Extended Minimum of Sunspot Cycle 23

Andres Munoz-Jaramillo[1], D. Nandy[2], P. C. H. Martens[3]

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7:30 AM Monday - 8:30 AM Thursday

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The minimum of solar cycle 23 was characterized by very weak polar field strength and a large number of sunspot-less days that was unprecedented in the space age. This has had significant consequences in the heliospheric space environment in terms of record-high cosmic-ray flux and low levels of solar irradiance - which is the primary natural driver of the climate system. During this un-anticipated phase, there was some speculation as to whether the solar minimum could lead to a Maunder-like grand minimum which coincided with the Little Ice Age. Here we present the first consistent explanation of the defining characteristics of this unusual minimum based on variations in the solar meridional plasma flows, and discuss how our results compare with observations.

This work is funded by NASA Living With a Star Grant NNX08AW53G to Montana State University/Harvard-Smithsonian Center for Astrophysics and the Government of India’s Ramanujan Fellowship.

P17.44

Ca Ii K And H Measurements From The Solis Iss Instrument

Luca Bertello[1], A. A. Pevtsov[1], A. Pietarila[1], J. W. Harvey[1], R. M. Toussaint[1], SOLIS Team

[1]National Solar Observatory.

7:30 AM Monday - 8:30 AM Thursday

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Precise measurements of the disk integrated solar Ca II K and H lines play a critical role in many investigations of solar activity and studies related to solar irradiance variability. The Integrated Sunlight Spectrometer(ISS) operating at the National Solar Observatory at Kitt Peak (Arizona) since December 2006 is designed to obtain high spectral resolution (R = 300,000) observations of the Sun as a star in a broad range of wavelengths (350 nm -1100 nm). The ISS is one of three instruments, with the Vector Spectro-Magnetograph (VSM) and the Full Disk Patrol (FDP), comprising the Synoptic Optical Long-term Investigations of the Sun (SOLIS) - a synoptic facility for solar observations operating at NSO/Kitt Peak. The ISS takes daily observations of solar spectra in nine spectral bands, including the Ca II K and H lines. We describe recent improvements in data reduction of Ca II K and H observations, and present time variations of parameters derived from the profiles of these spectral lines. Some properties of these time series are also discussed.

P17.45

Full-disk Solar H-alpha Images From GONG

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[1]*National Solar Obs.,* [2]*AFRL,* [3]*Cobham,* [4]*Daystar Filters.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Since mid-2010 the Global Oscillation Network Group (GONG) has collected H-alpha images at six sites around the world. These images provide a near real-time solar activity patrol for use in space weather applications and also an archive for research purposes. Images are collected once per minute, dark, smear, and flat corrected, compressed and then sent via the Internet to a 'cloud' server where reduction is completed. Various reduced images are usually available within a minute after exposure. The H-alpha system is an add-on to the normal GONG helioseismology instrument and does not interfere with regular observations. A polarizing beamsplitter sends otherwise unused 656 nm light through two lenses to a Daystar 0.04 nm mica etalon filter. The filter is matched to an image of the GONG light feed entrance pupil and sees an image of the Sun at infinity. Two lenses behind the filter form the solar image on a DVC-4000 2k x 2k interline transfer CCD camera. Exposure times are automatically adjusted to maintain the quiet disk center at 20% of full dynamic range to avoid saturation by bright flares. Image resolution is limited by diffraction, seeing and some high-order wavefront errors in the filters. A unique dual-heater system was developed by Daystar to homogenize the passband characteristics of the mica etalons. The data are in regular use for space weather forecasting by the U.S. Air Force Weather Agency, which funded construction and installation of the instruments. Operational and reduction improvements are underway and archived data are already being used for research projects. The Web site URL is http://halpha.nso.edu.

P17.46

Solar Magnetic Fields As Observed By Solis

Anna Pietarila[1], L. Bertello[1], L. Callahan[1], B. Harker[1], J. Harvey[1], A. Marble[1], A. Pevtsov[1], R. Toussaint[1]
[1]*National Solar Observatory.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Vector Spectromagnetograph (VSM), part of the Synoptic Optical Long-term Investigations of the Sun (SOLIS), makes spectropolarimetric observations of the full-disk of the Sun in the photospheric Fe I lines around 630 nm (Stokes I, Q, U and V) and the chromospheric Ca II 854.2 nm (Stokes I and V) line. We present some of the updated SOLIS VSM data products and show how they compare with data from other instruments, e.g., SDO/HMI and Hinode/SP. We also illustrate some of the differences between the photospheric and chromospheric magnetograms, and how they can be used to study the height variation of the magnetic field.

P17.47

Status of Synoptic Optical Long-term Investigation of the Sun (SOLIS) Project.

Alexei A. Pevtsov[1], K. Streander[1], J. Harvey[1], L. Bertello[1], D. Branston[1], J. Britanik[1], L. Callahan[1], L. Cole[1], E. Galayda[1], B. Harker[1], D. Hauth[1], D. Jaksha[1], C. Leiker[1], A. Marble[1], N. Mills[1], A. Pietarila[1], K. Schramm[1], E. Stover[1], I. Suarez-Sola[1], R. Toussaint[1]
[1]*National Solar Observatory.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Synoptic Optical Long-term Investigation of the Sun (SOLIS) is a suite of three instruments to study various aspects of solar activity. Vector Stokes Magnetograph (VSM) takes full disk longitudinal magnetograms in the photosphere (Fe I 6301 A-6302 A) and the chromosphere (Ca II 8542A), the

photospheric vector magnetograms, and the full disk images of equivalent width for He I 10830A. The VSM data set goes back to August 2003. Integrated Sunlight Spectrometer (ISS) provides high-resolution spectra of sun-as-a-star for nine selected spectral bands (starting from December 2006). Full-Disk Patrol (FDP) observes full disk images of the Sun at high cadence in several selected wavelengths (starting from June 2011). In the last two years, the SOLIS instruments and data reduction went through a series of upgrades resulting in higher data quality. These upgrades include new CCD cameras, photo guider, and improved magbias calculations and data reduction of ISS line profiles. We will present the current status of SOLIS, and show the comparison between SOLIS observations with other instruments.

P17.48

Dynamic Current Sheet Formation and Evolution with Application to Inter-(Super)granular Flow Lanes and Quasi-Homologous Jet Activity

Justin K. Edmondson[1], M. Velli[1]
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center

The coronal magnetic field structure is an immensely complex system constantly driven away from equilibrium by global drivers such as photospheric flow, flux emergence/cancellation at the lower boundary, helicity injection and transport, etc. In low-beta plasma systems, such as solar corona, the Maxwell stresses dominate forces and therefore the system dynamics. General Poynting stress injection (i.e., flux injection, helicity injection, translational motions, or any combination thereof) results in (possibly large) geometric deformations of the magnetic field, such that the Maxwell stresses distribute as uniformly as possible, constrained by the distorted geometry and topology of the bounding separatricies. Since the topological connectivity is discontinuous across these separatrix surfaces, the magnetic stresses will be discontinuous there as well, manifesting as current sheets within the field. The solar magnetic field undergoes major geometric expansion passing from the photosphere, through the chromosphere, into the corona. No matter the specific details, a mixed polarity distribution at the lower boundary and the divergence-free condition require invariant topological features such as an X-line and separatricies to exist between fields emanating from separate regions of the photosphere. We present the results of fully-3D numerical simulations of a simplified low-beta model of this field expansion. A symmetric injection of Maxwell stresses into this geometry inflates strongly line-tied fields, generating a region of large current densities and magnetic energy dissipation. Elsewhere the injected stresses accumulate along the existing separatricies. There is no evidence of reconnection dynamics until after the initial left-right parity is broken. Once the symmetry breaks, the X-line deforms explosively into a Syrovatskii-type current sheet, leading to a succession of quasi-homologous jet dynamics. The bursty-oscillations of these jets occur as the stresses within the low-lying arcades are alternately relived by reconnection. These results have applications to jet activity in the low-corona, and general lower-coronal boundary dynamics.

P17.49

Fields, Flares, And Forecasts

L. Boucheron[1], **Amani Al-Ghraibah**[1], J. McAteer[1], H. Cao[1], J. Jackiewicz[1], B. McNamara[1], D. Voelz[1], B. Calabro[1], K. DeGrave[1], M. Kirk[1], A. Madadi[1], A. Petsov[1], G. Taylor[1]
[1]*New Mexico State University.*

7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center

Solar active regions are the source of many energetic and geo-effective events such as solar flares and coronal mass ejections (CMEs). Understanding how these complex source regions evolve and produce

these events is of fundamental importance, not only to solar physics, but also to the demands of space weather forecasting. We propose to investigate the physical properties of active region magnetic fields using fractal-, gradient-, neutral line-, emerging flux-, wavelet- and general image-based techniques, and to correlate them to solar activity. The combination of these projects with solarmonitor.org and the international Max Millenium Campaign presents an opportunity for accurate and timely flare predictions for the first time.
Many studies have attempted to relate solar flares to their concomitant magnetic field distributions. However, a consistent, causal relationship between the magnetic field on the photosphere and the production of solar flares is unknown. Often the local properties of the active region magnetic field - critical in many theories of activity - are lost in the global definition of their diagnostics, in effect smoothing out variations that occur on small spatial scales. Mindful of this, our overall goal is to create measures that are sensitive to both the global and the small-scale nature of energy storage and release in the solar atmosphere in order to study solar flare prediction. This set of active region characteristics will be automatically explored for discriminating features through the use of feature selection methods. Such methods search a feature space while optimizing a criterion - the prediction of a flare in this case. The large size of the datasets used in this project make it well suited for an exploration of a large feature space.
This work is funded through a New Mexico State University Interdisciplinary Research Grant.

P18
Upper Atmosphere
Poster
Exhibit Hall 1 - Las Cruces Convention Center

P18.01
Are Spicules the Primary Source of Hot Coronal Plasma?
James A. Klimchuk[1]
[1]NASA GSFC.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The recent discovery of Type II spicules has generated considerable excitement. It has even been suggested that these ejections can account for a majority of the hot plasma observed in the corona, thus obviating the need for “coronal” heating. If this is the case, however, then there should be observational consequences. We have begun to examine some of these consequences and find reason to question the idea that spicules are the primary source of hot coronal plasma.

P18.02
Comparison of Farside Observations of Solar Activity from STEREO's Extreme UltraViolet Imager and the Global Oscillations Network Group (GONG)
Paulett C. Liewer[1], I. Gonzalez-Hernandez[2], W. T. Thompson[3], J. R. Hall[1], F. Hill[2]
[1]Jet Propulsion Laboratory, California Institute of Technology, [2]National Solar Observatory, [3]Adnet Systems Incorporated.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Beginning February 18, 2011, the STEREO mission, for the first time, gave us a “whole Sun” view of the entire corona in extreme ultraviolet (EUV) light. At this time, the twin STEREO spacecraft were 180° apart and roughly ±90° from Earth. For the next several years, as the STEREO spacecraft drift further from Earth, EUV images from STEREO combined with the Earth-side images from the Solar Dynamics

Observatory will continue to show the solar activity in the chromosphere and corona for the full Sun. Here, we compare these three-spacecraft EUV observations of farside solar activity with the prediction of far side active regions from helioseismology using NSO GONG observations (see http://stereo-ssc.nascom.nasa.gov/beacon/beacon_farside.shtml). We compare cases where (1) a known active region persists throughout its farside passage, and (2) where a new active region emerges on the farside and rotates around to the Earth-side. We also discuss tools developed to help further in-depth comparison of solar observations utilizing far-side data.

P18.03

Magnetic Energy Storage in Coronal Active Regions

Richard Wolfson[1], C. Drake[1], M. Kennedy[1]

[1]Middlebury College.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

We consider magnetic energy storage in a force-free coronal model that simulates an active region by superposing a strong, localized magnetic bipole on a global background dipole. As we found earlier for dipolar and quadrupolar boundary conditions, our solutions develop detached flux ropes, whose energy can exceed that of the corresponding open field; this excess energy is available to power eruptive events such as coronal mass ejections. Our earlier work, and that of others on related magnetic configurations, has generally yielded excess energies of at most approximately 25 percent of the corresponding potential-field energy. Our new active-region models greatly exceed that value, with stressed force-free fields whose energy excess above the open-field state can be well over 100 percent of the energy stored in the associated potential field. Moving the model active region poleward increases the maximum value of this excess stored energy.

This work is funded by NSF grant AGS0940503 to Middlebury College.

P18.04

Whither goes Cycle 24? A View from the Fe XIV Corona

Richard C. Altrock[1]

[1]Air Force Research Lab..

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

Solar Cycle 24 had a historically prolonged and weak start. Observations of the Fe XIV corona from the Sacramento Peak site of the National Solar Observatory showed an abnormal pattern of emission compared to observations of Cycles 21, 22, and 23 from the same instrument. The previous three cycles had a strong, rapid "Rush to the Poles" in Fe XIV. Cycle 24 displays a delayed, weak, intermittent, and slow "Rush" that is mainly apparent in the northern hemisphere. If this Rush persists at its current rate, evidence from previous cycles indicates that solar maximum will occur in approximately early 2013. At lower latitudes, solar maximum previously occurred when the greatest number of Fe XIV emission regions* first reached approximately 20° latitude. Currently, the value of this parameter at 20° is approximately 0.15. Previous behavior of this parameter indicates that solar maximum should occur in approximately two years, or 2013. Thus, both techniques yield an expected time of solar maximum in early 2013.

*annual average number of Fe XIV emission features per day greater than 0.19

P18.05

Propagating Kink Waves in Stratified Magnetic Waveguides of the Solar Corona

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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Recent observations using the Coronal Multi-Channel Polarimeter (CoMP) show ubiquitous propagating waves of low amplitude in magnetic loops of the solar corona. These observations have been interpreted as magnetohydrodynamic (MHD) resonant kink waves. It has been shown that resonant absorption is a robust physical mechanism to explain the observed damping of MHD kink waves in the solar atmosphere due to naturally occurring plasma inhomogeneity in the direction transverse to the magnetic field. In the present study, for the first time we investigate the properties of propagating kink waves in solar magnetic waveguides including the effects of both longitudinal and transverse plasma inhomogeneity. Importantly, it is found that the wavelength is only dependent on the longitudinal stratification and the amplitude is simply a product of the two effects. In light of these results the advancement of solar atmospheric magnetoseismology by exploiting high spatial/temporal resolution observations of propagating kink waves in magnetic waveguides to determine the length scales of the plasma inhomogeneity along and transverse to the direction of the magnetic field is discussed.

P18.06
Photospheric Flux Cancellation and the Build-up of Sigmoidal Flux Ropes
Antonia Savcheva[1], L. Green[2], E. DeLuca[3], A. van Ballegooijen[3]
[1]Boston University, [2]Mullard Space Science Laboratory, University College London, United Kingdom, [3]Harvard-Smithsonian Center for Astrophysics.
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The magnetic structure of sigmoidal active regions is generally associated with the presence of a twisted flux rope held down by a potential arcade. There are competing theories of how the flux rope develops - by flux emergence, cancellation, or footpoint motions. We look at how flux cancellation in several sigmoidal regions, observed with XRT and AIA, affects the buildup of the underlying flux ropes. We use MDI and HMI magnetograms to quantify the flux cancellation, and the flux rope insertion method to construct non-linear force free field models of the regions. We present magnetic maps and the 3D flux rope structure. We correlate the locations of flares and build-up of free energy and helicity with flux cancellation events. We show how the flux ropes energy and flux budget changes with the different stages in the flux cancellation.

P18.07
MHD Simulations of Coronal Plumes
Roberto Lionello[1], M. Velli[2], J. A. Linker[1], Z. Mikic[1]
[1]Predictive Science Incorporated, [2]Jet Propulsion Laboratory.
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The expansion of a coronal hole filled with a discrete number of higher density coronal plumes is simulated using a time-dependent 2D code. A solar wind model including an exponential coronal heating function and a flux of Alfven waves propagating both inside and outside the structures is taken as a basic state. Different plasma plume profiles are obtained by using different scale heights for the heating rates. Remote sensing and solar wind in situ observations are used to constrain the parameter range of the study. Time dependence due to plume ignition and disappearance is also discussed. Velocity differences of the order of ~50 km/s, such as those found in microstreams in the high-speed solar wind, may be

easily explained by slightly different heat deposition profiles in different plumes. Statistical pressure balance in the fast wind data may be masked by the large variety of body and surface waves which the higher density filaments may carry, so the absence of pressure balance in the microstreams should not rule out their interpretation as the extension of coronal plumes into interplanetary space. Mixing of plume-interplume material via the Kelvin-Helmholtz instability seems to be possible, within the parameter ranges of the models defined here, only at large distances from the Sun, beyond 0.2-0.3 AU. Plasma and composition measurements in the inner heliosphere, such as those which will become available with Solar Orbiter and Solar Probe Plus, should therefore definitely be able to identify plume remnants in the solar wind.

P18.08

3D Structure and the Evolution of EUV Bright Points Observed by STEREO/SECCHI/EUVI: Evidence for Coronal Magnetic Reconnection Driven by Emerging Magnetic Flux?

Ryun Young Kwon[1], J. M. Davila[2], L. Ofman[1]

[1]Catholic University and NASA Goddard Space Flight Center, [2]NASA Goddard Space Flight Center.

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The 3D structure of EUV bright points and its physical relation with the underlying magnetic flux concentrations are unveiled here observationally for the first time. The heights of EUV bright points have been measured within their lifetimes by 3D reconstruction method developed by Kwon, Chae, & Zhang (2010) using data sets taken from STEREO/SECCHI/EUVI. We found three distinct changes in the heights which were decreasing, increasing, and constant. In general, EUV bright points are multi-temperature loop system whose hot loops (T~10^6.2K) with an average height of 8.9Mm are overlying cooler loops (T < 10^6.0K) with an average height of 6.7Mm. This loop system has cool legs which have the peak temperature of T~10^4.9K and an average height of 5.2Mm. The heights were found to have remarkable correlations with lengths and distances of two opposite magnetic flux concentrations, indicating that the 3D structures of bright points were determined by the geometry of associated photospheric magnetic fluxes. Accordingly, the three types of bright points we found were associated with three distinct types of their underlying magnetic fragments: converging, diverging, and shearing. In all cases, both flux emergences and flux cancellations were observed during the lifetimes of the bright points. The flux emergences were dominant in the initial phase and the flux cancellations were significant after the intensities reached their maxima. Our results suggest that EUV bright points may be the flaring loop systems (Masuda et al. 1994) formed by coroanl magnetic reconnection and the flux emergence appears to be important to driving the coronal magnetic reconnection.

P18.09

New Results Revealed By Enhanced Extreme-Ultraviolet Images

Guillermo A. Stenborg[1], A. Vourlidas[2], R. Howard[2]

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Groundbreaking observations of the low solar corona at extreme ultraviolet (EUV) wavelengths have been provided by the EIT instrument on board SOHO for more than 15 years. At the beginning of 2007, the EUVI instruments onboard the twin STEREO S/C opened doors and commenced to image the EUV low corona with a better cadence and better spatial resolution from two vantage points off the Sun-Earth line. And now, since February 2010 the AIA instrument on board the Solar Dynamics Observatory observes the low EUVI corona at a 10 sec cadence in 8 wavelengths. Despite the increasing quality of the EUV observations, they have not been fully exploited. A customized wavelet-based image cleaning and enhancing technique that exploits the multi-scale nature of the observed solar features has been developed (Stenborg et al., 2008) to maximize the scientific return of the EIT observations. We have now adapted it to work with STEREO/EUVI and SDO/AIA images. Its application has already helped unveil phenomena only theorized before, as well as revealed phenomena that have not found a satisfactory explanation yet. In this presentation, a brief survey of the new products and recent discoveries will be shown.

P18.10

Topology of Coronal Fields from Potential Field Models

Marc L. DeRosa[1], C. J. Schrijver[1], G. Barnes[2]

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The topology of the solar coronal magnetic field has been the subject of much recent interest, due to its apparent importance in determining (for example) the sources of the solar wind, the evolution of coronal hole boundaries, and whether the configurations of coronae overlying active regions are unstable and thus possibly eruption-prone. We identify the topological skeleton (null points, spline lines, separators, and separatrix surfaces) for a selection of dates of interest from the database of potential-field source-surface models available through the ``PFSS'' SolarSoft package. Several features of interest have been identified by recent studies (e.g., Antiochos et al. 2007, Parnell et al. 2010, Titov et al. 2011), including exceedingly narrow channels of open field or separators associated with inferred reconnection sites. We find that these features of interest occur frequently in the topologies of even potential-field models of the magnetic corona. The actual solar corona is of course likely to involve even more complex topologies, especially as its dynamics and evolution are taken into account.

P18.11

GX_Simulator: An Interactive Idl Widget Tool For Visualization And Simulation Of Imaging Spectroscopy Models And Data

Gelu M. Nita[1], G. D. Fleishman[1], D. E. Gary[1], A. A. Kuznetsov[2], E. P. Kontar[3]

[1]NJIT, [2]Armagh Observatory, United Kingdom, [3]University of Glasgow, United Kingdom.

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An interactive IDL widget application intended to provide a flexible tool that allows the user to generate spatially resolved radio and/or X-ray spectra is presented. The object-based architecture of this application provides full interaction with local 3D magnetic field models (e.g., from an extrapolation) that may be embedded in a global coronal model. Various tools provided allow users to explore the magnetic connectivity of the model by generating magnetic field lines originating in user-specified volume positions. Such lines may serve as reference lines for creating magnetic flux tubes, which are further populated with user-defined analytical thermal/non thermal particle distribution models. By default, the application integrates IDL callable DLL and Shared libraries containing fast GS emission codes developed in FORTRAN and C++ and soft and hard X-ray codes developed in IDL. However, the interactive interface allows interchanging these default libraries with any user-defined IDL or external callable codes designed to solve the radiation transfer equation in the same or other wavelength ranges of interest. We illustrate the tool capacity and generality by a real-time computation of microwave and X-ray images from realistic magnetic structures obtained from nonlinear force-free field extrapolations.
This work was supported in part by NSF grants AGS-0961867, AST-0908344, and NASA grants NNX10AF27G and NNX11AB49G to New Jersey Institute of Technology, by a UK STFC rolling grant,

STFC/PPARC Advanced Fellowship, and the Leverhulme Trust, UK. Financial support by the European Commission through the SOLAIRE and HESPE Networks is gratefully acknowledged.

P18.12

Activity-brightness Correlations For The Sun And Sun-like Stars

D Preminger[1], G. Chapman[1], A. Cookson[1]
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We examine the effects of active regions on the relative brightness of the solar disk at three different wavelengths. Our study is based on photometric parameters derived from images taken at the San Fernando Observatory, and examines daily data for two full solar cycles. We measure the contrast of solar features on broadband red and blue images, and on Ca II K-line images, which allows us to compute the net brightness variations due to solar activity. We show that while the Ca II K-line variability is directly correlated with the solar activity cycle, variability in the red and blue continuum is anti-correlated with solar activity, on solar cycle timescales. Our blue and red continuum filters are quite similar to the Stromgren b and y filters used to measure stellar photometric variability. Sun-like stars whose continuum brightness varies inversely with activity are therefore revealed to be similar to the Sun.

This work has been supported in part by NASA LWS Grant NNX07AT19G and NSF Grant ATM-0848518.

P18.13

The Solar Corona and a CME at the 2010 Total Eclipse

Jay M. Pasachoff[1], V. Rusin[2], H. Druckmüllerová[3], M. Saniga[4], M. Lu[1], C. Malamut[1], D. B. Seaton[5], L. Golub[6], A. J. Engell[6], S. W. Hill[7], R. Lucas[8]
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The 11 July 2010 total solar eclipse was observed on the ground from French Polynesia and, 83 minutes later, from Easter Island, and near-simultaneous images were made with spacecraft instruments including AIA/SDO, HMI/SDO, EUVI/STEREO, SWAP/PROBA2, EIT/SOHO, and LASCO/SOHO. We report on changes in the corona detectable with high-resolution image processing of the ground-based eclipse coronal imaging, including two CME's that were seen to evolve. We compare with the spacecraft images to give a complete depiction of coronal structure at the time of the eclipse, which corresponded to a low but rising phase of the solar-activity cycle.

We acknowledge the support of NASA's MSFC NNX10AK47A, NSF REU AST-1005024 with DoD ASSURE, VEGA 2/0098/10 of the Slovak Acad. Sci, 205/09/1469 of the Czech Science Foundation, PRODEX C90345 of ESA/BELSPO, FP7/2007-2013/218816 SOTERIA, Lockheed Martin; for equipment: Nikon Professional Services, ASTELCO Systems GmbH (Germany), and National Geographic Society's Photographic Division; and colleagues Y.-M. Wang (NRL), S. Habbal (U. Hawaii), H. Lanteires (Tatakoto), and J. Kern (Carnegie Obs.).

P18.14

Modeling TSI Variations from SORCE/TIM

Gary A. Chapman[1], A. Cookson[1], D. Preminger[1]
[1]*CSUN.*

7:30 AM Monday - 8:30 AM Thursday

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Total Solar Irradiance (TSI) measurements have been available from the TIM instrument on the SORCE spacecraft since 2003. We compare TSI data with photometric indices from red and K-line images obtained on a daily basis at the San Fernando Observatory (SFO). For 1375 days of data from 2003 March 02 to 2010 May 05 we compare the data in linear multiple regression analyses. The best results come from using only two photometric indices, the red and K-line photometric sums, and SORCE TSI 6-hour averages interpolated to the SFO time of observation. For this case, we obtain a coefficient of multiple correlation, R^2, of 0.94798 and a quiet-Sun irradiance, $S_o~=~1360.778~\pm~0.004~W/m^2$. These results provide tighter contstraints than before on hypotheses linking TSI variations with assumed changes in the quiet Sun. This research has been partially supported by NSF Grant ATM-0848518.

P18.15
Modeling Waves And Flows In Active Region Loops
Leon Ofman[1], T. Wang[1], J. M. Davila[2]
[1]Catholic University and NASA's GSFC, [2]NASA's GSFC.
7:30 AM Monday - 8:30 AM Thursday
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Recent Hinode/EIS observations indicated that slow magnetosonic waves are present in active region loops. Some of the spectral data were also interpreted as evidence of quasi-periodic flows. We perform three dimensional MHD model of an active region with waves and flows in coronal loops. The model is initiated with a dipole magnetic field and gravitationally stratified density, and velocity pulses are driven periodically in localized regions at the footpoints of magnetic loops. The resulting flows produce higher density loops compared to the surrounding plasma by injecting material along the field. We find that the excitation of periodic flows with subsonic speeds result in the excitation of slow magnetosonic waves that propagate along the loops. The phase speed of the waves is ~100 km/s, close to coronal sound speed. When the amplitude of the driving pulses is increased we find that slow shock trains are produced. Using the results of the 3D MHD model we suggest that the observed slow magnetosonic waves and quasi periodic-flows are driven by the same quasi-periodic impulsive events at the bases of active regions.

P18.16
Statistical Determination and Comparison of Non-thermal Velocity Distributions from EIS Full-CCD Linewidth Measurements
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[1]Catholic Univ of America/ NASA GSFC, [2]NASA GSFC.
7:30 AM Monday - 8:30 AM Thursday
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Excess broadening in the emission line spectra from non-thermal motions provide an unresolved energy input into the coronal plasma. The driving mechanism for and significance of the energy contributions of this non-thermal component has been a subject of much discussion. Observationally constraining the non-thermal contributions to line broadening in the coronal emission spectra provides valuable limitations which coronal physics models must take into account. Using full-CCD raster observations from EIS, we determine a distribution of non-thermal velocities for all lines in each full-CCD raster observation for both spatially-averaged and spatially-resolved EIS spectra. We present here composite non-thermal velocity distributions incorporating a multiple elements, ionization states and temperatures for a variety of EIS observations including both active region and quiet sun emission. We determine an expectation value for the velocity of the non-thermal component from this composite statistical

approach. Initial spatially-averaged results from 7 independent EIS rasters show a strong Gaussian peak at approximately 20 km/s per second.. We address the implications of this consistent velocity and energy peak in the spatially-averaged results as well as present and compare our analysis from spatially-resolved spectra for each EIS raster included in the spatially-averaged study.

P18.17

How Geometric Factors Affect Coronal Loop Properties

Yung Mok[1], R. Lionello[2], Z. Mikic[2], J. Linker[2]

[1]Univ. of California, Irvine, [2]Predictive Science Inc..

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We studied over 200 closed field lines from a realistic FF field in the neighborhood of a sunspot group. Each field line can be perceived as a coronal loop with plasma density and temperature profiles when appropriate heating and radiative cooling are applied. These field lines have a variety of properties, including spatially varying flux tube area and the geometric shape that determines gravity projection. As a result, we see a large range of loop behaviors. Some reach a static equilibrium. Some reach a steady state with a one-way siphon flow. However, most of them do not reach a steady state. Their temperature/density oscillate in time between a hot phase and a cool phase periodically, with approximately 90 degrees phase difference between temperature and density. By artificially modifying their geometric properties and/or heating, we show that we can alter their behaviors, for example, from an oscillating type to a steady-state type. Our study underscores the importance of using the correct geometry when using 1D simulation to model coronal loops.

P18.18

VlA And SOHO Observations Of Decimetric Bursts And Type I Noise Storm Depressions In Association With Evolving Coronal Loops And Coronal Mass Ejections

Robert F. Willson[1]

[1]Tufts Univ..

7:30 AM Monday - 8:30 AM Thursday

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Very Large Array (VLA) observations at 91 cm wavelength have been combined with data from the SOHO (EIT and LASCO) solar mission to investigate evolving magnetic fields above active regions and their association with nonthermal electrons that give rise to Type I noise storms and impulsive decimetric bursts in the middle corona. The VLA observations provide information about the medium-sized and large-scale magnetic structures in the corona where nonthermal particle acceleration and energy release take place. On one day, a decimetric pulsation source at the limb appeared to be associated with coronal heating and structural changes in the underlying loops imaged by EIT on SOHO. On another day, the intensity of a long-lasting type I noise storm source transiently decreased as a coronal mass ejection, observed by LASCO, propagated outwardly from the limb. These observations suggest that the thermal environment of the corona above the region where the quiescent noise storm was detected was affected by energy deposited in this region of the corona by the CME.

P18.19

X-ray Bright Point Evolution as a Global Phenomenon

Matthew R. Voigt[1], P. S. Hardersen[1]

[1]University of North Dakota.

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X-ray bright points (XBPs) are small, complex, loop-like structures found within the corona of the Sun. They emit within the soft X-ray portion of the electromagnetic spectrum and are easily imaged by instruments such as the Hinode X-ray Telescope (XRT). XRT data are being used to conduct a two-week longitudinal study to determine how XBPs evolve and change, individually and as a global coronal phenomenon, in size, morphology, and flux. XBPs from thirty synoptic images taken during solar minimum in March 2008 are being calibrated and measured. The goal of this research is to examine XBPs over a greater time span that most previous studies and to provide additional data to constrain XBP formation and dissolution mechanisms.
Images are calibrated using SolarSoft routines provided by the XRT science team. The data reduction process includes image flattening, defining XBP boundaries using a minimum flux threshold technique, and calculating individual XBP integrated fluxes and areas. This information, coupled with the latitudinal and longitudinal position of each XBP, provides insight into XBP evolution as individual and global structures. By studying XBPs through a greater time span, it may be possible to gain a better understanding of XBP lifespans and the range of lifespans, differences in XBP activity throughout a solar cycle, and why XBPs can persist in the normal corona as well as in coronal holes.
This information will also be useful for models that not only test proposed XBP formation and dissolution mechanisms, but can also assist in constraining XBP flux contributions to the corona. This work represents one of the first two solar physics projects from the University of North Dakota (see also: Hardersen et al., 2011, this meeting). Our goal is to develop a robust, thriving solar physics research group at the University of North Dakota.

P18.20

Current Sheet Formation and Reconnection at a Magnetic X Line

C. Richard DeVore[1], S. K. Antiochos[2]
[1]NRL, [2]NASA GSFC.
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Phenomena ranging from the quiescent heating of the ambient plasma to the highly explosive release of energy and acceleration of particles in flares are conjectured to result from magnetic reconnection at electric current sheets in the Sun’s corona. We are investigating numerically the formation and eventual reconnection of a current sheet in an initially potential 2D magnetic field containing a null. Subjecting this simple configuration to unequal stresses in the four quadrants bounded by the X-line separatrix distorts the potential null into a double-Y-line current sheet. Although the gas pressure is finite in our simulations, so that the plasma beta is infinite at the null, we find that even small distortions of the magnetic field induce the formation of a tangential discontinuity there. This result is well known to occur in the zero-beta, force-free limit; surprisingly, it persists into the high-beta regime where, in principle, a small plasma pressure inhomogeneity could balance all of the magnetic stress. In addition to working to understand the dynamical details of this ideal process, we are examining the effect of resistive dissipation on the development of the current sheet and are seeking to determine the critical condition for fast-reconnection onset in the sheet. Our progress on understanding these issues, and the implications for the dynamic activity associated with current sheets in the solar corona, will be reported at the conference. We gratefully acknowledge NASA sponsorship of our research.

P18.21

Automated Detection of Oscillatory Behavior in the Corona

Brandon Calabro[1], J. McAteer[1]
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7:30 AM Monday - 8:30 AM Thursday

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We present an automated analysis package that reads in 3D data cubes and extracts oscillatory behavior metadata. The code extracts specific information through the time dimension of each pixel and outputs just four image files of oscillatory periodicity, duration, start time and peak time that represent the entire data cube.
This metadata shows that there are several factors that are creating these oscillatory behaviors within the corona. Waves, nanoflares and flows are found to be the main contributing factors. Upwardly propagating waves differ significantly within the quiet and active regions of the Sun. Nanoflares are found when small regions of pixels quickly brighten and then dim. Flows are defined as regions of pixels that brighten and this brightening moves over a larger region over time.
This code will be run as part of the SDO Feature Finding Team on selected data from AIA, including pre-flare, post-flare and at times of emerging flux. We will also run this on large quiet Sun data to determine more accurately which factors (waves or nanoflares) are the major contributor to the heating of the corona.

P18.22

Coronal Loop detection and seismology

Alexander Pevtsov[1], R. T. J. McAteer[1], J. Jackiewicz[1], M. Kirk[1], B. McNamara[1], K. DeGrave[1], A. Amani Al-Ghraibah[1], L. Boucheron[1], D. Voelz[1], H. Cao[1], G. Taylor[1]
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7:30 AM Monday - 8:30 AM Thursday
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Using a TRACE image with a bipolar active region and over one hundred distinguishable loops, we examine several current methods for automated coronal loop detection. Using the same TRACE image, several new approaches are also taken in an attempt to increase accuracy and completeness rates for the automated detection process. By means of these new methods the expectation is to achieve a higher degree of completeness while maintaining a high level of accuracy in the detection process. To increase completeness, an automated attempt for the reconnection between orphaned loop segments will also be tested. In the future, an approach to reconstruction of three-dimensional images from several two-dimensional images can be devised by using the detected coronal loops and a known 3D offset of each image. However this process heavily depends on the ability to accurately and completely detect the coronal loops.

P18.23

The Convex-Hull Method for Solving Differential Emission Measures in the Solar Corona

Mark A. Weber[1]
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7:30 AM Monday - 8:30 AM Thursday
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The Differential Emission Measure (DEM) describes the temperature distribution of the solar corona, but the inversion of the observations through the instrument's temperature response functions is mathematically ill-posed and typically under-constrained. The most commonly used techniques (e.g., the EM Loci Method, forward-fitting iterators, etc.) each have their drawbacks, but most importantly, they do not guarantee the solution is the globally minimum chi-square solution nor provide a way to quantitatively explore the range of solutions in the neighborhood of the globally minimum solution, which is necessary for properly evaluating levels of confidence. The Convex-Hull Method surmounts the mathematical difficulties of the DEM inversion, providing a more accurate characterization of the solution space with which to evaluate physical models against observations. I demonstrate how this

method can be used to constrain the set of temperature distributions observed in the solar corona. This work was supported under contract SP02H1701R from Lockheed-Martin to SAO, and under contract NNM07AB07C from NASA to SAO.

P18.24

Forward Modeling for Unresolved Flaring Loops

Adam Kobelski[1], D. E. McKenzie[1]

[1]Montana State University.

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The apparent width of observed coronal loops can have significant effects on the perceived evolution of flaring active regions. Frequently, comparing a model flare to observation requires an estimate of the filling factor of loops contributing to the signal. If the analysis assumes the loops are resolved, the cooling times derived from the observations are often much longer than predicted by models. We have developed software to forward model the cooling of flaring loops, and estimate their observational signatures. This allows exploration of the physical parameters necessary within a given model to reproduce the observations. We can then estimate the number of unresolved strands contained within the observed flare loop. We will present early results from this study using data from Yohkoh/SXT. The implementation of Hinode/XRT observations to improve our spatial resolution and thermal range will also discussed.

This work is supported by NASA under contract NNM07AB07C with the Harvard-Smithsonian Astrophysical Observatory. Yohkoh data are provided courtesy of the NASA-supported Yohkoh Legacy Archive at Montana State University.

P18.25

Solar Polar Coronal Hole Areas Through the Past Solar Minimum

Shea Hess Webber[1], N. Karna[2], W. D. Pesnell[3], M. Kirk[4]

[1]Catholic University, [2]George Mason University, [3]NASA GSFC, [4]New Mexico State University.

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We have used the perimeter tracking algorithm and analysis of EIT synoptic maps to extend our timeseries of polar coronal hole areas through solar minimum (through 2010). Both algorithms use 171, 195, and 304 Å images from the Extreme ultraviolet Imaging Telescope (EIT) on SOHO, the first to measure the perimeter of polar coronal holes as they appear on the limbs and the second the area of the polar coronal hole during each Carrington rotation. Line-of-sight magnetic field synoptic maps are also used to estimate the polar coronal hole area. We have updated the time series and we are analyzing uncertainties in EIT ephemeris data. We remain convinced that the northern polar hole area is measurably smaller in the recent minimum than it was at the beginning of cycle 23, while the southern polar hole area is roughly the same. Polar hole areas found via perimeter tracking agree within uncertainty with those determined using EIT synoptic map analysis. This work was supported by the Solar Dynamics Observatory.

P18.26

Role of Small-Scale Brightenings in On-Disk Coronal Hole Evolution

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In this study, we investigate the properties of small-scale brightenings that occur in and near the boundary of an on-disk coronal hole using an automatic detection algorithm. Previously, attempts to explain the quasi-rigid rotation of on-disk CH's by small-scale reconnections at the boundary have been observationally limited. Using SDO/AIA 171,193 and SDO/HMI high cadence observations, we attempt to re-examine the role small-scale brightenings may have in the evolution of on-disk CHs. We examine spatial and temporal evolution, intensity, distribution within the CH, correlation to magnetic activity, and correspondence to the distribution of the 'squashing factor', Q. We present the preliminary results of our study and discuss implications for CH boundary theories.

P18.27

Differential Emission Measure Analysis of a Polar Coronal Hole During the Recent Solar Minimum

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[1]Columbia University, [2]University of Michigan.

7:30 AM Monday - 8:30 AM Thursday

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We have performed a differential emission measure (DEM) analysis for a polar coronal hole observed during the solar minimum in 2007. The analysis was performed for the above-limb portions of five observations from the EUV Imaging Spectrometer on Hinode. The slit pointings also included quiet Sun corona near the boundary with the coronal hole. Our DEM analysis showed that none of the positions were completely isothermal. Instead the emitting material appeared to have a significant high-temperature tail and was consistent with being composed of two plasmas at different temperatures, as measured in K, of log T = 5.95 and log T = 6.15. The lower temperature peak was dominant in the coronal hole and the higher temperature peak dominant in the quiet Sun corona. We used our DEM curves to model isothermal analyses and found that relatively small deviations from isothermality can distort the results inferred using an isothermal analysis method. Isothermal temperature analyses actually measure a DEM-weighted average and can infer artificial temperature gradients if the high and low temperature parts of the DEM curve do not change uniformly with position. The isothermal analyses also do not detect different structures along the line-of-sight, which can affect the interpretation of density diagnostic line ratios.

P18.28

Coronal Bright Points and Quiet Sun Areas Observed with EUNIS-07 and EIS

Jeffrey W. Brosius[1], T. J. Wang[1], D. M. Rabin[2], R. J. Thomas[2], E. Landi[3]

[1]Catholic University of America, [2]NASA's Goddard Space Flight Center, [3]University of Michigan.

7:30 AM Monday - 8:30 AM Thursday

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The Extreme-Ultraviolet Normal-Incidence Spectrograph is a sounding rocket instrument with two independent but co-pointing imaging spectrographs. One spectrograph observes emission lines in a long-wavelength (LW) channel (300-370 A), while a second observes lines in a short-wavelength (SW) channel (170-205 A). The instrument was last flown on 6 November 2007 (EUNIS-07), when there were no active regions on the solar disk. After the flight, the absolute radiometric responses of both channels were derived from laboratory measurements obtained in the same facility used for pre-flight calibrations of SOHO/CDS and Hinode/EIS. Coordinated EUNIS-07 and EIS observations of quiet sun area near disk center reveal that the sensitivity of both EIS wavebands had diminished to 82% of their pre-launch values (Wang et al. 2011). Here we use the combined EUNIS-07 and EIS spectra to investigate quiet sun areas and small bright points observed by both instruments, as well as a larger, brighter bright point that was observed only by EUNIS-07.

P18.29

Determining the Differential Emission Measure of Bright Points Using AIA, XRT And EIS

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Bright points (BPs) are small bi-polar regions on the Sun with temperatures that range from 1 MK to 2.5 MK. We are in the initial stages of a statistical study of BP properties including the relationship between the BP differential emission measure (calculated from image data) and size. In this poster, we present preliminary results on the ability to calculate the BP differential emission measure using AIA data. We will answer the question: Can observations from AIA alone constrain the differential emission measure of BPs? First, we define a hypothetical differential emission measure and calculate the expected AIA and XRT intensities. We then attempt to reconstruct the differential emission measure from a subset of the intensities. We determine the minimum intensities required for differential emission measure calculation. We then present the differential emission measure of an observed BP determined from EIS intensities and demonstrate the ability of the AIA and XRT intensities to calculate it.

P18.30

Vector Tomography Based on Hanle and Zeeman Effects Observed from Ecliptic Plane

Maxim Kramar[1], H. Lin[2], S. Gibson[3]
[1]The Catholic University of America, [2]Institute for Astronomy, The University of Hawaii, [3]High Altitude Observatory.

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The magnetically sensitive coronal emission lines provide information about coronal magnetic field via Hanle and Zeeman effects. As the measured emission are integrated over line-of-sight, the vector tomography must be used for deriving 3D magnetic field configuration. The unique solution for any field configuration exists when observations are done from both ecliptic and out of ecliptic plane and supplied by photospheric magnetic field measurements. When observations are only from the ecliptic plane, the number of field configurations which are possible to reconstruct are reduced. We study here what types of coronal magnetic field configurations can be reconstructed based on Hanle and Zeeman effects provided by CoMP and SOLARC instruments. Effect of noise in the data and uncertainty in 3D reconstruction of the coronal density and temperature are also studied.

P18.31

Probing Coronal Magnetic Connectivity on Local and Global Scales

Chris Lowder[1], J. Qiu[1]
[1]Montana State University.

7:30 AM Monday - 8:30 AM Thursday
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Magnetic reconnection and other magnetohydrodynamic interactions between an erupting flux rope and the overlying global magnetic field of the solar corona play an important role in predicting and interpreting possible interactions with magnetic clouds at 1AU. I employ coronal dimming signatures as a diagnostic analogue of the open or closed nature and subsequent evolution of the local magnetic field. In addition, potential field source surface models will yield insight into the global overlying magnetic topology. Existing statistical data on coronal dimming, several detailed case studies, and mathematical models of the flux rope / global field interaction will yield crucial insight into the eruption process, a critical component to space weather predictions.

P18.32

Small-Scale Magnetic Reconnection at Equatorial Coronal Hole Boundaries

Derek Lamb[1], C. E. DeForest[1]

[1]Southwest Research Institute.

7:30 AM Monday - 8:30 AM Thursday

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Coronal holes have long been known to be the source of the fast solar wind at both high and low latitudes. The equatorial extensions of polar coronal holes have long been assumed to have substantial magnetic reconnection at their boundaries, because they rotate more rigidly than the underlying photosphere. However, evidence for this reconnection has been sparse until very recently. We present some evidence that reconnection due to the evolution of small-scale magnetic fields may be sufficient to drive coronal hole boundary evolution. We hypothesize that a bias in the direction of that reconnection is sufficient to give equatorial coronal holes their rigid rotation. We discuss the prospects for investigating this using FLUX, a reconnection-controlled coronal MHD simulation framework. This work was funded by the NASA SHP-GI program.

P18.33

Temperature Structure of a Coronal Cavity

Therese A. Kucera[1], S. E. Gibson[2], D. J. Schmit[3]

[1]NASA's GSFC, [2]NCAR/HAO, [3]U. Colorado, NCAR/HAO.

7:30 AM Monday - 8:30 AM Thursday

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We analyze the temperature structure of a coronal cavity observed in Aug. 2007. Coronal cavities are long, low-density structures located over filament neutral lines and are often seen as dark elliptical features at the solar limb in white light, EUV and X-rays. When these structures erupt they form the cavity portions of CMEs. It is important to establish the temperature structure of cavities in order to understand the thermodynamics of cavities in relation to their three-dimensional magnetic structure. To analyze the temperature we compare temperature ratios of a series of iron lines observed by the Hinode/EUV Imaging Spectrometer (EIS). We also use those lines to constrain a forward model of the emission from the cavity and streamer. The model assumes a coronal streamer with a tunnel-like cavity with elliptical cross-section and a Gaussian variation of height along the tunnel length. Temperature and density can be varied as a function of altitude both in the cavity and streamer. The general cavity morphology and the cavity and streamer density have already been modeled using data from STEREO's SECCHI/EUVI and Hinode/EIS (Gibson et al 2010 and Schmit & Gibson 2011).

P18.34

Study of the Coronal Wave Event of February 15, 2011 Over the Entire Solar Surface.

Oscar Olmedo[1], A. Vourlidas[2], J. Zhang[1], X. Cheng[1]

[1]George Mason University, [2]Naval Research Laboratory.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

We investigate the coronal wave associated with the February 15, 2011 X-class flare. The flare occurred at 1:44 UT in active region NOAA 11158. We use observations from the Atmospheric Imaging Assembly (AIA) aboard Solar Dynamics Observatory, and the Extreme Ultraviolet Image (EUVI) aboard the Solar Terrestrial Relations Observatory to study the propagation of the coronal wave over the entire solar surface with the help of full Sun synoptic maps. The high-cadence AIA observations allow us to examine the temporal evolution of the wave in great detail. Our investigation focuses on two aspects: (i) The

apparent transmission and reflection of the wave through a coronal hole, and (ii) the thermal response in the corona during the coronal wave passage.

P18.35

Viewing The Entire Sun With STEREO And SDO

William T. Thompson[1], J. B. Gurman[1], T. A. Kucera[1], R. A. Howard[2], A. Vourlidas[2], J. Wuelser[3], D. Pesnell[1]
[1]NASA/GSFC, [2]Naval Research Laboratory, [3]Lockheed Martin Solar and Astrophysics Laboratory.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

On 6 February 2011, the two Solar Terrestrial Relations Observatory (STEREO) spacecraft were at 180 degrees separation. This allowed the first-ever simultaneous view of the entire Sun. Combining the STEREO data with corresponding images from the Solar Dynamics Observatory (SDO) allows this full-Sun view to continue for the next eight years. We show how the data from the three viewpoints are combined into a single heliographic map. Processing of the STEREO beacon telemetry allows these full-Sun views to be created in near-real-time, allowing tracking of solar activity even on the far side of the Sun. This is a valuable space-weather tool, not only for anticipating activity before it rotates onto the Earth-view, but also for deep space missions in other parts of the solar system. Scientific use of the data includes the ability to continuously track the entire lifecycle of active regions, filaments, coronal holes, and other solar features. There is also a significant public outreach component to this activity. The STEREO Science Center produces products from the three viewpoints used in iPhone/iPad and Android applications, as well as time sequences for spherical projection systems used in museums, such as Science-on-a-Sphere and Magic Planet.

P19
BBSO
Poster

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P19.01

Sunspot Umbral Dots Detected with the New Solar Telescope

Ali Kilcik[1], V. Yurchyshyn[1], V. Abramenko[1], P. Goode[1], W. Cao[1]
[1]Big Bear Solar Observatory.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

We present a study of bright umbral dots detected inside a large sunspot of NOAA AR 11108. This study is based on high resolution data recorded on September 20, 2010 with the New Solar Telescope (NST) at Big Bear Solar Observatory. The data set, spanning 46 min, consists of a total of 184 adaptive optics corrected and speckle reconstructed images obtained with a 0.3 nm passband TiO filter centered on the 705.7 nm spectral line. The image cadence is 15 s and the pixel size of 0.0375 arcsec.
Bright umbral dots (UDs) were detected and tracked using an automatic routine. Here we only focus on long living UDs (>150 s in life time) and a total of 513 such features were detected during the observed period. We found that the average lifetime of a UD is 7.4 min and an average size is 0.34 arcsec. There is a tendency for larger UDs to be brighter (and more circular). Many UDs are not of circular shape. We will also present probability distribution of various physical parameters and compare the results to similar earlier studies.

P19.02

NST: Thermal Modeling for a Large Aperture Solar Telescope

Roy Coulter[1]
[1]Big Bear Solar Observatory.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Late in the 1990s the Dutch Open Telescope demonstrated that internal seeing in open, large aperture solar telescopes can be controlled by flushing air across the primary mirror and other telescope structures exposed to sunlight. In that system natural wind provides a uniform air temperature throughout the imaging volume, while efficiently sweeping heated air away from the optics and mechanical structure. Big Bear Solar Observatory's New Solar Telescope (NST) was designed to realize that same performance in an enclosed system by using both natural wind through the dome and forced air circulation around the primary mirror to provide the uniform air temperatures required within the telescope volume. The NST is housed in a conventional, ventilated dome with a circular opening, in place of the standard dome slit, that allows sunlight to fall only on an aperture stop and the primary mirror. The primary mirror is housed deep inside a cylindrical cell with only minimal openings in the side at the level of the mirror. To date, the forced air and cooling systems designed for the NST primary mirror have not been implemented, yet the telescope regularly produces solar images indicative of the absence of mirror seeing. Computational Fluid Dynamics (CFD) analysis of the NST primary mirror system along with measurements of air flows within the dome, around the telescope structure, and internal to the mirror cell are used to explain the origin of this seemingly incongruent result. The CFD analysis is also extended to hypothetical systems of various scales. We will discuss the results of these investigations.

P19.03

Tiny Pores Observed by New Solar Telescope and Hinode

KyungSuk Cho[1], S. Bong[1], J. Chae[2], Y. Kim[1], Y. Park[1], K. Ahn[3], Y. Katsukawa[4]
[1]KASI, Korea, Republic of, [2]SNU, Korea, Republic of, [3]BBSO, [4]NAOJ, Japan.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Seoul National University and Korea Astronomy and Space Science Institute installed Fast Imaging Solar Spectrograph (FISS) in the Cude room of the 1.6 m New Solar Telescope (NST) at Big Bear Solar Observatory on May 14, 2010. FISS is a unique system that can do imaging of H-alpha and Ca II 8542 band simultaneously, which is quite suitable for studying of dynamics of chromosphere. To investigate the relationship between the photospheric and low-chromospheric motions at the pore region, we took a coordinate observation with NST/FISS and Hinode/SOT for new emerging active region (AR11117) on October 26, 2010. In the observed region, we could find two tiny pores and two small magnetic concentrations (SMCs), which have similar magnetic flux with the pores but do not look dark. Magnetic flux density and Doppler velocities at the photosphere are estimated by applying the center-of-gravity (COG) method to the HINODE/spectropolarimeter (SP) data. The line-of-sight motions above the photosphere are determined by adopting the bisector method to the wing spectra of Ha and CaII 8542 lines. **As results, we found the followings.** (1)There are upflow motion on the pores and downflow motion on the SMCs. (2)Towards the CaII 8542 line center, upflow motion decrease and turn to downward motion in pores, while the speed of down flow motion increases in the SMCs. (3)There is oscillating motion above pores and the SMCs, and this motion keep its pattern along the height. (4) As height increase, there is a general tendency of the speed shift to downward on pores and the SMCs. **In this poster, we will present preliminary understanding of the** coupling of pore dynamics between the photosphere and the low-chromosphere.

P19.04

Active Region High Velocity Events Observed by Fast Imaging Solar Spectrograph on the NST

Kwangsu Ahn[1], J. Chae[2], J. Nah[3], H. Park[2], B. Jang[3], H. Yang[2], Y. Park[3], W. Cao[1], P. R. Goode[1]
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Fast Imaging Solar Spectrograph (FISS) is the only spectrograph-based instrument on the NST that is currently operational. With a high spectral resolution of 1.4 x 10^5 and simultaneous dual spectral band imaging, this instrument can accurately determine the physical parameters of chromospheric features --- filaments, jets and so on. Initial observations captured several peculiar dynamic events that showed high line-of-sight velocities of the order of 20 km s^-1 in the vicinity of sunspots. We expect that FISS will provide a better understanding of the physics in the chromosphere with the aid of the unprecedentedly high spatial resolution of NST.

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ATST
Poster
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P20.01
The Visible Broadband Imager: The Sun at High Spatial and Temporal Resolution
Woeger Friedrich[1], A. Tritschler[1], H. Uitenbroek[1], T. Rimmele[1]
[1]National Solar Observatory.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Visible Broadband Imager (VBI) will be the first of the five first-light instruments for the Advanced Technology Solar Telescope (ATST). It is designed to observe the solar atmosphere at heights ranging from photosphere to chromosphere. High frame-rate detectors that sample the FOV of up to 2.8 arcmin in diameter critically near or at the diffraction limit of ATST's 4 meter aperture will facilitate near real-time speckle reconstruction imaging. With its focus on high-spatial resolution, the VBI will be addressing scientific questions related to the smallest structures visible in the solar atmosphere today with high photometric precision. The capability to observe the solar atmosphere with a cadence of about 3 seconds per reconstructed image will enable the VBI to temporally resolve fast evolving structures.
In this contribution we present the current design of the VBI and highlight some scientific questions related to fast evolving, small-scale features within the solar atmosphere that the VBI will address.

P21
SDO
Poster
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P21.01
Evolution of Magnetic Field in the Flaring Active Region 11158 Observed by SDO/HMI
Xudong Sun[1], T. Hoeksema[1], Y. Liu[1], T. Wiegelmann[2], K. Hayashi[1]
[1]Stanford University, [2]MPI, Germany.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We report the evolution of the magnetic field in NOAA AR11158 over 5 days (2011 Feb 12-16) using preliminary vector magnetograms from the Helioseismic and Magnetic Imager (HMI) on board the Solar Dynamic Observatory (SDO). This region consisted of two pairs of major sunspots and displayed a

complex quadrupolar field topology. It produced multiple major flares and eruptions, including the first X-class flare of the current solar cycle. Strong shear motion and flux emergence were both present, with apparent emergence preceding each major flare. We reconstruct the coronal field from a series of vector data using a non-linear force-free (NLFF) extrapolation. The estimated free magnetic energy shows a great increase during the early emergence of the current-carrying flux, while a significant, permanent decrease (~0.5e32 erg, or 20%) is found after the X-class flare despite continuous flux injection. We relate this decrease to a previously reported, sudden change of the photospheric field after the flare. The extrapolated coronal field structure correspondingly becomes more "compact": the low-lying of field appears more sheared and stores more free energy, and higher-altitude field decays faster with height and becomes more potential. The coronal field overall becomes less-energetic.

P21.02

Studying Solar Active Regions with HMI Data

Yang Liu[1], J. Hoeksema[1], K. Hayashi[1], X. Sun[1], P. Schuck[2], K. Muglach[3]
[1]Stanford University, [2]NASA, [3]NASA/Artep, Inc..

7:30 AM Monday - 8:30 AM Thursday

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Full disk field of view, continuous time coverage, high temporal and spatial resolutions, and consistent data quality, these specifications of
the HMI observational data allows us to study in detail the evolution of solar active regions during the course from emerging to decaying.
Using the HMI vector magnetic field data (test version), we study the magnetic energy and helicity in emerging active regions. First, we apply
the code DAVE4VM (Schuck 2008) to the time-series vector magnetic field data to derive the plasma velocity; then we break down the energy and
helicity fluxes into two components, one due to vertical advection of the magnetic field through the photosphere, and the other due to the
horizontal motion that shears the field lines. We analyze the roles these two processes play in accumulating the energy and helicity in the
corona, and explore their correlations with the evolution of active regions.

P21.03

Patterns of Nanoflare Heating Exhibited by Active Regions Observed with SDO/AIA

Nicholeen Viall[1], J. Klimchuk[1]
[1]NASA Goddard Space Flight Center.

7:30 AM Monday - 8:30 AM Thursday

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It seems largely agreed that many coronal loops---those observed at a temperature of about 1 MK---are bundles of unresolved strands that are heated by storms of impulsive nanoflares. The nature of coronal heating in hotter loops and in the very important but largely ignored diffuse component of active regions is much less clear. Are these regions also heated impulsively, or is the heating quasi steady? The spectacular new data from the Atmospheric Imaging Assembly (AIA) telescopes on the Solar Dynamics Observatory (SDO) offer an excellent opportunity to address this question. We analyze the light curves of coronal loops and the diffuse corona in 6 different AIA channels and compare them with the predicted light curves from theoretical models. Light curves in the different AIA channels reach their peak intensities with predictable orderings as a function of the nanoflare storm properties. These orderings, or time lags, are clearly exhibited in loop observations in all channels. What is especially exciting is that we identify these time lag patterns in observations of the seemingly steady diffuse

corona as well. We model the diffuse corona as a line-of-sight integration of many thousands of completely independent, impulsively heated strands. The time lags of the simulated and actual observations are in excellent agreement. Our results suggest that impulsive nanoflare heating is ubiquitous within active regions.
This research was supported through an appointment to the NASA Postdoctoral Program at the Goddard Space Flight Center, administered by Oak Ridge Associated Universities through a contract with NASA.

P21.04

Modeling Fast Magnetosonic Waves Observed by SDO in Active region Funnels

Leon Ofman[1], W. Liu[2], A. Title[2], M. Aschwanden[2]
[1]Catholic University and NASA's GSFC, [2]Lockheed Martin Solar and Astrophysics Laboratory.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Recently, quasi-periodic, propagating waves have been observed in EUV by the SDO/AIA instrument in about 10 flare/CME events thus far. A typical example is the waves associated with the 2010 August 1 C3.2 flare/CME that exhibited arc-shaped wave trains propagating in an active region magnetic funnel with ~5% intensity variations at speeds in the range of 1000-2000 km/s. The fast temporal cadence and high sensitivity of AIA enabled the detection of these waves. We identify them as fast magnetosonic waves driven quasi-periodically at the base of the flaring region, and develop a three-dimensional MHD model of the event. For the initial state we utilize the dipole magnetic field to model the active region, and include gravitationally stratified density at coronal temperature. At the coronal base of the active region we excite the fast magnetosonic wave by periodic velocity pulsations in the photospheric plane confined to the funnel of magnetic field line. The excited fast magnetosonic waves have similar amplitude, wavelength and propagation speeds as the observed wave trains. Based on the simulation results, we discuss the possible excitation mechanism of the waves, their dynamical properties, and the use of the event for coronal MHD seismology.

P21.05

First Results from Differential Emission Measure Tomography with SDO/AIA

Richard Frazin[1], A. M. Vásquez[2], E. Landi[1], W. Manchester IV[1], Z. Huang[1]
[1]University of Michigan, [2]University of Buenos Aires/CONICET, Argentina.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We present, for the first time, the results of 3D differential emission measure tomography (DEMT) applied to AIA data. The procedure has only be applied to STEREO/EUVI data previously (ApJ 701, 547). The tomographic reconstruction of 30.4 nm channel data provides a convenient tool for qualitative mapping of filaments, whereas combining the tomographic reconstructions from the bands dominated by coronal Fe lines yields a 3D determination of the electron density and temperature as well as higher order information. Compared to DEMT with EUVI, AIA provides enhanced temperature coverage and opportunity for testing assumptions used in the DEM inversion. Furthermore, we discuss the importance to stray light reduction and atomic physics uncertainties to DEMT science.

P21.06

Probing Flare Temperatures Using AIA Dispersion Patterns In Conjunction With EVE And RHESSI Spectra

Claire Raftery[1], S. Krucker[1]
[1]UC Berkeley.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center

The thermal distribution of plasma in solar flares has been studied extensively and yet, remains evasive. Using the revolutionary spatial resolution and cadence of SDO/AIA, we analyze diffraction and dispersion effects out to more than 40 orders. Comparing the dispersion patterns to spectral results from SDO/EVE and RHESSI, and synthetic spectra from CHIANTI, we identify the distribution of plasma temperatures in a compact flaring loop with 12 second cadence. Unlike traditional spectroscopy, the high cadence of the AIA observations allow us to capture the highly dynamic nature of these eruptions with no compromise for spatial resolution or cadence.

P21.07

Flare-excited Waves in the Solar Interior and Atmosphere

Alexander G. Kosovichev[1]

[1]*Stanford Univ..*

7:30 AM Monday - 8:30 AM Thursday

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The X2.2 flare of February 15, 2011, produced powerful waves traveling in the solar interior and atmosphere, which were observed with the HMI and AIA instruments on SDO. These data provide a unique opportunity for high-resolution spatial and spectral analyses of the helioseismic and atmospheric responses and their relationship to the flare energy release. In particular, the analysis of the SDO/HMI and X-ray data from RHESSI shows that the helioseismic waves were initiated by the photospheric impact in the early impulsive phase, observed prior to the hard X-ray (50-100 keV) impulse, and were probably associated with atmospheric heating by relatively low-energy electrons (6-50 keV) and heat flux transport. The impact caused a short wave-like motion in the sunspot penumbra prior to the appearance of the helioseismic wave. The AIA observations revealed for the first time the propagation of this wave in the upper atmosphere, and the accompanying shock wave. The multi-instrument observations of the flare-excited waves open new perspectives for studying the energy release and transport in solar flares, and also for the magnetic field seismology in active regions.

P21.08

Comparison of Vector Magnetograms from the Solenoidal and Irrotational Components of the Magnetic Field

Paul Bryans[1], W. D. Pesnell[1]

[1]*NASA Goddard Space Flight Center.*

7:30 AM Monday - 8:30 AM Thursday

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According to the Helmholtz Theorem, the solar magnetic field can be defined in terms of an irrotational and a solenoidal component. We will discuss the partitioning of the field into these components as a means of attributing elements of the magnetic field to its vorticity and divergence. We will then discuss the advantages of this decomposition as a metric for comparing vector magnetograms of varying spatial and temporal resolution.

P21.09

Multi-wavelength Observation Of A Coronal Jet Supporting The Emerging Flux Reconnection Model

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[1]*Dept. of Astronomy & Space Science, Kyung Hee University, Korea, Republic of,* [2]*Max-Plank Institute for Solar System Research, Germany,* [3]*School of Space Research, Kyung Hee University, Korea, Republic of,* [4]*Kwasan and Hida Observatories, Kyoto University, Japan.*

7:30 AM Monday - 8:30 AM Thursday

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We have investigated a coronal jet near the limb on 2010 June 27 by Hinode/X-Ray Telescope (XRT), EUV Imaging Spectrograph (EIS), SDO/Atmospheric Imaging Assembly (AIA), and STEREO. From EUV (AIA and EIS) and soft X-ray (XRT) images we identify the erupting jet feature in cool and hot temperatures. Using the high temporal and multi wavelength AIA images, we found that the hot jet preceded its associated cool jet and their structures are well consistent with the numerical simulation of the emerging flux-reconnection model. From the spectroscopic analysis, we found that the jet structure changes from blue shift to red one with time, which may indicate the helical structure of the jet. The STEREO observation, which enables us to observe this jet on the disk, shows that there was a dim loop associated with the jet. Considering that the structure of its associated active region seen in STEREO is similar to that in AIA observed 5 days before, we compared the jet morphology on the limb with the magnetic fields extrapolated from a HMI vector magnetogram observed on the disk. Interestingly, the comparison shows that the open and closed magnetic fields correspond to the jet and the dim loop, respectively, as the emerging flux reconnection model predicted.

P21.10

Subsurface Structure and Dynamics of Active Regions Observed with SDO/HMI

Alexander G. Kosovichev[1], J. Zhao[1]

[1]*Stanford Univ..*

7:30 AM Monday - 8:30 AM Thursday

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The HMI instrument on SDO has provided unprecedented opportunities to investigate the subsurface evolution of active regions. We use maps of subsurface flows and wave-speed perturbations, obtained using the HMI time-distance helioseismology pipeline, to study links between the subsurface properties and surface magnetic structures, and their relationships to the flaring and CME activity for several interesting active regions. A particular attention is paid to AR1158, which produced X2.2 flare.

P21.11

Helioseismic Studies With Multi-wavelength Data From HMI And AIA Onboard SDO

Frank Hill[1], K. Jain[1], S. Tripathy[1], S. Kholikov[1], I. Gonzalez Hernandez[1], J. Leibacher[1], R. Howe[2], F. Baudin[3], M. Carlsson[4], W. Chaplin[2], T. Tarbell[5]

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7:30 AM Monday - 8:30 AM Thursday

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The successful launch of the Solar Dynamics Observatory (SDO) in February 2010 opens important, new possibilities for helioseismic exploration of the solar interior and atmosphere using multi-wavelength observations from multiple instruments. In order to better understand the solar interior and atmosphere, as well as the physics of the helioseismic modes and waves themselves, we exploit the potential of the Atmospheric Imaging Assembly (AIA) 1600 and 1700 Angstrom continuum measurements and the contemporaneous Helioseismic and Magnetic Imager (HMI) Fe I 6173.3 Angstrom velocity and intensity observations. Standard techniques of helioseismology e.g Sun-as-a-star, spherical harmonic analysis, ring diagrams, and time- distance analysis are applied to obtain acoustic mode parameters and other characteristics. Here we present our preliminary results, and interpret these in the context of the differences in the heights of formation of the lines.

P21.12

The Photospheric Velocity Field of Active Regions Derived from SDO/HMI Vector Magnetograms

Karin Muglach[1], P. Schuck[2], HMI vector magnetogram team

[1]*GSFC, Artep Inc.,* [2]*GSFC.*

7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We present a first analysis of solar active regions observed with the Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO). Since HMI continuously observes the complete solar disk at a good spatial resolution we are able to follow active regions over several days, providing the opportunity to study the evolution of the flow field during the various stages of development of the active regions. HMI measures the photospheric vector magnetic field at a cadence of 12 min. To determine the velocity field we use the optical flow technique DAVE4VM (differential affine velocity estimator for vector magnetograms) and apply it to the vector magnetic field data from SDO/HMI.

P21.13
Evidence For Forced Kink-mode Loop Oscillations Observed By Sdo/aia
Tongjiang Wang[1], L. Ofman[1], J. M. Davila[2], Y. Su[1]
[1]*Catholic Univ of America / NASA GSFC,* [2]*NASA GSFC.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Transverse loop oscillations were first discovered by TRACE in EUV wavelength and interpreted as global fast kink modes. These oscillations are impulsively excited by flares or filament eruptions and often show a strong damping within few oscillation periods. The oscillations and the damping mechanism have been intensively studied in observation and theory, leading to great advance in coronal seismology. However, measurements of the damping rate remains difficult, often limited by the short length of the detectable oscillation sequence in one single filter. SDO/AIA with multiple wavebands of unprecedentedly high sensitivity and wide temperature coverage provides a good opportunity in improving the accuracy of these measurements. Here we present an example of long-lasting oscillation events observed using SDO/AIA. In this event, kink oscillations of a slowly evolving coronal loop seen in 171, 193 and 211 A bands are excited by several flow ejections. The oscillations last over one and a half hours with periods of 3-4 min and no evident decay. In particular, the amplitudes of the oscillations show increase during the period of a large flow ejection with speeds of 200-300 km/s which lasts for about a half hour, and then falls down at speeds of 60-70 km/s measured in 304 A band. We interpret the growing oscillations as driven fast magnetosonic waves by impacting flows. We perform preliminary 3D MHD study of the event using an idealized bipolar active region model.

P21.14
Direct Imaging by SDO/AIA of Quasi-periodic Propagating Fast Mode Magnetosonic Waves of ~2000 km/s in the Solar Corona
Wei Liu[1], A. M. Title[2], J. Zhao[3], L. Ofman[4], C. J. Schrijver[2], M. J. Aschwanden[2], B. De Pontieu[2], T. D. Tarbell[2]
[1]*Stanford-Lockheed Institute for Space Research,* [2]*Lockheed Martin Solar and Astrophysics Laboratory,* [3]*Stanford University,* [4]*Catholic University of America and NASA Goddard Space Flight Center.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Quasi-periodic, propagating fast mode magnetosonic waves in the corona were difficult to observe in the past due to relatively low instrument cadences. We report here unprecedented evidence of such waves directly imaged in EUV by the new SDO/AIA instrument. In the 2010 August 1 C3.2 flare/CME event, we find arc-shaped wave trains of 1-5% intensity variations emanating near the flare kernel and propagating outward along a funnel of coronal loops. Sinusoidal fits to a typical wave train indicate a phase velocity of 2350 +/- 210 km/s. Similar waves propagating in opposite directions are observed in closed loops between two flare ribbons. In the k-omega diagram of the Fourier wave power, we find a

bright ridge that represents the dispersion relation and can be well fitted with a straight line passing through the origin, giving an equal phase and group velocity of 1630 +/- 760 km/s averaged over the event. This k-omega ridge shows a broad frequency distribution with prominent power at four non-harmonic frequencies, 5.5, 14.5, 25.1, and 37.9 mHz, among which the 14.5 mHz (period: 69 s) signal is the strongest. The signal at 5.5 mHz (period: 181 s, same as chromospheric 3-minute oscillations) temporally coincides with flare pulsations, suggesting a common origin of possibly quasi-periodic magnetic reconnection. The instantaneous wave energy flux of (0.1-2.6)e7 ergs/cm^2/s estimated at the coronal base is comparable to the steady-state heating requirement of active region loops.

P21.15

AIA Observations of Sunspot Waves

John W. Leibacher[1], E. Soubrié[2], F. Auchère[2], F. Baudin[2]

[1]*National Solar Observatory,* [2]*Institut d'Astrophysique Spatiale, France.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

Waves in the low solar atmosphere above sunspots *i*) present an interesting phenomenon in their own right, *ii*) are potentially a probe of magnetic structures (*e.g.* "plumes") in the sunspot atmosphere and a source of excitation of higher, coronal loop waves, and *iii*) are coupled to umbral flashes and sub-surface, helioseismic waves in a manner that is not fully understood. We present an analysis of AIA observations of waves in AR 11092, showing their propagation, temporal coherence, and angular symmetry; characterizing them in terms of frequency, amplitude, and propagation speed.

P21.16

Simulating Coronal Emission in Six AIA Channels Using Quasi-Static Atmosphere Models and Non-Linear Magnetic Field Models

Anna Malanushenko[1], C. Schrijver[2], M. DeRosa[2], M. Aschwanden[2], M. S. Wheatland[3], A. A. van Ballegooijen[4]

[1]*MSU,* [2]*Lockheed Martin,* [3]*Sydney Institute for Astronomy, Australia,* [4]*Harvard-Smithsonian Center for Astrophysics.*

7:30 AM Monday - 8:30 AM Thursday

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We present the results of simulations of the EUV coronal emission in AIA channels. We use a non-linear force-free model of magnetic field constructed in such a way that its field lines resemble the observed coronal loops in EUV. We then solve one-dimensional quasi-steady atmosphere model along the magnetic field lines (Schrijver & Ballegooijen, 2005). Using coronal abundances from CHIANTI and AIA response functions we then simulate the emission that would be observed in AIA EUV channels. The resulting intensities are compared against the real observations in a manner similar to that in Aschwanden et. al., 2011. The study is similar to those by Lindquist et. al., 2008, with a few important differences. We use a model of the coronal magnetic field that resembles the topology observed in EUV, we study EUV emission of cool loops (rather than SXR) and we make use of high resolution and cadence AIA and HMI data.

P21.17

Pulsed Flows Along a Cusp Structure Observed with SDO/AIA

Barbara Thompson[1], P. Démoulin[2], C. Mandrini[3], M. Mays[1], L. Ofman[4], L. Van Driel-Gesztelyi[5], N. Viall[1]

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7:30 AM Monday - 8:30 AM Thursday

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We present observations of a cusp-shaped structure that formed after a flare and coronal mass ejection on 14 February 2011. Throughout the evolution of the cusp structure, blob features up to a few Mm in size were observed flowing along the legs and stalk of the cusp at projected speeds ranging from 50 to 150 km/sec. Around two dozen blob features, on order of 1 - 3 minutes apart, were tracked in multiple AIA EUV wavelengths. The blobs flowed outward (away from the Sun) along the cusp stalk, and most of the observed speeds were either constant or decelerating. We attempt to reconstruct the 3-D magnetic field of the evolving structure, discuss the possible drivers of the flows (including pulsed reconnection and tearing mode instability), and compare the observations to studies of pulsed reconnection and blob flows in the solar wind and the Earth's magnetosphere.

P21.18

Computing Magnetic Energy From Aia Images And Hmi Line-of-sight Magnetograms

Dana Longcope[1], A. Malanushenko[2], L. Tarr[1]

[1]*Montana State Univ.,* [2]*Lockheed Martin Space and Astrophysics Laboratory.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

The state of the art for computing the magnetic energy in an active region's corona is to extrapolate a non-linear force-free field from vector magnetic field data. This method infers coronal properties from photospheric data without direct use of any coronal information. We present here an alternative which uses the shapes of loops visible in EUV or soft X-ray images to infer coronal currents. The method of Malanushenko et al. (2009) is used to infer magnetic field strength along each coronal loop. This sparse sampling of magnetic information is used in a Monte Carlo integral to compute the total magnetic energy. We also present a method for computing the free energy (the difference between the energy of the actual field and the corresponding potential field) directly as a single Monte Carlo integral. Both integrals are estimates with known statistical uncertainties which are reasonably small for samples as small as 25 loops. We demonstrate the method using a test field and then apply it to observations of an active region.

P21.19

SDO/AIA Observations of Coronal Condensation Leading to Prominence Formation

Wei Liu[1], T. Berger[2], B. C. Low[3], R. Casini[3]

[1]*Stanford-Lockheed Institute for Space Research,* [2]*Lockheed Martin Solar and Astrophysics Laboratory,* [3]*High Altitude Observatory.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

Coronal condensation takes place when million degree coronal plasma undergoes radiative cooling instability. Direct observation of coronal condensation in prominences has been difficult in the past, but with the launch of the Hinode/SOT and SDO/AIA instruments, numerous observations of plasma condensing "out of nowhere" high up in quiescent prominences have been captured. We present here one such event seen with SDO/AIA. On 25-Nov-2010, a prominence above the southwest limb is swept away by a nearby eruption, and for next a few hours there is no visible 304 A material in the local corona. Then, a portion of the coronal loops at the same location progressively sags and forms a local dip, where the first sign of new, cool material appears, 7.5 hours after the eruption. This is a clear indication of coronal condensation, and the gradual sag of the loops is likely a result of increasing weight of the condensed material that has been accumulated at the dip. Similar condensation occurs nearby at a larger rate and leads to the formation of a moderate-size prominence. The estimated prominence mass increases linearly for about 7 hours at a rate of 2.6e10 grams/sec and reaches approximately 6e14 grams. Simultaneously, the prominence drains through vertical flows of approximately 32 km/s, bringing the mass back to the chromosphere. We estimate the mass drain rate to be 2.7e10 grams/sec, which, together with the estimated mass accumulation rate, implies a coronal condensation rate of approximately 5.3e10 grams/sec. This study can provide critical information about the coupling between condensation energetics and MHD, prominence mass cycles, and coronal mass ejections initiated by loss of anchoring prominence mass (e.g., Low 2001).

P21.20

MHD Simulations Of The Solar Corona In Early August 2010 Using The Hmi Magnetic Field Data

Keiji Hayashi[1], X. Zhao[1], Y. Liu[1], X. Sun[1], J. Hoeksema[1], HMI team

[1]*Stanford University.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

The HMI is observing the line-of-sight magnetic field, vector field and the Doppler plasma velocity. The full-disk magnetogram observation with high temporal and spatial resolution provides better global solar magnetic field map, in that the data gap is minimized and the noise level is quite low.
To utilize the benefit of the HMI's magnetogram observation, we conducted the MHD simulation of the global solar corona using the HMI data. We chose a period around August 1st, 2010, to see how the magnetic field connectivity in the global scale had changed around the period: In early August period, the changes of the global coronal magnetic field seen at the entire Earth-side hemisphere seem to be well related with the emergence of the sunspot at the north-east part of the full disk images, though the dynamics involving both magnetic field and plasma will be retrieved by means of the MHD simulation models.
We used the synchronic frame format to make the global solar surface magnetic field maps so that the magnetic field distribution at the time of interest will be better specified thus the simulated situation will be more realistic. In addition, we used the daily-updated global maps that are made by regularly replacing the portion of the global map with the meridional slip of the full-disk data on regular (daily) basis as well as the standard ones that are well low-nose dataset made with better-calibrated data.

P21.21

Preliminary Results From An Automated X-ray Bright Point Detector for AIA

Steven H. Saar[1], S. Farid[1]

[1]*Harvard-Smithsonian, CfA.*

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

We present preliminary results of X-ray Bright Point (XBP) properties derived from a new, automated XBP finder for AIA developed as part of the Feature Finding Team for SDO Computer Vision. We analyze several days of data and explore the size, location, intensity, local environment, and lifetime of the XBPs, and the relationships between these properties.
This work was supported by NASA Grant NNX09AB03G to the Smithsonian Astrophysical Observatory and contract SP02H1701R from Lockheed-Martin to SAO.

P21.22

Comparison Of Simulated And Observed Loop-top Emission In Flares Using The AIA Telescopes On SDO

Kathy Reeves[1], A. Engell[1], L. Ji[2], R. Smith[1], L. Golub[1]

[1]*Harvard-Smithsonian, CfA,* [2]*Purple Mountain Observatory, China.*

7:30 AM Monday - 8:30 AM Thursday

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We investigate the temporal behavior of loop-top emission in flaring loops observed by AIA's six EUV passbands for several flares of different sizes. These flares are chosen because they exhibit extended periods of loop-top emission in the 193 A channel, thought to be hot emission from Fe XXIV. The flare light curves from this loop-top emission clearly show the progression of flare cooling through the various ionization states of iron that dominate the AIA bands. We use the model of Reeves, Warren & Forbes (2007), which predicts extended periods of loop-top flare emission, to model the flare loop energization, and explore the effects of different energy release rates and durations on the simulated flare light curves. We also explore the conditions under which non-equilibrium ionization effects may be important in these events.

P21.23

Transient Artifacts in SDO/HMI Flare Observations

Juan Carlos Martinez Oliveros[1], C. Lindsey[2], H. Hudson[1], J. Schou[3], S. Couvidat[3]

[1]SSL - University of California Berkeley, [2]NorthWest Research Associates - Colorado Research Associates Division, [3]Hansen Experimental Physics Lab (HEPL) - Stanford University.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

The Helioseismic and Magnetic Imager (HMI) on SDO provides a new tool for the systematic observation of white-light flares, including Doppler and magnetic information as well as continuum. In our initial analysis of the highly impulsive gamma-ray flare SOL2010-06-12T00:57 (Martinez-Oliveros et al. 2011), we detected an apparently artifactual blue shift in the two footpoint sources. We have now deployed the PASCAL algorithm for the same flare as viewed in GONG++ data. This algorithm makes it possible to obtain much better photometry (plus Doppler and magnetic measurements) from the ground-based data. Using GONG++ we have demonstrated the artifactual nature of the apparent blueshift, finding instead weak redshifts at the foopoints. We discuss the flare physics associated with these observations and describe the use of PASCAL (with GONG++ or other ground-based data) as a complement to the systematic SDO data.

P21.24

Doppler Signatures In EVE Spectra

Hugh S. Hudson[1], P. Chamberlin[2], T. Woods[3], L. Fletcher[4], D. Graham[4]

[1]UC, Berkeley, [2]NASA GSFC, [3]University of Colorado, [4]University of Glasgow, United Kingdom.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

The Extreme-ultraviolet Variability Experiment (EVE) on SDO is providing a comprehensive set of EUV spectra of the Sun as a star. The routine sampling is with 10 s integrations at a resolution of 0.1 nm. Although this resolution corresponds to only some 1000 km/s in velocity space, we demonstrate that the instrument is stable enough to detect the SDO orbital motion of a few km/s readily in the bright He II line at 30.4 nm. We find the random error in the centroid location of this line to be less than one pm (less than 1 km/s) per 10 s integration. We also note systematic effects from a variety of causes. For flare observations, the line centroid position depends on the flare position. We discuss the calibration of this effect and show that EVE can nonetheless provide clear Doppler signatures that may be interpreted in terms of flare dynamics. This information has some value in and of itself, because of EVE's sensitivity, but we feel that it will be of greatest importance when combined with imagery (e.g., via AIA) a modeling. We discuss flare signatures in several events, e.g. the gamma-ray flare SOL2010-06-12 and SOL2011-02-16T:07:44, taking advantage of AIA image comparisons.

P21.25

Understanding The Extreme Ultraviolet Irradiance Evolution Of Long Duration Events Using Data From Solar Dynamics Observatory (SDO) Extreme Ultraviolet Variability Experiment (EVE)
Rachel Hock[1]
[1]*University of Colorado LASP.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Since its launch on 11 February 2010, NASA's Solar Dynamic Observatory (SDO) has observed numerous solar flares. Between 1 May 2010 and 31 March 2011, the Extreme ultraviolet Variability Experiment (EVE) captured over 350 C-class, 43 M-class, and 2 X-class events. Long duration events or flares lasting more than one hour are of particular interest because they release a large amount to energy over a long time and are often associated with filament eruptions, large coronal mass ejections and dimmings in certain EUV lines such as Fe IX (17.1 nm). In these long duration events, the EUV irradiance from 2-3 MK emission can peak up to a hour after the GOES soft x-ray peak. In this work, we present observations of several long duration events and look at the correlation between the duration of the flare and the delay in EUV emission.

P21.26
Monitoring Image Alignments and Flat Fields for AIA/SDO Data Images
Richard A. Shine[1], C. Wolfson[1], P. F. Boerner[1], T. D. Tarbell[1], R. W. Nightingale[1]
[1]*Lockheed Palo Alto Res. Lab..*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The images from the 4 telescopes on the Atmospheric Imaging Assembly (AIA) on board the NASA Solar Dynamics Observatory (SDO) have different offsets (from sun center), plate scales, and absolute rotations that can be measured and corrected for accurate alignment. The most variable of these is the offsets presumably due to small thermal flexings of the telescopes. Here we describe the techniques used to make these measurements and show how the image alignments vary with time. Weekly measurements are made as part of the data monitoring that capture much of the drift in the geometric corrections but shorter time variations of typically a pixel also exist in the offsets. Angles and scales have much better short term stability. We hope to eventually capture these variations for the mission or at least provide software for end users.
We also describe progress made in determining flat fields for the 10 wavebands and show how these have been varying over the mission to date.
This work was supported by NASA under the SDO/AIA contract NNG04EA00C.

P21.27
Preliminary PSF Inversion for SDO/AIA Lunar Occutation Data
Craig DeForest[1], B. Poduval[2]
[1]*Southwest Research Inst.,* [2]*Self.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We present initial results from PSF inversion of the AIA eclipse data from fall 2010. Initial stray light estimates for the 171 band are favorable compared to TRACE, and comparable to STEREO/EUVI.

P21.28
SDO Data Access and Analysis using the Heliophysics Events Knowledgebase
Neal E. Hurlburt[1], the HEK team, A. Somani[1]
[1]*Lockheed Martin Corp..*
7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center
The immense volume of data generated by the suite of instruments on the Solar Dynamics Observatory (SDO) requires new tools for efficient identifying and accessing data that is most relevant for research. We have developed the Heliophysics Events Knowledgebase (HEK) to fill this need. The solar and spacecraft events captured in the HEK can be searched and downloaded through web services and web clients and used to efficiently access relevant SDO data. We review the HEK system, which combines automated data mining using feature-detection methods and high-performance visualization systems, and discuss recent updates, improvements and future plans.

P21.29
Solar Dynamics Observatory Pipeline Data Throughput Considerations
Francisco I. Suarez Sola[1], A. Amezcua[2], A. Davey[3], J. Hourcle[4], VSO Team
[1]National Solar Observatory, [2]Stanford University, [3]HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS, [4]Goddard Space Center.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Solar Dynamics Observatory (SDO) and its interface with the Virtual Solar Observatory (VSO) has brought a number of challenges when it comes to dealing with the volume of data and keeping track of it. After almost a year in operation we can now draw some conclusions on the system performance and how it could be further improved. In this poster we compare, in development cost and coding choices, a Straight Throughout Processing (STP) system design with a typical solar pipeline, with particular focus on the SDO pipeline. We will also bring suggestions on how a STP system design, together with the know-how accumulated in 8 years of VSO development, can help to leverage load on a pipeline and possibly obtain a higher system throughput.

P21.30
Accessing SDO Data : The Poster
Joseph Hourcle[1], K. Addison[2], R. Bogart[3], P. Chamberlin[4], S. Freeland[5], V. K. Hughitt[2], J. Ireland[2], M. Maddox[4], D. Mueller[6], A. Somani[5], J. Sommers[3], B. Thompson[4], The solar physics data community
[1]NASA/GSFC (Wyle), [2]NASA/GSFC (ADNET), [3]Stanford University, [4]NASA/GSFC, [5]Lockheed Martin ATC, [6]ESA, ESTEC, Netherlands.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
As the data from SDO are useful for a variety of purposes, including solar physics, helioseismology, atmospheric science, space weather forecasting, education and public outreach, a wide variety of tools have been development to cater to the different needs of the various groups. Systems have been developed for pipeline processing, searching, browsing, subsetting, or simply just moving around large volumes of data.
We present a quick overview of the different systems that can be used to access SDO data including (J)Helioviewer, the Heliophysics Event Knowledgebase (HEK), the Virtual Solar Observatory (VSO), the Integrated Space Weather Analysis System (iSWA), the Data Record Management System (DRMS), and various websites. We cover web-based applications, application programming interfaces (APIs), and IDL command line tools.
This poster serves as a supplement to the oral presentation as a place to distribute information about the various interfaces and to collect feedback about any unmet needs for data access.

P21.31
Solar Subsurface Dynamics from the First Year of SDO/HMI Time-Distance Helioseismology Analysis

Junwei Zhao[1], R. S. Bogart[1], A. G. Kosovichev[1], K. Nagashima[1]
[1]*Stanford Univ..*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
It has been about one year since SDO/HMI started to take continuous observations of the Sun. Time-distance pipeline designed for a routine processing of HMI observations has generated plenty of results. We will present the solar interior rotational rate and meridional flow speed and their evolution during the entire year. For local areas, we study the subsurface flows of supergranules and some selected active regions. We also apply the time-distance analysis in higher latitude areas, and study the rotational and meridional speed above the latitude of 65 degree.

P21.32
Accessing SDO Data
Joseph Hourcle[1], The solar physics data community
[1]*NASA/GSFC (Wyle IS).*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
As the data from SDO are useful for a variety of purposes, including solar physics, helioseismology, atmospheric science, space weather forecasting, education and public outreach, a wide variety of tools have been development to cater to the different needs of the various groups. Systems have been developed for pipeline processing, searching, browsing, subsetting, or simply just moving around large volumes of data.
We present a quick overview of the different systems that can be used to access SDO data including (J)Helioviewer, the Heliophysics Event Knowledgebase (HEK), the Virtual Solar Observatory (VSO), the Integrated Space Weather Analysis System (iSWA), the Data Record Management System (DRMS), and various websites. We cover web-based applications, application programming interfaces (APIs), and IDL command line tools.

P21.33
On the Relationship Between Small-Scale Sigmoids and Coronal Jets
Noureddine Raouafi[1]
[1]*Johns Hopkins University/Applied Physics Laboratory.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Observations from SDO/AIA and Hinode/XRT are used to study the structure of bright points sources of coronal jets. Several jets are found to emanate from S-shaped bright points suggesting the presence of coronal micro-sigmoids. These structures may provide explanation for numerous characteristics of coronal jets, such as helical structures and jet types.

P21.34
Bayesian Automatic Classification Of HMI Images
R. K. Ulrich[1], **John G. Beck**[1]
[1]*Univ. of California, Los Angeles.*
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The Bayesian automatic classification system known as "AutoClass" finds a set of class definitions based on a set of observed data and assigns data to classes without human supervision. It has been applied to Mt Wilson data to improve modeling of total solar irradiance variations (Ulrich, et al, 2010). We apply AutoClass to HMI observables to automatically identify regions of the solar surface. To prevent small

instrument artifacts from interfering with class identification, we apply a flat-field correction and a rotationally shifted temporal average to the HMI images prior to processing with AutoClass. Additionally, the sensitivity of AutoClass to instrumental artifacts is investigated.

P22
Solar Flares
Poster
Exhibit Hall 1 - Las Cruces Convention Center

P22.01

Characterizing Chromospheric Flares and Sequential Brightenings

Michael S. Kirk[1], K. S. Balasubramaniam[2], J. Jackiewicz[1], J. McAteer[1], R. Milligan[3]
[1]New Mexico State University, [2]Air Force Research Laboratory, [3]Queens University, United Kingdom.

7:30 AM Monday - 8:30 AM Thursday

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Solar sequential chromospheric brightenings (SCBs) are typically observed in conjunction with flares that have associated coronal mass ejections (CMEs). To characterize these ephemeral events, we developed automated procedures to identify and track subsections of large solar flares and the SCBs using the ISOON telescope's H-alpha data. This software package extracts physical quantities such as temporal variation of flare and SCB intensities, apparent proper motion of the moving ribbons, and the speed of SCB intensity propagation. Overlying the extracted features onto complementary datasets, we obtain underlying Doppler velocity and magnetic intensity measurements. We demonstrate that flare ribbons can be fully characterized by subdividing them into discrete flare kernels. We also present evidence that SCBs are a different class of brightening than the flare ribbons.

P22.02

Testing the Thin Flux Tube Model with Fully Three-dimensional Magnetohydrodynamic Simulations

Silvina Guidoni[1], D. W. Longcope[1], M. G. Linton[2]
[1]Montana State University - Bozeman, [2]Naval Research Laboratory.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center

Observations of supra-arcade downflows suggest that some flare reconnection may occur in patches within the current sheet above the arcade. The energy release following such reconnection may be modeled using the thin flux tube formalism. The patch of reconnection creates two bent flux tubes which retract rapidly due to magnetic tension. In the model, the supersonic collision of plasma generates shocks inside the retracting tube. We test the validity of the thin flux tube formalism by comparing results of the model with those from fully three-dimensional magnetohydrodynamic (MHD) simulations (using ARMS code). Patchy reconnection is produced in the MHD simulation by temporarily enhancing resistivity within a small region straddling an equilibrium current sheet. The subsequent dynamics are compared to the predictions of the the thin flux tube model initialized with the same bent flux tube. The MHD simulations show similar flux tube retraction. There are also MHD shocks within the retracting flux tubes whose magnitude and locations compare favorably to those from the thin flux tube model. This work was supported by NASA, NSF, DOD, and DOE.

P22.03

HXR and Microwave Spectroscopy of the X2.2 flare on February 15 2011

Yan Xu[1], S. Park[2], D. E. Gary[1], S. Bong[2], J. Jing[1], H. Wang[1]
[1]New Jersey Institute of Tech., [2]Korea Astronomy and Space Science Institute, Korea, Republic of.

7:30 AM Monday - 8:30 AM Thursday

Exhibit Hall 1 - Las Cruces Convention Center
We present a spectroscopic study of an X-class flare observed on 2011 Feb. 15, which is confirmed as a white-light flare by HINODE/SOT continuum images. HXR observation of this flare was taken by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) and radio observation was taken by the Korean Solar Radio Burst Locator (KSRBL).
During the ~10 minute lifetime of this flare, four major temporal peaks have
been identified in both HXR and radio emissions. Spectra at each individual peak are obtained with a frequency range in microwave from ~5 to 18 GHz and an energy range in HXR from 35 to 150 keV, respectively. The high cadence observations in HXR and microwave provide an unique tool to diagnose the properties of energetic electrons and their temporal evolution. In particular, we will present the result of electron power index as derived from these two wavelengths, and its peak-to-peak variation.

P22.04

Solar Eruptive Events (SEE) Mission for the Next Solar Maximum

Robert P. Lin[1], S. Krucker[1], A. Caspi[1], G. Hurford[1], B. Dennis[2], G. Holman[2], S. Christe[2], A. Y. Shih[2], S. Bandler[2], J. Davila[2], R. Milligan[2], S. Kahler[3], M. Weidenbeck[4], G. Doschek[5], A. Vourlidas[5], G. Share[6], J. Raymond[7], M. McConnell[8], G. Emslie[9]
[1]UC, Berkeley, [2]GSFC, [3]AFRL, [4]JPL, [5]NRL, [6]U. Maryland, [7]SAO, [8]Univ. of New Hampshire, [9]Western Kentucky Univ..
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Major solar eruptive events consisting of both a large flare and a near simultaneous large fast coronal mass ejection (CME), are the most powerful explosions and also the most powerful and energetic particle accelerators in the solar system, producing solar energetic particles (SEPs) up to tens of GeV for ions and 10s-100s of MeV for electrons. The intense fluxes of escaping SEPs are a major hazard for humans in space and for spacecraft. Furthermore, the solar plasma ejected at high speed in the fast CME completely restructures the interplanetary medium, producing the most extreme space weather in geospace, at other planets, and in the heliosphere. Thus, the understanding of the flare/CME energy release process and of the related particle acceleration processes in SEEs is a major goal in Heliophysics. Here we present a concept for a Solar Eruptive Events (SEE) mission, consisting of a comprehensive set of advanced new instruments on the single spacecraft in low Earth orbit, that focus directly on the coronal energy release and particle acceleration in flares and CMEs. SEE will provide new focussing hard X-ray imaging spectroscopy of energetic electrons in the flare acceleration region, new energetic neutral atom (ENA) imaging spectroscopy of SEPs being accelerated by the CME at altitudes above ~2 solar radii, gamma-ray imaging spectroscopy of flare-accelerated energetic ions, plus detailed EUV/UV/Soft X-ray diagnostics of the plasmas density, temperature, and mass motions in the energy release and particle acceleration regions. Together with ground-based measurements of coronal magnetic fields from ATST, FASR, and COSMO, SEE will enable major breakthroughs in our understanding of the fundamental physical processes involved in major solar eruptive events.

P22.05

Temporal Variability of Ion Acceleration and Abundances in Solar Flares

Albert Y. Shih[1], D. M. Smith[2], R. P. Lin[3]
[1]NASA/GSFC, [2]SCIPP, University of California, Santa Cruz, [3]SSL, University of California, Berkeley.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Solar flares accelerate both ions and electrons to high energies, and their X-ray and gamma-ray signatures not only probe the relationship between their respective acceleration, but also allow for the

measurement of accelerated and ambient abundances. *RHESSI* observations have shown a striking close linear correlation of gamma-ray line fluence from accelerated ions >~20 MeV and bremsstrahlung emission from relativistic accelerated electrons >300 keV, when integrated over complete flares, suggesting a common acceleration mechanism. *SMM*/GRS observations, however, show a weaker correlation, and this discrepancy might be associated with previously observed electron-rich episodes within flares and/or temporal variability of gamma-ray line fluxes over the course of flares. We use the latest *RHESSI* gamma-ray analysis techniques to study the temporal behavior of the *RHESSI* flares, and determine what changes can be attributed to an evolving acceleration mechanism or to evolving abundances. We also discuss possible explanations for changing abundances.

P22.06

Uncombed Sunspot Penumbrae Are Combed by Large Flares

Haimin Wang[1], C. Liu[1], N. Deng[2]
[1]NJIT, [2]California State University.

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In the past two decades, the complex nature of sunspots is disclosed with high resolution observations. One of the most important findings is the ``uncombed'' penumbral structure, where the bright grains are more vertical while dark fibrils are more horizontal (Solanki and Montavon 1993). The Evershed flows are more closely associated with the horizontal component. On the other hand, it was found that flares may change the topology of the sunspot structure in delta configuration: the central structure at the flaring polarity inversion line becomes darkened while sections of peripheral penumbrae may disappear permanently associated with flares (Liu et al. 2005).

The high spatial and temporal resolution observations obtained with Hinode/SOT on December 6, 2006 and June 4, 2007 provide an excellent opportunity to study the evolution of penumbral fine structure associated with major flares. We found that in sections of penumbrae swept by flare ribbons, the dark fibrils completely disappear, while the bright grains evolve into faculae that resemble the structure of vertical magnetic flux tubes. Therefore, the original uncombed penumbral structure seems to be combed toward the vertical direction---the dark and bright components are no longer separated in orientation after the flares. These results provide a new insight into the possible impact by the coronal transients on the photospheric magnetic structure of sunspots, and shed new light on the obscure formation and decay mechanism of penumbrae.

Reference

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P22.07

Magnetic Oscillations Mark Sites of Magnetic Transients in an Acoustically Active Flare

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The flare of 2011 February 15, in NOAA AR11158, was the first acoustically active flare of solar cycle 24, and the first observed by the Solar Dynamics Observatory (SDO). It was exceptional in a number of respects (Kosovichev 2011a,b). Sharp ribbon-like transient Doppler, and magnetic signatures swept over parts of the active region during the impulsive phase of the flare. We apply seismic holography to a 2-hr time series of HMI observations encompassing the flare. The acoustic source distribution appears to have been strongly concentrated in a single highly compact penumbral region in which the continuum-intensity signature was unusually weak. The line-of-sight magnetic transient was strong in parts of the active region, but relatively weak in the seismic-source region. On the other hand, the neighbourhoods of the regions visited by the strongest magnetic transients maintained conspicuous 5-minutes-period variations in the line of sight magnetic signature for the full 2-hr duration of the time series, before the flare as well as after. We apply standard helioseismic control diagnostics for clues as to the physics underlying 5-minute magnetic oscillations in regions conducive to magnetic transients during a flare and consider the prospective development of this property as an indicator of flare potentiality on some time scale. We make use of high-resolution data from AIA, using diffracted images where necessary to obtain good photometry where the image is otherwise saturated. This is relevant to seismic emission driven by thick-target heating in the absence of back-warming. We also use RHESSI imaging spectroscopy to compare the source distributions of HXR and seismic emission.

P22.08

High-Resolution Imaging of Solar Flare Ribbons and its Implication on the Thick-Target Beam Model

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7:30 AM Monday - 8:30 AM Thursday

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We report on high-resolution optical and hard X-ray observations of solar flare ribbons seen during the GOES X6.5 class white-light flare of 2006 December 6. The data consist of imaging observations at 430 nm (the Fraunhofer G-band) taken by the Hinode Solar Optical Telescope (SOT) with the hard X-rays observed by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). The two sets of data show closely similar ribbon structures, strongly suggesting that the flare emissions in white light and in hard X-rays have physically linked emission mechanisms. While the source structure along the ribbons is resolved at both wavelengths (length ~30''), only the G-band observations resolve the width of the ribbon, with values between ~0.5'' and ~1.8''. The unresolved hard X-ray observations reveal an even narrower ribbon in hard X-rays (the main footpoint has a width perpendicular to the ribbon of <1.1'' compared to the G-band width of ~1.8'' suggesting that the hard X-ray emission comes from the sharp leading edge of the G-band ribbon. Applying the thick-target beam model, the derived energy deposition rate is $>5\times10^{12}$ erg s^{-1} cm^{-2} provided by electrons above 18 keV. This requires that the beam density of electrons above 18 keV be at least 1×10^{10} cm^{-3}. Even if field lines converge towards the chromospheric footpoints, the required beam in the corona has a too high density to be described as a dilute tail population on top of a Maxwellian core. We discuss this issue and others associated with this extreme event, which poses serious questions to the standard thick target beam interpretation of solar flares.

P22.09

Non-thermal and Super-hot Coronal Sources in the 2002 July 23 X4.8 Flare

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7:30 AM Monday - 8:30 AM Thursday

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The *Reuven Ramaty High Energy Solar Spectroscopic Imager* (RHESSI) has shown that super-hot (T > 30 MK) thermal plasmas occur frequently in intense, GOES X-class solar flares. Recent analysis suggests that such hot plasmas are substantially heated directly within the corona, and are both spatially and physically distinct from the usual ~10-20 MK "GOES-temperature" plasma formed by chromospheric evaporation. During the 2002 July 23 X4.8 flare, a strong non-thermal source is observed in the corona prior to the impulsive phase, and is taken to signal the onsent of particle acceleration by magnetic reconnection. A cospatial thermal source is also observed, but its temperature is only loosely constrained. During the impulsive phase proper, a 60-100 keV HXR source is briefly observable in the corona; new imaging analysis shows that it is cospatial with a ~36 MK super-hot source, whose temperature at this time *is* well-determined and which lies above the SXR-emitting GOES-temperature loops. A preliminary analysis indicates that this HXR source is distinctly non-thermal, and its timing suggests a second episode of magnetic reconnection further along the flaring arcade; the super-hot source may be located directly within the acceleration region, or at least presents a suitably-dense target for the emission of 60-100 keV hard X-rays. We discuss these observations, and their implications for particle acceleration and plasma heating in X-class flares.

P22.10

The Distributions of Post-Reconnection Flux Tube Sizes and Fluxes Determined from Supra-Arcade Downflows

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Supra-arcade downflows (SADs) are downward-moving features observed in the hot, low-density region above posteruption flare arcades. They are believed to be created by patchy reconnection in the post-CME current sheet. The sizes and fluxes of SADs provide information about the process of their creation. For example, the "fractal current sheet" scenario proposed in the literature may be expected to yield a power-law distribution of sizes and/or fluxes. We examine 120 cross-sectional areas and magnetic flux estimates from observations of SADs, and find that (1) the areas are consistent with a log-normal distribution, and (2) the fluxes are consistent with both a log-normal and an exponential distribution. Neither set of measurements is compatible with a power-law distribution, and so the data do not appear to support a fractal process for SAD creation. As an alternative, we consider a simple SAD growth scenario with minimal assumptions, capable of producing a log-normal distribution.

P22.11

The Height of White-light Flare Continuum Formation

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7:30 AM Monday - 8:30 AM Thursday

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White-light continuum and hard X-ray emission in flares have strong correlations in time and in horizontal position, but at present we do not have a clear idea about their height structures. On 24 February 2011 a white-light flare (SOL2011-02-24T07:35) was observed on the east limb, simultaneously by the Helioseismic Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO), and by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). This observation gives us the opportunity to determine the heights of these emissions directly, limited only by the limb references for the two spacecraft, with almost no projection undertainty. HMI obtained clear images in the pseudo-continuum around 6173A, and RHESSI obtained hard X-ray images. For both data sets, the precision of centroid determination is of order 0.1 arc s. We believe that the position of the white-light limb, as a local reference, can also be understood at a corresponding level of accuracy for the two data sets. We report the results of this analysis and discuss our findings in terms of present models of particle acceleration and energy transport in the impulsive phase.

P22.12

Measurement of Anisotropy in Solar Flares

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7:30 AM Monday - 8:30 AM Thursday
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The angular variation of high energy electrons during a solar flare is key to understanding the acceleration mechanism. High resolution X-ray spectra observed by RHESSI can be used to estimate this anisotropy. The effect of photospheric albedo, Compton scattering of X-ray photons from the photosphere, should greatly influence the observed spectrum if the X-ray emitting electrons are highly beamed. The observed spectra will thus contain signatures of the anisotropy. The technique of regularised inversion is used to determine the proportion of the electron flux directed downwards towards the photosphere compared to the electron flux directed towards the observer. The RHESSI flare database has been searched and analysis performed on all flares found to have statistically significant counts above 300 keV. In total 9 flares suitable for analysis were found. The anisotropy of these flares both over the entire impulsive phase and for shorter time intervals was measured and the flares have all been found to exhibit angular distributions which are close to isotropic.
EMD gratefully acknowledges the support of an SPD and STFC studentship. EK gratefully acknowledges financial support from an STFC rolling grant and STFC Advanced Fellowship.

P22.13
Flares Observed By Hinode During 14-18 February 2011
Peter R. Young[1], G. A. Doschek[2], H. P. Warren[2]
[1]George Mason University, [2]Naval Research Laboratory.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Active region AR 11158 produced an X1 flare and several M flares during 2011 February 14-18, and yielded the best set of flare observations captured by the Hinode satellite in four years. Finding the mechanisms responsible for flares was one of the major science goals of the Hinode mission, and data from AR 11158 will be presented to demonstrate how this goal is being achieved with Hinode data. A particular focus will be on relating plasma flows and temperature and density changes measured with the EIS instrument to the magnetic field evolution observed by SOT, and the coronal evolution observed with SDO/AIA.

P22.14
Slow-Mode Oscillations of Hot Coronal Loops Excited at Flaring Footpoints
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[1]Catholic Univ of America / NASA GSFC, [2]Lockheed Martin Solar and Astrophysics Laboratory, [3]NASA GSFC.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
A large number of strongly damped oscillations in hot coronal loops have been observed by SOHO/SUMER in the past decade in Doppler shifts of flaring (>6 MK) lines (Fe XIX and Fe XXI). These oscillations with periods on the order of 10-30 min were interpreted as fundamental standing slow modes. They often manifest features such as recurrence and association with a flow (100-300 km/s) pulse preceding to the oscillation, which suggests that they are likely driven by microflares at the footpoints. With coordinated RHESSI observations, we have found a dozen such events supporting this conjecture. A typical event is presetned here. By analyzing RHESSI hard X-ray and GOES/SXI soft X-ray emissions as well as SUMER Doppler shifts, we identify the flare that triggers the loop oscillations. From RHESSI spectra, we measure physical parameters such as temperature, emission measure, and

thermal/non-thermal energy contents as functions of time. We discuss the wave excitation mechanism based on these observations. Our results provide important observational constraints that can be used for improving theoretical models of magnetosonic wave excitation, and for coronal seismology.

P22.15

Magnetic Flux Change And Cancellation Associated With X- And M-class Flares

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7:30 AM Monday - 8:30 AM Thursday

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Recently it has become clear that photospheric magnetic fields change significantly, abruptly and permanently as a result of major X- and M-class flares. We perform a statistical study of permanent changes in longitudinal fields associated with solar flares by tracking magnetic features. The YAFTA feature tracking algorithm is applied to GONG++ one-minute magnetograms for 77 X- and M-class flares to analyze the evolution and interaction of the magnetic features and to estimate the amount of cancelled flux. We find that about twice as many magnetic flux decreases as increases occurred during the flares, consistent with collapsing loop structure. The flux changes were accompanied in most cases by significant cancellation, most of which occurred before and during the flares.

P22.16

Solar Flare Probability depending on Sunspot Classification, Its Area, and Its Area Change

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7:30 AM Monday - 8:30 AM Thursday

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We have investigated solar flare probability depending on sunspot classification, its area, and its area change using only solar white light data. For this we used the McIntosh sunspot group classification and then selected most flare-productive six sunspot groups : DKI, DKC, EKI, EKC, FKI and FKC. For each group, we classified it into three sub-groups according to sunspot area change : increase, steady, and decrease. For sunspot data, we used the NOAA active region information for 19 years (from January 1992 to December 2010): daily sunspot class and its area corrected for the projection effect. As a result, we find that the mean flare rates and the flare probabilities for the "increase" sub-groups are noticeably higher than those for other sub-groups. In the case of the (M+X)-class flares of 'kc' groups, the mean flare rates of the "increase"sub-groups are more than two times than those of the "steady"sub-groups. In the case of DKC sunspot group, the (M+X)-class flare probability of the "increase" sub-group is 53% while the "decrease" and "steady" sub-groups are 27% and 24%, respectively. This is statistical evidence that magnetic flux emergence is an very important mechanism for triggering solar flares since sunspot area can be a good proxy of magnetic flux. In addition, we are examining the relationship between sunspot area and solar flare probability. For this, we classified each sunspot group into two sub-groups: large and small. In the case of compact group, the solar flare probabilities noticeably increase with its area. We are going to develop a flare probability model depending on sunspot class, its area, and its area change.

P22.17

Estimating Flaring Probability from High-Cadence Images of the Solar Chromosphere

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7:30 AM Monday - 8:30 AM Thursday

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We applied principal component analysis to 8-10 hour sequences of chromospheric Hα images of selected solar active regions as observed by the U. S. Air Force Improved Solar Optical Observation Network (ISOON) telescope at Sacramento Peak, NM at one-minute intervals. A covariance matrix of all combinations of image time pairs was computed from the picture element Hα intensities from each image sequence, and eigenvalues and eigenvectors were computed. Computation of explained variance from the eigenvalues indicated that 99.9% of the characteristics were represented by the first 50 eigenvectors or so. The leading eigenvectors were matched at each image time with a flare category indicator deduced from coincident active region area-average Hα intensity and 1-8 Å GOES X-ray flux measurements at one-minute intervals. Multivariate discriminant analysis (MVDA) was applied to the eigenvector elements and flaring indicators from a training set of image sequences to compute a vector of coefficients whose linear combination with the eigenvector predictors maximizes the distinction among flaring groups. The discriminant function, computed from the dot product of the coefficients with the eigenvectors of an independent ISOON case, is used to compute the probability of each flaring group at each measurement time. Flare category indicators from independent case times are used to assess the flaring probability estimates. Multivariate logistic regression (MVLR) was also applied to the subset of eigenvectors in the training data, and the derived coefficients were also dotted with the independent eigenvalues to generate a separate flaring probability estimate. A total of 47 ISOON image sequences were available for training and flaring probability estimation. Preliminary results showed that the MVLR was competitive with MVDA in skill of diagnosing flaring probability. If this approach shows promise in a diagnostic mode, efforts will be made to extend it to short-term (1-3 hour) prognostic mode.

P22.18

Predictions Of Energy And Helicity In Four Major Eruptive Solar Flares

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In order to better understand the solar genesis of interplanetary magnetic clouds (MCs) we model the magnetic and topological properties of four large eruptive solar flares and relate them to observations. We use the three-dimensional Minimum Current Corona model and observations of pre-flare photospheric magnetic field and flare ribbons to derive values of reconnected magnetic flux, flare energy, flux rope helicity and orientation of the flux rope poloidal field. We compare model predictions of those quantities to flare and MC observations and within the estimated uncertainties of the methods used find the following. The predicted model reconnection fluxes are equal to or lower than the observed reconnection fluxes from the ribbon motions. Both observed and model reconnection fluxes match the MC poloidal fluxes. The predicted flux rope helicities match the MC helicities. The predicted free energies lie between the observed energies and the estimated total flare luminosities. The direction of the leading edge of the MC's poloidal field is aligned with the poloidal field of the flux rope in the AR rather than the global dipole field. These findings compel us to believe that magnetic clouds associated with these four solar flares are formed by low-corona magnetic reconnection during the eruption, rather than eruption of pre-existing structures in the corona or formation in the upper corona with participation of the global magnetic field. We also note that since all four flares occurred in active regions without significant pre-flare flux emergence and cancellation, the energy and helicity we find are stored by shearing and rotating motions, which are sufficient to account for the observed radiative flare energy and MC helicity.

P22.19

Using Supra-Arcade Downflows as Probes of Particle Acceleration in Solar Flares

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Extracting information from coronal features above flares has become more reliable with the availability of increasingly higher spatial- and temporal-resolution data in recent decades. We are now able to sufficiently probe the region high above long-duration flaring active regions where reconnection is expected to be continually occurring. Flows in the supra-arcade region, first observed with Yohkoh/SXT, have been theorized to be associated with newly-reconnected outflowing loops. High resolution data appears to confirm these assertions. Assuming that these flows are indeed reconnection outflows, then the detection of those directed toward the solar surface (i.e. downflowing) should be associated with particle acceleration between the current sheet and the loop footpoints rooted in the chromosphere. RHESSI observations of highly energetic particles with respect to downflow detections could potentially constrain electron acceleration models. We provide measurements of these supra-arcade downflows (SADs) in relation to reconnection model parameters and present preliminary findings comparing the downflow timings with high-energy RHESSI lightcurves.

P22.20

Comparison Between Observation and Simulation of Magnetic Field Changes Associated with Flares

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It has been a long-standing question in solar physics how magnetic field structure changes with eruptive events (e.g., flares and coronal mass ejections). In an effort to understand the physics behind the phenomena, we present the eruption-associated changes in magnetic inclination angle, the horizontal component of magnetic field vectors, the Lorentz force, the magnetic shear angle and the footpoint motion of the flare. The study is mainly based on the three-dimensional MHD simulation of the evolution of the magnetic field in the corona by Yuhong Fan, and compared with some observational data. The results suggest that the field lines at the flaring magnetic polarity inversion line become more horizontal near the surface, that is in agreement with the prediction of Hudson et al. In addition, the footpoints show the de-shearing and diverging motion following the converging motion during the flare.

P22.21

Heating of Flare Loops During a Two-ribbon Flare

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[1]Montana State Univ..

7:30 AM Monday - 8:30 AM Thursday

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Many eruptive flares exhibit two extended ribbons in the lower-atmosphere outlining the feet of the post-flare coronal arcade. High-cadence high-resolution UV observations by TRACE reveal that the flare ribbon consists of small patches sequentially brightened along the ribbon, suggesting that reconnection takes place sequentially forming individual post-flare loops along the arcade, as often seen in coronal observations in the EUV wavelengths. These reconnection events and formation of new loops continue well into the decay phase. Our recent study (Qiu et al. 2010) further shows that the spatially resolved UV brightness at the foot-points of individual loops grows rapidly on timescales of ~1 minutes, followed by a long decay on timescales of more than 10 minutes. The rapid rise of UV radiation is correlated with the

hard X-ray light curve during the impulsive phase, hence is most likely a direct response of instantaneous heating in the reconnection formed flux tubes. In this study, we utilize the spatially resolved UV brightness time profiles to reconstruct instantaneous heating functions of individual flux tubes, and compute evolution of each flux tube using the EBTEL model (Klimchuk et al. 2008). To build the heating function, we take into account the scaling between the total UV peak count rate, the hard X-ray energy flux derived from RHESSI spectral analysis during the impulsive phase, and as well the reconnection rate that persists from the pre-impulsive phase to the decay phase. The sum of the computed coronal radiation in all the flux tubes compares favorably with the gross coronal radiation observed by GOES. This study presents the first effort to constrain heating functions of flare loops directly using all available observables, and provides a method to examine physics of heating discrete flux tubes formed by reconnection events throughout the flare. This work is supported by NSF grant ATM-0748428.

P22.22

Evidence for Magnetic Reconnection in a Flare and CME Observed By RHESSI and SDO/AIA

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The double coronal X-ray sources (Sui and Holman 2003, Liu et al. 2008) observed by RHESSI are believed to be evidence for the existence of a current sheet in between. On the other hand, evidence for magnetic reconnection (inflows, outflows, flux rope, cusp, current sheet and down flows) has been reported in EUV observations. However, there are few (Liu et al. 2010, but with no RHESSI observation) that show the combined features expected from reconnection theory. We report a study of two limb flares and a related CME observed by RHESSI and SDO/AIA at 18:00 UT-21:00 UT on Mar. 08 2011. The SDO-AIA data show the formation and eruption of the flux rope (CME). The X-ray emission observed by RHESSI shows an extended source at both thermal and non-thermal energies above the flaring loop. During the two hard X-ray peaks, RHESSI images indicate a reverse Y-shape structure above the flaring loop and a Y-shape structure high in the corona. We also observe inflows between the two RHESSI coronal sources after the second peak at 18:19 UT. The flux rope erupted one hour later. Down flows were seen above the post flare loops at this time. These provide evidence for magnetic reconnection and a failed eruption, inhibited by an overlying magnetic structure in the corona at least an hour before the successful CME. We will compare the results with previous observations and flare/CME models.

P22.23

The Great Decimetric Solar Spike Burst of 2006 December 6: Possible Evidence for Field-aligned Potential Drops in Post-eruption Loops

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7:30 AM Monday - 8:30 AM Thursday

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A 1.4 GHz solar radio burst associated with a 3B/X6 eruptive flare on 2006 December 6 had the highest peak flux density (~10^6 sfu) of any event yet recorded at this frequency. The decimetric event characteristics during the brightest emission phase (numerous intense, short-lived, narrow-band bursts that overlapped to form a continuous spectrum) suggest electron cyclotron maser (ECM) emission. The peak 1.4 GHz emission did not occur during the flare impulsive phase but rather ~45 minutes later, in association with post-eruption loop activity seen in H-alpha and by *Hinode* EIS. During the Waves/LASCO era, three other delayed bursts with peak intensities >10^5 sfu in the 1.0-1.6 GHz (L-band) frequency range have been reported and appear to have characteristics similar to the December 6 burst. In each of

these three cases type IV bursts were reported in a range from ~150 to ~1500 MHz. Assuming a common ECM emission mechanism across this frequency range implies a broad span of source heights in the associated post-eruption loop systems. Difficulties with an ECM interpretation for these events include the generation of the lower frequency component of the type IVs and the long-standing problem of escape of the ECM emission from the loops. Magnetic-field-aligned potential drops, analogous to those observed for Earth's auroral kilometric radiation, could plausibly remove both of these objections to ECM emission.

P22.24

Three-Dimensional Magnetic Reconnection Through A Moving Magnetic Null.

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7:30 AM Monday - 8:30 AM Thursday

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We model the dynamics of three-dimensional (3D) magnetic reconnection in a system where magnetic fields are observed to evolve from an unstable force-free equilibrium to a minimum energy state by way of global rearrangement of the magnetic topology. The process conserves total magnetic helicity and reconnection through a magnetic null is the dominant magnetic energy loss mechanism. During the period of most intense reconnection, the 3D localized reconnection region is observed to follow the magnetic null moving at a substantial fraction of the Alfven speed (up to 0.2 v_Alf). Here, we will explore the qualitative effects of a moving 3D reconnection region on the rate of change of magnetic topology and the associated non-ideal electric fields. The quantitative impact of background plasma beta and ion inertia (the Hall effect) on the measured correlation between the motion of the magnetic null and the reconnection region will also be demonstrated. This research is supported by the Office of Naval Research.

P22.25

On the Magnetic Field Variations and HXR Emission of the First X-class Flare in the 24th Solar Cycle

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7:30 AM Monday - 8:30 AM Thursday

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Multi-wavelength studies of energetic solar flares with seismic emissions have revealed interesting common features between them. We studied the first seismically active flare of the 24th solar cycle (SOL2011-02-15T01:52 X2.2) detected by HMI/SDO (Kosovichev, 2011) using a pixel-by-pixel light-curve characterization of the fluctuations of the photospheric longitudinal magnetic field based on HMI data. For context we used HXR RHESSI data to find a correlation between these sources and the spatial location of the transient longitudinal magnetic field changes in the photospheric region where this flare took place.

P22.26

Abrupt Longitudinal Magnetic Field Changes During A Flare Observed By Hmi And Gong

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7:30 AM Monday - 8:30 AM Thursday

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We characterize the photospheric longitudinal magnetic field changes that occurred during the 6 November 2010 M5.4 flare observed by both the Helioseismic and Magnetic Imager (HMI) and the Global Oscillation Network Group (GONG). We compare maps of the field changes as well as pixel-by-pixel mosaic plots of the field against time across the active region. The HMI data show larger-amplitude field changes and more complex spatial structure and temporal variation than the GONG data. Besides obvious differences in spatial resolution and seeing conditions, these discrepancies might be due to differences in the structure of the photosphere at the different formation heights of the absorption lines used in measuring the magnetic field strength.

P22.27

Study of Magnetic Helicity Injection in the Active Region NOAA 11158 Associated with the X-class Flare of 2011 February 15

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The main objective of this study is to examine a long-term (a few days) precondition and a trigger mechanism for an X2.2 flare peaking at 01:56 UT on 2011 February 15 in GOES soft X-ray flux. For this, we investigated the variation of magnetic helicity injection through the photospheric surface of the flare-productive active region NOAA 11158 during (1) the long-term period of February 11 to 15 with a 1-hour cadence and (2) the short-term period of 01:26 to 02:10 UT on February 15 with a 45-second cadence. The helicity injection was determined using line-of-sight magnetograms with high spatial and temporal resolution taken by the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO). As a result, we found two characteristic phases of helicity injection related to the X2.2 flare. A large amount of positive helicity was first injected over ~2 days with a phase of monotonically increasing helicity. And then the flare started simultaneously with a significant injection of the opposite (negative) sign of helicity around the flaring magnetic polarity inversion line. This observational finding clearly supports the previous studies that there is a continuous injection of helicity a few days before flares and a rapid injection of the helicity in the opposite sign into an existing helicity system triggers flares.

P22.28

Bayesian Analysis Of Rhessi Flare Data: Effect Of Prior Information OnDetermining The Low-energy Cutoff And The Total Electron Content

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We use a Bayesian/Markov chain Monte Carlo (MCMC) posterior analysis to determine credible intervals (error estimates) to the parameter values of emission models. We model a RHESSI spectrum from the X1.9 flare of 23 July 2002 as an isothermal component plus a non-thermal bremsstrahlung photon spectrum produced in thin-target interactions by an electron distribution that is a double power law above a low energy cutoff. The flare-injected electron distribution models mentioned above are subject to a low-energy cutoff. The location of this low-energy cutoff is not known precisely since the signal-to-noise ratio of the photons due to the non-thermal spectrum compared to the photons due to the thermal spectrum is small at the energies where the low-energy cutoff is thought to be. This parameter is of particular interest since it is a key component in determining the total electron content of flares.

Bayesian data analysis allow one to include information (priors) on the likely value of parameters. Priors force one to explicitly quantify the expectations of the range and behavior of parameter values in a model. Credible intervals to the model parameter values (derived via Bayesian/Markov chain Monte Carlo (MCMC) posterior analysis) therefore include the effect of this prior information. In analyzing flares, priors allow one to explicitly quantify the expected values of parameters in flare models. It is found that changing the prior of the total integrated electron flux model parameter from a flat prior (all values have equal probability) to a Jeffreys prior (orders of magnitude of the parameter value have equal probability) enhances peaks in the probability distribution of the low-energy cutoff below 25 keV. This prior-dependence suggests weak evidence for their actual presence. We find the most probable total electron content (along with its 68% and 95% credible interval) given the model flare spectra used.

P22.29

Accelerated Electron Spectra and Turbulence Characteristics from RHESSI Solar Flare Observations

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In the model of stochastic acceleration for solar flares, particles undergo simultaneous pitch angle scattering and acceleration by plasma waves or turbulence near the top of the flaring loop. The accelerated electrons produce hard X-ray (HXR) emission mainly at the loop top (LT) and the footpoints (FPs) by bremsstrahlung. As shown in Petrosian & Chen (2010, ApJ Letters, 712, 131), imaging spectroscopic observations of the LT and FP sources can directly give the accelerated electron spectrum, which is determined by the turbulence diffusion and direct acceleration rates, and can constrain some characteristics of turbulence in the coronal LT acceleration region. In particular, we can obtain the escape time, which is related to the pitch angle scattering rate of electrons by turbulence.
We will present results from application of this method to several solar flares observed by the RHESSI satellite using the regularized electron maps. Comparison of electron spectra obtained from solution of the Fokker-Planck equation with the directly observed LT electron spectra allows us to determine whether the required acceleration rate by turbulence is consistent with the scattering rate obtained primarily from the ratio of the LT to FP fluxes.
We will use the escape time obtained from the above analysis to obtain the accelerated electron spectrum from the regularized inversion of the spatially integrated flare HXR spectrum, which can be applied to many more flares as it does not require imaging spectroscopy.

P22.30

Deriving the Density and Ionization Profile along Flaring Loop

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Determining the evolution of the chromospheric and coronal plasma during a solar flare is a key step in understanding how this plasma responds to heating from nonthermal electrons or other sources, and in identifying the source(s) and location of heating.
We develop a method to derive the density structure of local plasma along flaring loops using nonthermal X-ray observations. The method is based on the relationship between emission and column density derived from our simple nonuniform ionization thick-target model (Su et al. 2011). A similar idea was presented by Leach and Petrosian (1981) and was applied to Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) observations of one flare by Liu et al. (2006). This method does not

require an assumed density structure, unlike other methods (Aschwanden et al. 2002, Prato et al. 2009, Kontar et al. 2008 and Saint-Hilaire et al. 2010) which use the peak or centroid positions of X-ray sources in different energy bands and an assumed form for the density structure.
Our method also determines the location of the transition layer between ionized and neutral gas, a new result in flare studies. Our preliminary results show an increase in the density of the loop top and an decrease in the height of the transition layer. These agree with the standard flare model and chromospheric evaporation. Using this method to derive the time evolution of density and ionization structure, we will compare our results with chromospheric evaporation models (Allred et al. 2005).

P22.31
RHESSI and SDO Observation Of HXR and UV/EUV Emissions in the 2011 March 7 Solar Flare
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We present analysis of the RHESSI and SDO observation of a very unusual M3.7 class solar flare on 2011 March 7 from the active region 11164, which was also detected by the Fermi Large Area Telescope above 100 MeV at gamma-rays and NoRP at microwaves. This flare was accompanied by a relatively strong CME and solar energetic particles.
During the flare, hard X-ray emission up to 300 keV was detected by RHESSI. The HXR images at 12-300 keV in the impulsive phase exhibit two footpoint sources with an unusually large separation of more than 120 arcsec and a thermal loop below 18 keV connecting the two footpoints. On the other hand, the SDO/AIA UV and EUV images indicate that the spatial structure of the flare is much more complicated than the above HXR picture. The UV continuum images at 1600 and 1700 angstrom show three elongated ribbons, the outer two being brightest and coincident with the HXR footpoints and the middle one without any detectable cospatial HXR source. Furthermore, the EUV images show a few arcade systems successively developing during the flare, while there are no clear EUV loops seen to connect the two HXR footpoints.
We will examine the magnetic configuration within the flaring regions using the RHESSI, SDO/AIA and SDO/HMI magnetogram data, and investigate the relation between UV ribbon brightening and electron heating in this flare. The relation between the HXR and EUV emission and other observations will be analyzed and described.

P22.32
Rapid Enhancement of Sheared Evershed Flow Along the Neutral Line Associated with an X6.5 Flare Observed by Hinode
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We present G-band and Ca II H observations of NOAA AR 10930 obtained by Hinode/SOT on 2006 December 6 covering an X6.5 flare. Local Correlation Tracking (LCT) technique was applied to the foreshortening-corrected G-band image series to acquire horizontal proper motions in this complex beta-gamma-delta active region. With the continuous high quality, spatial and temporal resolution G-band data, we not only confirm the rapid decay of outer penumbrae and darkening of the central structure near the flaring neutral line, but also unambiguously detect for the first time the enhancement of the sheared Evershed flow (average horizontal flow speed increased from 330+-3.1 to 403+-4.6 m/s) along the neutral line right after the eruptive white-light flare. Post-flare Ca II H images indicate that the

originally fanning out field lines at the two sides of the neutral line get connected. Since penumbral structure and Evershed flow are closely related to photospheric magnetic inclination or horizontal field strength, we interpret the rapid changes of sunspot structure and surface flow as the result of flare-induced magnetic restructuring down to the photosphere. The magnetic fields turn from fanning out to inward connection causing outer penumbrae decay, meanwhile those near the flaring neutral line become more horizontal leading to stronger Evershed flow there. The inferred enhancement of horizontal magnetic field near the neutral line is consistent with recent magnetic observations and theoretical predictions of flare-invoked photospheric magnetic field change.

P22.33

Solar Flare Detection With SWIFT and Real-time GONG H-alpha Images

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7:30 AM Monday - 8:30 AM Thursday

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The Air Force Weather Agency (AFWA) has begun the process of upgrading the Solar Observing Optical Network (SOON) with an Improved-SOON (ISOON). During the interim period, AFWA is supporting the addition and operation of a solar H-alpha (Hydrogen-alpha, 656.3 nm) full-disk image network utilizing the light feed from the National Solar Observatory's existing GONG (Global Oscillation Network Group) instruments. The H-alpha instruments at the GONG sites have been in operation collectively since the beginning of 2011, providing one to three H-alpha images per minute. Cross-site comparison and calibration of flare detection has begun using an image analysis tool called SWIFT (SWFL/ISOON Flare-cast Tool). SWIFT is a unique and versatile software package, designed originally for ISOON data, that has been attuned to ingest and display GONG H-alpha images in real-time. The SWIFT software allows a user to detect and analyze optical flares from solar active regions. The SWIFT software is in the process of being beta-tested at AFWA in collaboration with the Space Weather Center of Excellence's SWFL (Space Weather Forecasting Laboratory) to better forecast space weather events. Solar flares are of great interest to the Air Force Research Laboratory's Space Vehicles Directorate because they can trigger energetic particle events or coronal mass ejection events that impact the Earth's magnetosphere creating geomagnetic storms. Such events can result in satellite charging damage, increased satellite drag, power grid disruption, navigation system anomalies, and communication fadeouts. An overview of SWIFT, along with preliminary flare detection comparisons between GONG sites and the SOON flare reports, will be presented.

P22.34

Hard X-Ray Footpoint Convergence and Photospheric Field Change

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7:30 AM Monday - 8:30 AM Thursday

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We study the GOES-class X2.2 flare occurred at NOAA AR 11158 on 2011 February 15. An enhancement of transverse magnetic field by as much as 70% is observed by SDO/HMI at the flaring magnetic polarity inversion line (PIL). This rapid and irreversible field evolution occurs in between the hard X-ray (HXR) footpoints as observed by RHESSI, and is temporally associated with a jump of the conjugate footpoints from a highly sheared, widely separated configuration to a less sheared, less separated configuration. The dynamics is consistent with the tether-cutting model, in which the less sheared overlying field is stretched by the newly reconnected, highly sheared field and consequently reconnect below the highly

sheared field. The enhancement of transverse field could be due to tether-cutting reconnection which occurs in the low atmosphere.

P22.35

Estimation of Reconnection Electric Field in the 2003 October 29 X10 Flare

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The electric field in the reconnecting current sheet is estimated from the change rate of photospheric magnetic flux in the newly brightened areas of TRACE UV ribbons. The X10 flare on 2003 October 29 is selected due to its distinct two-phase HXR footpoint motion, two arcade systems with different magnetic shear, and the high-cadence and complete coverage of TRACE 1600 Å, MDI magnetogram, and RHESSI HXR observations. Besides the strengths of reconnection electric field in different flare phases, we particularly pay attention to the temporal correlation between the reconnection electric field and the corresponding characteristics at the conjugate HXR footpoints (such as the HXR emissions, HXR power-law spectral indexes, and the photospheric magnetic field strengths). We found that in the early impulsive phase, the reconnection electric field peaks just before the HXR emission peaks and the energy spectrum hardens. The result could be consistent with the scenario that more particles are accelerated to higher energies by larger reconnection electric field and then precipitate into lower chromosphere to produce stronger HXR emissions. Moreover, such particle acceleration mechanism plays most significant role in the impulsive phase of this X10 flare. In addition, our results provide the evidence that the highly-sheared magnetic field lines are mapped to the magnetic reconnection diffusion region to produce large reconnection electric field.

P22.36

Gamma-Ray and Neutron Evidence for Two Acceleration Episodes in the 2003 October 28 Solar Flare

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High-energy gamma-ray and neutron emission from the 2003 October 28 solar flare was observed by RHESSI, CORONAS and Integral and by the Tsumeb neutron monitor. Relativistic electron bremsstrahlung, nuclear deexcitation gamma-ray lines and continuum, the 0.511 MeV positron-annihilation line, the 2.223 MeV neutron-capture line, pion-decay emission, and neutrons were observed. Solar energetic particles accelerated by a shock associated with a coronal mass ejeciton (CME) were also observed in space and by ground-based monitors. This remarkably-wide range of observations offers a unique opportunity for studying ion acceleration. We review the high-energy emission theory and the procedure developed for analyzing such flare data. We discuss the results of applying the procedure to the October 28 flare data, and argue for the presence of two components of energetic particles producing the flare emissions, one accelerated by the flare itself and one accelerated by the CME-associated shock.

P22.37

Multi-thermal observations of the 2010 October 16 flare:heating of a ribbon via loops, or a blast wave?

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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
On 2010 October 16th SDO/AIA observed its first flare using automatic exposure control. Coincidentally, this flare also exhibited a large number of interesting features. Firstly, a large ribbon significantly to the solar west of the flare kernel was ignited and was visible in all AIA wavelengths, posing the question as to how this energy was deposited and how it relates to the main flare site. A faint blast wave also emanates from the flare kernel, visible in AIA and observed traveling to the solar west at an estimated speed of ~1000 km/s. This blast wave is associated with a weak white-light CME observed with STEREO B and a Type II radio burst observed from Green Bank Observatory (GBSRBS). One possibility is that this blast wave is responsible for the heating of the ribbon. However, closer scrutiny reveals that the flare site and the ribbon are in fact connected magnetically via coronal loops which are heated during the main energy release. These loops are distinct from the expected hot, post-flare loops present within the main flare kernel. RHESSI spectra indicate that these loops are heated to approximately 10 MK in the immediate flare aftermath. Using the multi-temperature capabilities of AIA in combination with RHESSI, and by employing the cross-correlation mapping technique, we are able to measure the loop temperatures as a function of time over several post-flare hours and hence measure the loop cooling rate. We find that the time delay between the appearance of loops in the hottest channel, 131 A, and the cool 171 A channel, is ~ 70 minutes. Yet the causality of this event remains unclear. Is the ribbon heated via these interconnected loops or via a blast wave?

P22.38
The Flare Productivity of Active Regions
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
Previous studies have shown that the flare frequency distribution is consistent with a power-law. Furthermore, studies have shown that regions of higher magnetic complexity produce more large flares. This may imply that the flare frequency distribution is harder for magnetically complex active regions. However, the relationship between source active regions’ magnetic complexity and the flare size distribution has not been extensively studied.
We present a new study of 25,000 microflares detected by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) from March 2002 to February 2007. For each flare, we have obtained the two classifications of magnetic complexity, the Mount Wilson Magnetic Classification and the Zurich/McIntosh Sunspot Classification, from the Solar Region Summary prepared by the National Oceanic and Atmospheric Administration (NOAA)/ Space Weather Prediction Center (SWPC), and compared them with the RHESSI flare size distribution as observed in the 12 to 25 keV energy range.
We find that, for both the Mount Wilson Magnetic Classification and the Zurich/McIntosh Sunspot Classification, the slopes of the microflare size distribution does not change as a function of magnetic complexity. This implies that there exists a fundamental “parent distribution” of flare size. We also find a good correlation between the number of flares produced and the region’s magnetic complexity for the Zurich/McIntosh Sunspot Classification. We conclude that the Zurich/McIntosh Classification is a more appropriate measure of flare productivity.

P22.39

Solar Flare Neutron Measurements for the Upcoming and Following Solar Maxima

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Because of the instrument selection process on the NASA mission Solar Probe Plus and the ESA mission Solar Orbiter, the opportunity for detecting and measuring neutrons in the inner heliosphere may regrettably be lost for the next solar cycle and perhaps longer. We must turn our attention to and focus on what can be accomplished from platforms at 1 AU. Measurements in the inner heliosphere would have constituted a unique window into the energetic ion problem in flares and the quiescent Sun. Ideally, such measurements would have been coupled with gamma and neutron measurements conducted at 1 AU. However, absent the inner heliosphere data, the solar flare neutron intensity at 1 AU still offers important information about solar flare ion acceleration, complementing that obtained from gamma-ray measurements. We review here opportunities and possibilities for neutron measurements at 1 AU. These include neutron-decay measurements with interplanetary particle detectors, direct neutron measurements on balloon platforms, low-Earth orbit platforms and ground based instruments. We further indicate how such measurements, in the past, and on future missions increase our sensitivity to flare phenomena and refine spectral and time-dependent results obtained with spectroscopic gamma measurements.

P23

Coronal Mass Ejections

Poster

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P23.01

A Multiscale Technique for Automatically Detecting and Tracking CMEs in Coronagraph Data

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Studying coronal mass ejections (CMEs) in coronagraph data can be challenging due to their diffuse structure and transient nature, and user-specific biases may be introduced through visual inspection of the images. The large amounts of data available from the SOHO, STEREO, and future Solar Orbiter missions, also makes manual cataloguing of CMEs tedious, and so a robust method of detection and analysis is required. This has led to the development of automated CME detection and cataloguing packages such as CACTus, SEEDS and ARTEMIS. However, the main drawbacks of these catalogues are: the CACTus method of detection fails to resolve CME acceleration profiles; the CACTus and SEEDS running-difference images suffer from spatiotemporal crosstalk; and the SEEDS and ARTEMIS detections are limited to only the LASCO/C2 field-of-view. Recently, the benefits of multiscale filtering of coronagraph data have been demonstrated in an effort to overcome current cataloguing issues. A multiscale decomposition can be applied to individual images in order to enhance the structure of CMEs whilst removing noise and small-scale features like stars. Here we present the development of a new, automated, multiscale, CME detection & tracking technique. It works by first separating the dynamic CME signal from the background corona and then characterising CME structure via a multiscale edge-detection algorithm. The detections are then chained through time to determine the CME kinematics and morphological changes as it propagates across the plane-of-sky. We demonstrate its application to a sample of LASCO data and prove its efficacy in detecting and tracking CMEs. This technique is being applied to the complete LASCO dataset, and it is planned to further develop it for implementation on the SECCHI/COR dataset in the near future.

P23.02

Physical Processes of Poloidal Flux Injection in CMEs

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7:30 AM Monday - 8:30 AM Thursday

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The erupting flux rope (EFR) model of CMEs has been extensively tested against CME dynamics observed by SOHO and STEREO, demonstrating good agreement between model results and data: the best-fit solutions can reproduce observed CME trajectories from the Sun to 1 AU to within 1-2% of the data, and such solutions yield the poloidal flux injection function whose temporal profiles closely match those of the associated soft X-ray flare emissions. This provides evidence that the flux injection function captures the underlying physical connection between CME acceleration and flare energy release [1]. This mathematical function admits two distinct physical interpretations. In this talk, the physical processes that can contribute to poloidal flux injection are discussed, one involving flux of subphotospheric source and the other of coronal source. Recently, Schuck [2] and earlier, Forbes [3] argued that there is insufficient Poynting flux observable through the photosphere to support the subphotospheric flux injection hypothesis. These calculations, however, impose ad hoc large-scale coherent horizontal fields in the photosphere and do not have any subphotospheric source of flux or any equations of motion describing an ``injection'' process from a source through a medium. That is, these arguments contain no flux injection mechanism that they purport to ``falsify'' and no physical properties of the convection zone. Physically relevant signatures of subphotospheric flux injection are discussed.

[1] Chen, J., and Kunkel, V. 2010, ApJ, 717, 1105.
[2] Schuck, P. W. 2010, 714, 68.
[3] Forbes, T. G. 2001, Eos Trans. AGU, 82(20), SH41C-03.

P23.03

Magnetic Topology of the Source Surface Potential Field on 1 August 2010

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7:30 AM Monday - 8:30 AM Thursday

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A sequence of coronal mass ejections was recently observed by the Solar Dynamics Observatory (SDO) on 1 August 2010.   The events were closely synchronized with one another, even though some of them occured at rather different locations. Therefore, it is tempting to assume that these events were causally linked with each other. In an attempt to verify this assumption and identify a plausible reason of such a link, we study the topological structure of the source surface potential field that has been computed from the observed photospheric magnetic field at the appropriate time period.   For this purpose, we investigate the respective magnetic connectivity in the obtained configuration by calculating and analyzing the distributions of the so-called squashing factor at the boundaries as well as at different cross-sections. This allows us to get a comprehensive understanding of the underlying structural skeleton of the magnetic cofiguration and identify the robust topological features that likely establish the assumed causal link in the indicated events. The obtained topological framework also provides a solid guide for further numerical modeling and analysis of the observational data of these eruptions.

P23.04

The Main Sequence of Explosive Emerging Solar Active Regions

David Falconer[1], R. Moore[2]
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We study the dependence of production of major CME/flare eruptions on the source active region's (AR's) location in (flux content, free energy) phase space. For this, an AR's flux content and a proxy of its free magnetic energy content can be adequately measured from 96-minute cadence SOHO/MDI magnetograms when the AR is within 30 degrees of disk center (Falconer et al 2008, ApJ, 688, 143). The AR's evolution in this phase space can thereby be tracked as it crosses the central disk. By our definition, an AR is (1) mature if its flux is growing by less than 50%/day when it rotates onto the 30-degree-radius central disk, or (2) emerging if its flux is growing faster than 50%/day when it enters the central disk or if it is born within the central disk. In an initial study of 46 ARs, 42 were mature and 4 were emerging. From ~1800 MDI magnetograms of the 42 mature ARs, we found that (1) mature ARs have a sharp upper bound on the free energy they can attain that increases with increasing flux content, and (2) for mature ARs, nearly all CMEs and X-class flares are produced by ARs that are near the free-energy limit line. These ARs constitute the main sequence of explosive mature ARs (Falconer et al 2009, ApJ, 700, L166). Two of the four emerging ARs attained free energy well beyond the limit for mature ARs of the same flux content, questioning whether emerging ARs have a free-energy limit and explosive main sequence like those for mature ARs. Here, we show from a much larger sample of ARs (~1000), of which about 1/3 are emerging, that emerging ARs do have a free-energy limit and a explosive main sequence, each offset to higher free energy relative to its mature-AR counterpart.

P23.05

The Reason for the Main Sequence of Explosive Solar Active Regions

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From measurement of magnetic flux and a proxy of free magnetic energy from 1800 SOHO/MDI line-of-sight magnetograms of 44 sunspot active regions, Falconer et al (2009, ApJ, 700, L169) showed (1) there is an upper limit to the free magnetic energy an active region can hold, (2) this limit increases with active-region magnetic size (flux content), (3) most major CME/flare eruptions are produce by active regions that are near their free-energy limit, (4) in (flux content, free-energy proxy) phase space, the source active regions for major CME/flare eruptions are concentrated along a main sequence, a path that runs close below the free-energy limit line, and (5) the free-energy limit and the main sequence probably result from the steep increase in CME/flare productivity as an active region approaches its free-energy limit, depleting the active region's free energy as fast as it is built up. Here we present (1) a new direct proxy of an active region's free magnetic energy, and (2) a corresponding proxy of the ratio of free energy to potential-field energy in the more-nonpotential parts of the active region. Each is measured from a vector magnetogram of the active region. From these two magnetic-energy proxies measured from Marshall Space Flight Center vector magnetograms of 42 of the active regions of Falconer et al (2009), we (1) affirm that the free-energy proxy measured in Falconer et al (2009) is indeed a proxy of an active region's free magnetic energy, (2) further support the above reason for the main sequence of explosive active regions, and (3) conclude that magnetic fields in active regions become ready to explode and produce CME/flare eruptions when their free energy becomes comparable to the potiential-field energy.

This work was supported by funding from NASA's Heliophysics Division, NSF's Division of Atmospheric Sciences, and AFOSR's MURI Program.

P23.06

Magnetic Field Strength in the Upper Solar Corona Using White-light Shock Structures Surrounding Coronal Mass Ejections

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7:30 AM Monday - 8:30 AM Thursday

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To measure the magnetic field strength in the solar corona, we examined 12 fast (> 1000 km s-1) limb CMEs which show clear shock-like structures in SOHO/LASCO observations. By applying piston-shock relationship to the observed CME's standoff distance and electron density compression ratio, we estimated the Mach number, Alfven speed, and magnetic field strength in the height range 3 to 15Rs. Main results from this study are: (1) the standoff distance observed in the solar corona is consistent with those from a magnetohydrodynamic (MHD) model and near-Earth observations; (2) the Mach number as a shock strength is in the range 1.49 to 3.52 from the standoff distance data, but when we use the compression ratio, the Mach number is in the range 1.47 to 1.90, implying that the measured density compression ratio is likely to be underestimated due to projection effects; (3) the Alfven speeds range from 259 to 982 km s-1 and the magnetic field strength is in the range 0.04 to 0.35 G when the standoff distance is used; (4) if we multiply the compression ratio by a factor of 2, the Alfven speeds and the magnetic field strengths are consistent in both methods; (5) the derived magnetic field strengths in the inner corona are similar to those of empirical models but noticeably higher in the upper corona. This is a new attempt to measure magnetic field strength from coronagraph observation alone. These observations are consistent with the idea that the diffuse structures surrounding the CME front can be interpreted as shock structures.

P23.07

Synchrotron Emission in Expanding CME Loops

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Hard X-ray and radio observations can be used to identify source of electron acceleration within the flare-CME system. Observations at meter wavelengths using the Nancay Radioheliograph are ideal for locating sources of synchrotron and plasma emission. Bastian et al. (2001) and Maia et al. (2007) imaged synchrotron emission present in the expanding loops of two independent CME's. It is unclear how these electrons were accelerated. Previous suggestions include acceleration at the reconnection site/current sheet between the flare and CME or in the foreshock generated as the ejected material propagates outward. We present observations of an event which occurred on the 14th of August which is a new candidate for studying these events.

P23.08

A Multi-vantage Point Study Of A CME Event Using SOHO/LASCO And STEREO Observations Together With The WSA/ENLIL Solar Wind And Cone CME Model

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7:30 AM Monday - 8:30 AM Thursday

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As we progress toward the maximum period of Solar Cycle 24, we have a unique opportunity to better understand the propagation and evolution of a CME given the multiple vantage points near 1 AU of such an event. In addition, with the wide availability of sophisticated, physics-based solar wind models, we can obtain a more global view of the CME evolution and propagation through numerical simulations. In this study, we simulate a CME event using the WSA/ENLIL 3D MHD solar wind model and daily updated solar magnetograms from GONG. To characterize the CME in the model, we use a simple geometrical description that assumes a cone shape for a CME and determine the CME width and central position from white light coronagraph images. We select a CME event that is observed by both STEREO (A and/or B) and SOHO/LASCO. Currently, both STEREO spacecraft are located ~90 degrees away from LASCO at L1. For a CME directed toward L1, i.e., a 'halo event', the same CME is observed as a limb event by STEREO. Such limb observations are ideal for determining the initial CME speed and width since there are less plane-of-sky projection effects. From a space weather perspective, studying halo CME events is important since they can strongly affect the space environment near Earth. To assess the accuracy of the cone+WSA/ENLIL model and the self-consistency of the results at different 'vantage points' in the model, we compare the modeled solar wind density, speed, and magnetic field magnitude with the values measured in-situ by ACE at L1 and STEREO.

P23.09

Magnetic Fields in ICMEs At 1 AU And Flux Injection Profile At the Sun

Valbona Kunkel[1], J. Chen[2], R. Howard[2]
[1]GMU, [2]NRL.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
With the SECCHI/STEREO observations, it is now possible to observe CME trajectories in interplanetary space. The twin spacecraft configuration of STEREO also allows one to, for the first time, continuously track a CME's trajectory from the Sun to 1 AU and in cases where the ejecta is encountered by another spacecraft at 1 AU, measure the in situ magnetic field and plasma properties of the CME ejecta. We have examined a number of CME events whose trajectories were continuously observed by one STEREO spacecraft and the ejecta were intersected by the other STEREO spacecraft or ACE at L1. We have applied the erupting flux rope model of CMEs (EFR) to these events and calculated the best-fit solutions and the physical quantities predicted by these solutions. For each event, it is possible to find a narrow range of solutions that fit the observed trajectory to within 1 to 2 % of the position data. The calculated magnetic field and average temperature and density of the resulting flux rope are compared with the in situ data. It is found that the 1-AU quantities predicted by the best-fit solutions for these events are in good agreement with the in situ data and that the calculated 1 AU magnetic field is insensitive to the form of the poloidal flux injection function, provided the injected energy is unchanged. We discuss in detail how the magnetic field of a CME evolves through interplanetary space, emphasizing the quantitative relationship between the CME trajectory and the evolution of the CME magnetic field. The discussion will focus on a physical understanding that can be used to interpret observational data and numerical results of simulation models of CMEs.

P23.10

Halo Coronal Mass Ejections: Comparing Observations to Models

Holly Gilbert[1], M. Orlove[2], O. St. Cyr[1], H. Xie[3], L. M. Mays[4], N. Gopalswamy[1]
[1]NASA's Goddard Space Flight Center, [2]NASA/GSFC, University of Maryland, [3]NASA/GSFC, The Catholic University of America, [4]NASA/GSFC, ORAU.
7:30 AM Monday - 8:30 AM Thursday

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Since 1996, the SOHO LASCO coronagraphs have detected “halo” CMEs that appear to be directed toward Earth, but information about the size and speed of these events seen face-on has been limited. From a single vantage point along the Sun-Earth line, the primary limitation has been ambiguity in fitting the cone model (or other forward-modeling techniques, *e.g.*, Thernisian *et al.*, 2006). But in the past few years, the STEREO mission has provided a view of Earth-directed events from the side. These events offer the opportunity to compare measurements (width and speed) of halo CMEs observed by STEREO with models that derive halo CME properties. We report here results of such a comparison on a large sample of LASCO CMEs in the STEREO era.

P23.11
Cme Evolution In The Interplanetary Space Based On Stereo Observations.
Watanachak Poomvises[1], N. Gopalswamy[2], J. Zhang[1]
[1]George Mason University, [2]NASA GSFC.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
STEREO/SECCHI observations help identify the true 3-D geometric structure of CMEs and track their true evolution in the inner heliosphere. Using STEREO observations, it is possible to obtain the true speed of CMEs, which is key in predicting the arrival time of CMEs at Earth (Gopalswamy et al. 2001). From the STEREO data, we are able to track and measure CMEs in 3-D by using Raytrace model (Thernisien et al 2006, 2009), which is free from projection effects and thus result in true CME velocities. Studied study 5 CME events, we found that the acceleration/deceleration of CMEs occur within 50 Rs from the Sun, after that the CME velocity converges to the narrow range (Poomvises et al 2010). Additionally, we found that expansion velocity of CMEs also converges to a narrow range after 50 Rs.
The observations are consistent with the theoretical flux rope model. The CME evolution can be explained by different forces that act on the CME: Lorentz force, thermal pressure force, gravity force, aero-dynamic drag force, and the magnetic drag force. The drag coefficient typically varies between 2.5 to 3.0, which is much smaller than the factor of twelve suggested by earlier studies. Moreover, the value of the polytropic index has been found to be between 1.35 to 1.60. Therefore, we have been able to narrow down the range of values for the drag coefficient and the polytropic index, which help in improve the prediction of CME travel time.

P23.12
Understanding Interplanetary Shock Dynamics In The Inner Heliosphere:The 2010 April 03 and August 01 Events
Hong Xie[1], L. May[2], C. O. St Cyr[3], N. Gopalswamy[3], D. Odstrcil[4], H. Cremades[5]
[1]Catholic University of America, [2]ORAU, [3]NASA/GSFC, [4]GMU, [5]UTN-FRM / CONICET, Argentina.
7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
The 2010 April 03 and 2010 August 01 CMEs were studied using observations from STEREO A and B, and SOHO LASCO, combined with ENLIL+Cone model simulations preformed at the Community Coordinated Modelling Center (CCMC). In particular, we identified the origin of CMEs using STEREO EUVI and/or SDO images. A flux-rope model fitting to the SECCHI A and B, SOHO/LASCO images was used to determine CME directions and actual speeds. J-maps from COR2/HI-1/HI-2 and simulations from CCMC were used to study the formation and evolution of the shocks in the inner heliosphere. We compared the simulation results with the observed height-time profiles of the shock from white light and kilometric type II (KmTII) burst (Wind/WAVES) observations. The predicted shock arrival at Earth is compared with in-situ observations from ACE. It is found that that ENLIL+cone model predicts the kinematics of shock

evolution well for both cases and the KmTII method is more successful when using ENLIL model plasma density.

P23.14

Asymmetric Magnetic Reconnection During Coronal Mass Ejections

Nicholas Arnold Murphy[1], A. K. Young[2], C. Shen[3], J. Lin[3], M. P. Miralles[1]

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7:30 AM Monday - 8:30 AM Thursday

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Flux rope models of coronal mass ejections (CMEs) typically predict the formation of a reconnecting current sheet between the flare site and the rising plasmoid. Sunward outflow is directed towards regions of high plasma and magnetic pressure, whereas antisunward outflow impacts the rising flux rope. There are likely to be strong gradients along the outflow direction for upstream density, pressure, and magnetic field strength. We use resistive magnetohydrodynamic (MHD) simulations to investigate the impact of asymmetry and current sheet motion during the reconnection process in the context of CME current sheets. Simulations of X-line retreat predict that most of the outflow energy is directed upward towards the rising flux rope, and show that the bulk plasma flow at the X-line is sometimes in the opposite direction of X-line retreat. CME current sheets are expected to be unstable to the formation of plasmoids, and our simulations of multiple competing X-lines show that the flow stagnation point is typically located between the X-line and a centrally located plasma pressure maximum. Simulations of line-tied asymmetric inflow reconnection show slow current sheet drifting and skewing of post-flare loops.

P23.15

Observing Flux Rope Formation During the Impulsive Phase of a Solar Eruption

Xin Cheng[1], J. Zhang[1], L. Yang[2], M. Ding[3]

[1]*GMU,* [2]*Stanford University,* [3]*NJU, , China, China.*

7:30 AM Monday - 8:30 AM Thursday

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Magnetic flux rope is believed to be an important structural component of coronal mass ejections (CMEs). While there exist much observational evidence of the flux rope post the eruption, e.g., as seen in remote-sensing coronagraph images or in-situ solar wind data, the direct observation of flux ropes during CME impulsive phase has been rare or non-exist. In this Letter, we present an unambiguous observation of a flux rope still in the formation phase in the low corona. The CME of interest occurred above the east limb on 2010 November 03 with footpoints partially blocked. The flux rope was seen as a blob of hot plasma in AIA 131 A passband (peak temperature ~11 MK) rising from the core of the source active region, rapidly moving outward and stretching upward the surrounding background magnetic field. The stretched magnetic field seemed to curve-in, similar to the classical magnetic reconnection scenario in eruptive flares. The flux rope was also seen as a dark cavity in AIA 211 A passpand (2.0 MK) and 171 A passband (0.6 MK); in these relatively cool temperature bands, a bright rim clearly enclosed the dark cavity. The bright rim likely represents the pile-up of the surrounding coronal plasma compressed by the expanding flux rope. The composite structure seen in AIA multiple temperature bands is very similar to that in the corresponding coronagraph images, which consists of a bright leading edge and a dark cavity, commonly believed to be a flux rope.

P23.16

Source of Coronal and IP Type II Bursts Inferred from Radio and White-light Observations

Pertti Makela[1], N. Gopalswamy[2], S. Yashiro[1]
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
We report on a study of the speeds of type II radio bursts in the metric (m) and dekameter-hectometric (DH) wavelength range constrained by the time-height measurements of the associated coronal mass ejections (CMEs). Dynamic spectra of type II bursts show occasionally a clear discontinuity in frequency and temporal overlap of metric and DH type II bursts. This has been interpreted to signify either (1) a different origin of the type II components, i.e., the DH-component is caused by a CME-driven shock and the m-component by a blast wave or unknown source, or (2) same source but a different location, i.e., the DH-component originates from the shock nose and the m-component from the shock flanks. Our preliminary results suggest that the single CME-driven shock scenario can match both m and DH-component of type II bursts reasonably well, assuming that true space speeds of the CMEs and shocks are utilized.

P23.17

Association of EUV Waves and Coronal Mass Ejections

Seiji Yashiro[1], N. Gopalswamy[2]
[1]Catholic University, [2]NASA/GSFC.
7:30 AM Monday - 8:30 AM Thursday
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The association between EUV waves and coronal mass ejections (CMEs) is difficult to establish for disk flares using observations from the Sun-Earth line because of visibility issues. The other possibility is the real absence of mass motion in flares. This issue can be effectively addressed by the twin spacecraft of the Solar Terrestrial Relations Observatory (STEREO) mission. The Ahead and Behind spacecraft of the STEREO mission were located around ±90° from the Sun-Earth line from 2010 to 2012. This is the first opportunity to investigate the connection between CMEs and EUV waves with a high degree of accuracy. During January 28 - March 9, 2011, two X- and 28 M-class flares occurred. We examined their CME associations using STEREO/SECCHI and SOHO/LASCO observations, and EUV wave associations using SDO/AIA data. We found that 10 out of 30 flares were associated with clear flux-rope CMEs (FRCMEs) while 16 did not have any erupting features above the flaring regions in the coronagraph images. The remaining four flares had narrow CMEs or outflow above the flaring regions but their connection to the flares is unclear. We also found all of the FRCME-associated flares had clear EUV waves, while the flares without CMEs also lacked EUV waves. We found one-to-one correspondence between EUV waves and FRCMEs.

P23.18

Comparison between Linear and Quadratic Drag Models for ICME Propagation

Yong-Jae Moon[1], B. Vrsnak[2], N. Gopalswamy[1], S. Yashiro[1]
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7:30 AM Monday - 8:30 AM Thursday
Exhibit Hall 1 - Las Cruces Convention Center
In this paper, we have examined a recent issue what kinds of drag form (linear or quadratic drag) is proper for interplanetary coronal mass ejections (ICMEs). For this work, we have examined well-observed LASCO CMEs associated with DH Type II bursts satisfying the following conditions: (1) the CMEs speeds are larger than 600 km/s, (2) their longitudes are larger than 60 degrees, (3) the numbers of their LASCO data points are larger than 6, and (4) their accelerations are smaller than -1 m/s^2. We

find that their accelerations (Log a) in the LASCO field of view has a very good quadratic relationship with the CME relative speeds Log (Vcme-400) with the correlation coefficient of R=0.83, supporting the quadratic drag force. Another test has been made by applying two drag models to two well-observed STEREO/SECCHI events. As a result, we found that (1) while two speed profiles are well fitted by the quadratic drag model, one speed profile can not be fitted by the linear model; (2) while the physical parameters for the quadratic model are well consistent with observations, the kinematic viscosity for the linear model should be four orders larger than its observed value. From this study, we conclude that the quadratic drag model for ICME propagation should be proper than the linear drag model.

P23.19

Metric Type II Emission in Association with an Erupting Plasmoid

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7:30 AM Monday - 8:30 AM Thursday

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We present observations of a metric type II radio burst that occurred on the 3rd of November 2010. The burst, which occurred in the frequency range of the Nancay Radioheliograph (NRH), was observed in conjunction with an erupting plasmoid. Events occurring in this frequency range are infrequent and as such makes this an interesting event to study. Using NRH observations together with images from the Atmospheric Imaging Assembly onboard the Solar Dynamics Observatory (SDO/AIA) we investigate the generation mechanism of this coronal type II burst.

P23.20

Comparisons of Remote And In-situ CME Features

Alysha Reinard[1], T. Mulligan[2], B. Lynch[3]

[1]*University of Colorado/NOAA,* [2]*Aerospace Corporation,* [3]*University of California.*

7:30 AM Monday - 8:30 AM Thursday

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We present a comparison of remote and in-situ CME ejecta using data from the Ulysses and SOHO missions. Quadrature occurs when two spacecraft form a 90 degree angle with the Sun. Quadrature studies allow the comparison of visible features of limb CMEs and and in-situ ICME properties. We investigate several events, including so-called "cannibal" CMEs, and compare the relationship between CME morphology and in-situ structures such as magnetic field, composition, and plasma properties.

P23.22

The 2011 February 15 Coronal Mass Ejection: Reconciling SOHO and STEREO Observations in Quadrature

N. Gopalswamy[1], S. Yashiro[1], P. Makela[1], M. L. Kaiser[1]

[1]*NASA GSFC.*

7:30 AM Monday - 8:30 AM Thursday

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The Large-Angle and Spectrometric Coronagraph (LASCO) on board SOHO observed a fast halo coronal mass ejection on 2011 February 15. The STEREO spacecraft were in qudrature with SOHO (STEREO-A ahead of Earth by 87 deg and STEREO-B 94 deg behind Earth), enabling CME measurement using the three spacecraft. The sky-plane speed measured by SOHO/LASCO is closely related to the expansion speed of the CME, while the radial speed was measured by STEREO-A and STEREO-B. In addition, STEREO-A and STEREO-B images measured the width of the CME, which is unknown from Earth view. From the SOHO and STEREO measurements, we confirm the relationship between the expansion speed (Vexp) and radial speed (Vrad) derived previously from geometrical considerations (Gopalswamy et al.

2009): = Vrad = ½ (1 + cot w) Vexp, where w is the half width of the CME. We can also measure the Earthward speed of the CME directly from the STEREO measurements. The travel time to Earth predicted from the Earthward speed using the Empirical Shock Arrival model is ~12 hours shorter than the actual travel time obtained from in situ measurements at L1. The primary reason for this discrepancy seems to be the interaction with the two preceding CMEs that slowed down the CME in question. The CME interaction is also confirmed from the radio enhancement observed by Wind/WAVES and STEREO WAVES experiments.

P24

Solar Wind, Energetic Particles & Heliospheric

Poster

Exhibit Hall 1 - Las Cruces Convention Center

P24.01

What Controls the Classification of Interplanetary Mass Ejections

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7:30 AM Monday - 8:30 AM Thursday

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In this paper we address a question what controls the classification of interplanetary mass ejections (ICMEs): magnetic cloud (MC) or ejecta (EJ). Using 186 shock-associated ICMEs from 1997 to 2006, we have examined three possible causes : (1) magnetic complexity with a proxy of sunspot number, (2) CME direction as a proxy of cone angle (the angle between the CME cone axis and the plane of sky), and (3) ICME-ICME interaction with a proxy of the number of halo CMEs. First, the fraction of MC is poorly anti-correlated (R=-0.36) with annual sunspot number. Second, the distribution of CME cone angle for 38 EJs is not much different from that for 16 MCs. Third, the annual fraction of magnetic cloud is well anti-correlated (R=-0.78) with the annual number of halo CMEs. To demonstrate such a relationship, we consider all halo CMEs during the same period and statistically searched the candidate of interacting ICMEs according to temporal and spatial closeness. As a result, we find that the annual fraction of interacting ICME candidates is well correlated (R=0.87) with the annual number of the halo CMEs as well as anti-correlated (R=-0.85) with the annual fraction of MCs. The contingency table between ICME-ICME interaction and MC occurrence also shows a good statistical result: Hit (110), False Alarm (53), Prediction of detection 'yes' (0.88), and Critical Success Index (0.62). Our results imply that the interaction of ICMEs is mainly responsible for their classification.

P24.02

Investigations to Determine the Origin of the Solar Wind with SPICE and SolarOrbiter

Donald M. Hassler[1], C. DeForest[1], E. Wilkinson[1], J. Davila[2], SPICE Team
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7:30 AM Monday - 8:30 AM Thursday

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At large spatial scales, the structure of the solar wind and it's mapping back to the solar corona, is thought to be reasonably well understood. However, the detailed structure of the various source regions at chromospheric and transition region heights is extremely complex, and less well understood. Determining this connection between heliospheric structures and their source regions at the Sun is one of the overarching objective of the Solar Orbiter mission. During perihelion segments of its orbit, when the spacecraft is in quasi-corotation with the Sun, Solar Orbiter will determine the plasma parameters and compositional signatures of the solar wind, which can be compared directly with the spectroscopic

signatures of coronal ions with differing charge-to-mass ratios and FIP. One of the key instruments on the Solar Orbiter mission to make these remote sensing measurements is the SPICE (Spectral Imaging of the Coronal Environment) imaging spectrograph. SPICE will provide the images and plasma diagnostics needed to characterize the plasma state in different source regions, from active regions to quiet Sun to coronal holes. By comparing composition, plasma parameters, and low/high FIP ratios of structures remotely, with those measured directly at the Solar Orbiter spacecraft, Solar Orbiter will provide the first direct link between solar wind structures and their source regions at the Sun. This talk will provide a background of previous compositional correlation measurements and an outline of the method to be used for comparing the spectroscopic and in-situ plasma parameters to be measured with Solar Orbiter.

P24.03

Comparing ADAPT-WSA Model Predictions With EUV And Solar Wind Observations

Charles Arge[1], C. J. Henney[1], K. Shurkin[2], W. Toussaint[3], J. Koller[4], J. W. Harvey[3]

[1]AFRL, [2]University of New Mexico, [3]NSO, [4]LANL.

7:30 AM Monday - 8:30 AM Thursday

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Global estimates of the solar photospheric magnetic field distribution are critical for space weather forecasting. These global maps are the essential data input for accurate modeling of the corona and solar wind, which is vital for gaining the basic understanding necessary to improve forecasting models needed for Air Force operations. We are now testing the global photospheric field maps generated by the Air Force Data Assimilative Photospheric flux Transport (ADAPT) model as input to the WSA coronal and solar wind model. ADAPT incorporates the Los Alamos National Laboratory data assimilation methodology with a modified version of the Worden and Harvey photospheric magnetic flux transport model. The ADAPT maps provide a more instantaneous snapshot of the global photospheric field distribution compared to traditional synoptic maps. In this presentation, we make a detailed comparison of WSA coronal and solar wind model output with STEREO EUVI disk observations and in situ plasma observations from the STEREO and ACE spacecraft. The current orbital configuration of the two STEREO spacecraft is such that they provide a nearly instantaneous global snapshot of the Sun's coronal hole distribution. In addition, the STEREO observations along with those from the ACE spacecraft provide three widely spaced ecliptic locations at ~1 AU to sample the solar wind plasma. In combination, these differing observations from multiple spacecraft provide a unique and highly sensitive test of the ability of the WSA model to capture the global coronal hole and solar wind structure. This is done using both ADAPT and standard updated photospheric field maps as input to the model.

P24.04

A Reconsideration of the Kiplinger Effect

Stephen W. Kahler[1], A. Tylka[2], G. Share[3]

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7:30 AM Monday - 8:30 AM Thursday

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The Kiplinger effect is an observed association of solar energetic particle (SEP) events with a "soft-hard-harder" (SHH) spectral evolution during the extended phases of the associated solar hard X-ray flares. Besides its possible use as a space weather predictor of SEP events, the Kiplinger effect has been interpreted as evidence of SEP production in the flare site itself. This interpretation contradicts the widely accepted view that SEPs of large events are predominately or entirely accelerated in shocks driven by coronal mass ejections (CMEs). We examine the evidence supporting the association of SHH flares with SEP events and note the limitations of that association. The latter include the criteria used to define the SHH events and the peak intensities of the associated SEP events. The relationship of SHH and non-SHH X-ray flares to their associated CMEs is also explored to attempt to understand the physical relationship among SEP events, SHH flares, and CMEs.

P24.05

In-site Measurement of Solar Wind Speed Profiles Near the Sun Using Sun-grazing Comets

Phillip Hess[1], J. Zhang[1]

[1]*George Mason University.*

7:30 AM Monday - 8:30 AM Thursday

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Since Biermann first postulated the idea of the solar wind in 1956 using the ion tails of comets as evidence, comets have been used as a means for measuring the velocity of the solar wind. While studies in the past used comets observed at a large distance from the Sun to measure the approximate constant velocity that the solar wind eventually reaches, new observations from the SOHO and STEREO missions have allowed for similar observations to be collected from sun-grazing comets at distances much closer to the sun. These comets can be used to understand how the solar wind accelerates before reaching its constant velocity. In this study, the method used by Brandt et. al. (1972) for measuring solar wind velocity at 1 A.U. by observing the difference between the direction of the ion tail and the direction of the comet's velocity is adapted for distances closer to the sun using the 3-dimensional data available from combining images from the COR1 and COR2 fields of view in STEREO-A and STEREO-B on the sun-grazing comet observed on March 12, 2010. Preliminary results show that the method works. We will present the solar wind velocity profile near the Sun in the meeting.

P24.06

The Coronal Physics Investigator (cpi) Experiment For Iss: A New Vision For Understanding Solar Wind Acceleration

John C. Raymond[1], P. H. Janzen[2], J. L. Kohl[1], D. B. Reisenfeld[2], B. D. G. Chandran[3], S. R. Cranmer[1], T. G. Forbes[3], P. A. Isenberg[3], A. V. Panasyuk[1], A. A. van Ballegooijen[1]

[1]*Harvard-Smithsonian, CfA,* [2]*University of Montana,* [3]*University of New Hampshire.*

7:30 AM Monday - 8:30 AM Thursday

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We propose an Explorer Mission of Opportunity program to develop and operate a large-aperture ultraviolet coronagraph spectrometer called the Coronal Physics Investigator (CPI) as an attached International Space Station (ISS) payload. The primary goal of this program is to identify and characterize the physical processes that heat and accelerate the primary and secondary components of the fast and slow solar wind. Also, CPI can make key measurements needed to understand CMEs. CPI is dedicated to high spectral resolution measurements of the off-limb extended corona with far better stray light suppression than can be achieved by a conventional instrument. UVCS/SOHO allowed us to identify what additional measurements need to be made to answer the fundamental questions about how solar wind streams are produced, and CPI's next-generation capabilities were designed specifically to make those measurements. Compared to previous instruments, CPI provides unprecedented sensitivity, a wavelength range extending from 25.7 to 126 nm, higher temporal resolution, and the capability to measure line profiles of He II, N V, Ne VII, Ne VIII, Si VIII, S IX, Ar VIII, Ca IX, and Fe X, never before seen in coronal holes above 1.3 solar radii. CPI will constrain the properties and effects of coronal MHD waves by (1) observing many ions over a large range of charge and mass,(2) providing simultaneous measurements of proton and electron temperatures to probe turbulent dissipation mechanisms, and (3) measuring amplitudes of low-frequency compressive fluctuations. CPI is an internally occulted ultraviolet coronagraph that provides the required high sensitivity without the need for a deployable boom, and with all technically mature hardware including an ICCD detector. A highly experienced

Explorer and ISS contractor, L-3 Com Integrated Optical Systems and Com Systems East will provide the tracking and pointing system as well as the instrument, and the integration to the ISS.

P24.07

The Connection Between Small Gamma-ray Flares And SEPs With Comptel/CGRO

Georgia De Nolfo[1], C. Young[2]

[1]NASA/GSFC, [2]NASA/GSFC/Adnet.

7:30 AM Monday - 8:30 AM Thursday

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The origin of SEPs is still debated today. There is evidence to support an origin rooted deep within the solar corona, e.g. a flare origin, as well as evidence for an origin as far out as several solar radii from coronal shocks or CMEs. The composition, spectra, and time dependencies are tell-tales of SEP origin. Another key indicator of SEP origin is the accelerated ion distribution at the flare deduced from neutral radiation: gamma-rays and neutrons. For large flares, comparisons appear to suggest an origin divided between an escaping flare population and a population of coronal particles (or some admixture) accelerated through CME-driven shocks. Small flares conform to a different picture in which their origin is rooted at the flare. These small flares, as defined by their X-ray emission, have been found to correlate with the presence of small “impulsive” (enriched in electrons and heavy nuclei) SEP events, suggesting that small SEP events are dominated by flare particles. However, small SEPs are generally not accompanied by nuclear gamma-ray emission as might be expected if their origin is at the flare. The existence of this emission is not clear due to a lack in instrumentation capable of operating above the sensitivity threshold for observing gamma-ray emission from small flares (< C-class). The COMPton TELescope (COMPTEL) aboard the Compton Gamma Ray Observatory (CGRO) provided unprecedented, and as yet unsurpassed, sensitivity to γ rays in the 0.7 to 30 MeV energy range. Focusing on COMPTEL data from 2000, a cursory search has identified a handful of gamma-ray flares that are associated with 3He-rich SEP events. We present preliminary results of the spectral analysis of these flares and discuss the correlations between small impulsive or 3He-rich SEP events.

P24.08

"Streamer Blob" Outflow from Interchange Reconnection

Benjamin J. Lynch[1], J. K. Edmondson[2], Y. Li[1]

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7:30 AM Monday - 8:30 AM Thursday

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Given the recent observational results of interchange reconnection processes in the solar corona and theoretical development of the S-Web model for the slow solar wind, we present further analysis of the 3D MHD simulation of interchange reconnection by Edmondson et al. (2009). Specifically, we will analyze the observable properties of the dynamic streamer belt jump that corresponds to previously closed streamer belt flux opening up via interchange reconnection. We quantify the system's kinetic energy and open flux evolution in time and show that the material released from the reconnection region outflow is qualitatively similar to the transient slow solar wind features known as "streamer blobs". Our simulation results imply that the commonly accepted interpretation of streamer blobs as small-scale magnetic flux-ropes may not be universally applicable. Additionally, we examine the synthetic emission from the density evolution above the surface and show the correspondence between coronal "dimming" and the opening up of previously closed flux. We will discuss future improvements to the MHD simulations that include a solar wind outflow and more rigorous comparisons to observations.
BJL and YL acknowledge support from NASA HGI NNX08AJ04G and JKE acknowledges support from the NASA Postdoctoral Program.

Monday, June 13, 2011, 8:30 AM - 10:20 AM

01

Parker Lecture I and Instrumentation and Methods

Oral

Exhibit Hall 1 - Las Cruces Convention Center

01.01

Modeling the Physical Connection Between the Solar Convection Zone and Corona

William P. Abbett[1]
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8:30 AM - 9:20 AM

Exhibit Hall 1 - Las Cruces Convention Center

How magnetic energy and flux emerges from below the surface into the solar atmosphere is a topic ripe for theoretical and observational investigation, particularly in the SDO era. Data from this mission is showing us that magnetic fields from the interior emerge through the surface, and energize the dynamic chromosphere and corona over a wide range of spatial and temporal scales. The interplay between granular-scale magnetic features, and large-scale structures from decaying active regions, for example, are seen to affect the large-scale solar magnetic field in complex ways. Being able to model these interactions in a way that captures the disparate spatial and temporal scales of the convection zone-to-corona system while simultaneously allowing for direct comparison with observations would be of enormous value in the effort to better understand the physics of coronal heating, the energetics of the solar wind, and the onset of magnetic eruptions (among other phenomena). In this lecture, I will summarize current progress in the effort to model the magnetic and energetic connection between the solar interior and atmosphere, and will describe the limitations and challenges inherent to this holistic approach.

01.02

The Expanded Owens Valley Solar Array

Dale E. Gary[1], G. J. Hurford[2], G. M. Nita[1], S. M. White[3], S. D. Tun[1], G. D. Fleishman[1], J. M. McTiernan[2]
[1]*NJIT,* [2]*UC/Berkeley,* [3]*Air Force Research Lab.*

9:20 AM - 9:35 AM

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The Expanded Owens Valley Solar Array (EOVSA) is now under construction near Big Pine, CA as a solar-dedicated microwave imaging array operating in the frequency range 1-18 GHz. The solar science to be addressed focuses on the 3D structure of the solar corona (magnetic field, temperature and density), on the sudden release of energy and subsequent particle acceleration, transport and heating, and on space weather phenomena. The project will support the scientific community by providing open data access and software tools for analysis of the data, to exploit synergies with on-going solar research in other wavelengths.

The New Jersey Institute of Technology (NJIT) is expanding OVSA from its previous complement of 7 antennas to a total of 15 by adding 8 new antennas, and will reinvest in the existing infrastructure by replacing the existing control systems, signal transmission, and signal processing with modern, far more capable and reliable systems based on new technology developed for the Frequency Agile Solar Radiotelescope (FASR). The project will be completed in time to provide solar-dedicated observations during the upcoming solar maximum in 2013 and beyond. We provide an update on current status and our preparations for exploiting the data through modeling and data analysis tools.

This research is supported by NSF grants AST-0908344, and AGS-0961867 and NASA grant NNX10AF27G to New Jersey Institute of Technology.

01.03

Search of Continuum Solar Flare Radiation from GHz to THz Frequencies

P. Kaufmann[1], E. Correia[2], C. Giménez de Castro[3], G. Hurford[4], R. P. Lin[4], V. S. Makhmutov[5], R. Marcon[6], A. Marun[7], **J.-P. Raulin**[3], A. Y. Shih[8], Y. I. Stozhkov[5], A. Válio[3], T. Villela[9]
[1]Universidade Presbiteriana Mackenzie/CRAAM and Unicamp/CCS, Brazil, [2]Universidade Presbiteriana Mackenzie/CRAAM and INPE, Brazil, [3]Universidade Presbiteriana Mackenzie/CRAAM, Brazil, [4]Space Sciences Lab, University of California, [5]Lebedev Physics Institute, Russian Federation, [6]Universidade Estadual de Campinas/IFGW and OS "Bernard Lyot", Brazil, [7]Complejo Astronomico El Leoncito/CONICET, Argentina, [8]NASA Goddard Space Flight Center, [9]Instituto Nacional de Pesquisas Espaciais, Brazil.
9:35 AM - 9:50 AM
Exhibit Hall 1 - Las Cruces Convention Center

The new solar burst emission spectral component showing sub-THz fluxes increasing with frequency, spectrally separated from the well known microwave component, brings serious constraints for interpretation. The knowledge of THz continuum spectral shape is essential to investigate the nature of the emission mechanisms involved. New 45 and 90 GHz solar polarimeters are being installed at El Leoncito high altitude observatory, where sub-THz (0.2 and 0.4 THz) solar flare flux data are being obtained regularly since several years. The development of THz photometers for continuum requires solutions for several technical challenges. To avoid atmospheric attenuation the THz solar observations should be carried in space or at selected frequency windows on exceptionally high sites near the South Pole. A double THz solar photometer system has been developed to operate at center frequencies of 3 and 7 THz. Golay cell sensors are used, preceded by a low pass membrane filter (f < 15 THz), resonant metal mesh band-pass filters with center frequencies at 3 and 7 THz (± 10% bandwidth), and a tuning fork resonant chopper. The incoming solar signal is collected by 75 mm diameter Cassegrain telescopes which reflectors' surfaces are roughened in order to diffuse most of the visible and near IR thermal radiation. Brazil funding agency FAPESP has recently approved the construction of the dual THz frequency photometer system to be flown in a long duration stratospheric balloon flight in Antarctica (two weeks circumnavigation) in cooperation with University of California, Berkeley, together with GRIPS (Gamma-Ray Imaging Polarimeter for solar flares) experiment. One test flight is planned for 2012. USA. Another balloon flight over Russia (one week) is considered between 2014-2016, in a cooperation with Moscow Lebedev Physics Institute.

01.04

Adaptive Optics At The New Solar Telescope
- Present, Future And Beyond -

Aglae Kellerer[1]
[1]Big Bear Solar Observatory.
9:50 AM - 10:05 AM
Exhibit Hall 1 - Las Cruces Convention Center

The New Solar Telescope (NST) on Big Bear Lake, California, has a 1.6m off-axis primary mirror and is equipped with a 76 element adaptive-optics system. Diffraction limited resolution is attained in the visible after speckle reconstruction. Without speckle reconstruction, and under good atmospheric conditions, the resolution approaches the diffraction limit in the infrared. However, with a single deformable mirror, the atmospheric turbulence is corrected only inside the isoplanatic patch, typically 10" in diameter.
Sunspots and active regions extend over roughly1'-2'. To attain the diffraction-limit over such field sizes,

multi-conjugate adaptive optics (MCAO) applies a wavefront correction that varies inside the field. At the NST we will use three deformable mirrors to correct for the atmospheric turbulence inside a field of 90". This will be done in two stages: in summer 2011, a 308 element ground-conjugated adaptive-optics system should yield diffraction limited resolution in the visible, over the isoplanatic patch.
In spring 2012 the addition of two deformable mirrors with 308 and 76 effective actuators should allow us to approach the diffraction limit in the visible, and inside a 90" field of view. The optimum conjugation heights of the two mirrors will be assessed after an atmospheric monitoring campaign.
The adaptive-optics development at NST will prepare the way for the 4m off-axis ATST telescope, which is to see first light in 2016.

01.05

The Virtual Solar Observatory at Eight and a Bit!

Alisdair R. Davey[1], The VSO Team
[1]*SAO.*

10:05 AM - 10:20 AM

Exhibit Hall 1 - Las Cruces Convention Center

The Virtual Solar Observatory (VSO) was the first virtual observatory in the solar and heliophysics data space. It first saw the light of day in 2003 with a mission to serve the solar physics community by enabling homogenous access to heterogeneous data, and hiding the gory details of doing so from the user. The VSO pioneered what was to become the "Small Box" methodology, setting out to provide only the services required to navigate the user to the data and then letting them directly transferred the data from the data providers. After eight and a bit years the VSO now serves data from 72 different instruments covering a multitude of space and ground based observatories, including data from SDO. Dealing with the volume of data from SDO has proved to be our most difficult challenge, forcing us from the small box approach to one where the various VSO sites not only serve SDO data, but are central to the distribution of the data within the US and to Europe and other parts of the world. With SDO data serving mostly in place we are now working on integration with the Heliophysics Event Knowledgebase (HEK) and including a number of new solar data sets in the VSO family. We have a complete VSO search interface in IDL now, enabling searching, downloading and processing solar data, all be done without leaving the IDL command line, and will be releasing a brand new web interface providing users and data providers, with the ability to create far more detailed and instrument specific searches. Eight years on and the VSO has plenty of work in front of it.

Monday, June 13, 2011, 11:00 AM - 12:30 PM

02

Solar Interior

Oral

Exhibit Hall 1 - Las Cruces Convention Center

02.01

Helioradiology: A New View Of The Deep Solar Interior: Indications Of A Slowly Rotating Core And An Inner Tachocline

Peter A. Sturrock[1], E. Fischbach[2], J. H. Jenkins[2]
[1]Stanford Univ., [2]Purdue Univ..

11:00 AM - 11:15 AM

Exhibit Hall 1 - Las Cruces Convention Center

Analyses of several radionuclide experiments give strong evidence that decay rates are NOT constant (as we have all been led to believe). To date, there is evidence for three periodicities: one with an annual period; a second with a period of order one month; and one that is approximately semi-annual. The first may be attributed partly to the eccentricity of the Earth's orbit, and partly to a north-south asymmetry in whatever solar radiation is responsible for the variations. The second may be attributed to the influence of solar rotation; however, the synodic period is in the range 30 - 33 days, indicative of a slowly rotating region - presumably the core. The third may be interpreted as a Rieger oscillation, except that it occurs in an inner tachocline (separating the core from the radiative zone) rather than in the outer tachocline, that separates the radiative zone from the convection zone. The mechanism by which the Sun influences nuclear decay rates is presently unknown. There are reasons to suspect that neutrinos are involved, but this would require that neutrinos have previously unsuspected properties.
This work was supported by the NSF grant AST-0607572 and DOE grant DE-AC-02-76ER071428.

02.02

The Waldmeier Effect and Asymmetry of Solar Magnetic Cycles in a Surface-Shear Dynamo Model

Valery Pipin[1], A. Kosovichev[2]
[1]UCLA; HEPL Standford University; ISTP Irkutsk, [2]HEPL, Stanford University.

11:15 AM - 11:30 AM

Exhibit Hall 1 - Las Cruces Convention Center

We present a study of solar dynamo model distributed in the bulk of the convection zone with toroidal magnetic-field flux concentrated in a near-surface layer. We explore how this effect may depend on spatial variations of the turbulent parameters and the differential rotation near the surface. The model includes the magnetic helicity non-linear feedback on the dynamo alpha-effect. We compute the magnetic cycle characteristics predicted by the model, including the cycle skewness (associated with duration of the growth and decay phases) and the duration-strength dependence (Waldmeier's effects). We confront the theoretical expectations with the solar sunspot cycle properties.

02.03

The Sun's Meridional Circulation - not so Deep

David H. Hathaway[1]
[1]NASA/MSFC.

11:30 AM - 11:45 AM

Exhibit Hall 1 - Las Cruces Convention Center

The Sun's global meridional circulation is evident as a slow poleward flow at its surface. This flow is observed to carry magnetic elements poleward - producing the Sun's polar magnetic fields as a key part

of the 11-year sunspot cycle. Flux Transport Dynamo models for the sunspot cycle are predicated on the belief that this surface flow is part of a circulation which sinks inward at the poles and returns to the equator in the bottom half of the convection zone - at depths between 100 and 200 Mm. Here I use the advection of the supergranule cells by the meridional flow to map the flow velocity in latitude and depth. My measurements show that the equatorward return flow begins at a depth of only 35 Mm - the base of the Sun's surface shear layer. This is the first clear (10 sigma) detection of the meridional return flow. While the shallow depth of the return flow indicates a false foundation for Flux Transport Dynamo models it helps to explain the different meridional flow rates seen for different features and provides a mechanism for selecting the characteristic size of supergranules.

02.04

The Magnetic Fields of the Solar Interior

Charles Baldner[1], S. Basu[1]

[1]*Yale University.*

11:45 AM - 12:00 PM

Exhibit Hall 1 - Las Cruces Convention Center

Measuring the internal magnetic fields of the Sun would provide important constraints on our understanding of the mechanisms that underly solar activity. Using helioseismology, one can in principal detect the effects of magnetic fields on the internal thermal structure, and directly measure magnetic fields through their effects on helioseismic mode propagation. In this work, we have used a full solar cycle's worth of high quality helioseismic data from the Michelson Doppler Imager (MDI) instrument onboard the SOHO spacecraft to explore changes in the interior thermal structure. We find evidence for thermal changes at the base of the convection zone correlated with solar activity. To explain these changes in terms of magnetic fields, we model the effects of magnetic fields on the global mode splitting coefficients. The signal at the base of the convection zone is too small to make a determination of magnetic fields, but we find magnetic fields concentrated in the near-surface layers. We follow this up by looking at the thermal structure of a large number of active regions.

02.05

The Double-Ring Algorithm: Reconciling Surface Flux Transport Simulations and Kinematic Dynamo Models

Andres Munoz-Jaramillo[1], D. Nandy[2], P. C. H. Martens[3], A. R. Yeates[4]

[1]*Harvard-Smithsonian Center for Astrophysics,* [2]*Indian Institute of Science Education and Research - Kolkata, India,* [3]*Montana State University,* [4]*University of Dundee, United Kingdom.*

12:00 PM - 12:15 PM

Exhibit Hall 1 - Las Cruces Convention Center

The emergence of tilted bipolar active regions and the dispersal of their flux, mediated via processes such as diffusion, differential rotation and meridional circulation is believed to be responsible for the reversal of the Sun's polar field. This process (commonly known as the Babcock-Leighton mechanism) is usually modeled as a near-surface, spatially distributed α-effect in kinematic mean-field dynamo models. However, this formulation leads to a relationship between polar field strength and meridional flow speed which is opposite to that suggested by physical insight and predicted by surface flux-transport simulations. With this in mind, we present an improved double-ring algorithm for modeling the Babcock-Leighton mechanism based on active region eruption, within the framework of an axisymmetric dynamo model. We demonstrate that our treatment of the Babcock-Leighton mechanism through double-ring eruption leads to an inverse relationship between polar field strength and meridional flow speed as expected, reconciling the discrepancy between surface flux-transport simulations and kinematic dynamo models. Finally, we show how this new formulation paves the way

for applications, which were not possible before, like understanding the nature of the extended minimum of sunspot cycle 23 and direct assimilation of active region data.
This work is funded by NASA Living With a Star Grant NNX08AW53G to Montana State University/Harvard-Smithsonian Center for Astrophysics and the Government of India's Ramanujan Fellowship.

02.06

The Rise of Active Region Flux Tubes in the Turbulent Solar Convective Envelope

Maria A. Weber[1], Y. Fan[1], M. Miesch[1]
[1]High Altitude Observatory.

12:15 PM - 12:30 PM

Exhibit Hall 1 - Las Cruces Convention Center

We use a thin flux tube model in a rotating spherical shell of turbulent convective flows to study how active region scale flux tubes rise buoyantly from the bottom of the convection zone to near the solar surface. We investigate toroidal flux tubes at the base of the convection zone with field strengths ranging from 15 kG to 100 kG at initial latitudes ranging from 1 to 40 degrees. We find that the dynamic evolution of the flux tube changes from convection dominated to magnetic buoyancy dominated as the initial field strength increases from 15 kG to 100 kG. At 100 kG, the development of rising loops are mainly controlled by the growth of the magnetic buoyancy instability. Mean properties of the emerging loops are in agreement with previous thin flux tube models in the absence of convection. At a low field strength of 15 kG, the development of the rising loops are largely controlled by convective flows, and the properties of the emerging loops are significantly changed compared to previous results in the absence of convection. With convection, the rise times are drastically reduced (from years to months), and the loops are able to emerge at low latitudes. However the tilt angles of these emerging loops show large scatters and are not consistent with Joy's law of active region tilts. In order for the mean tilts of emerging loops to be consistent with Joy's Law, the initial field strength at the base of the convection zone needs to be greater than or equal to 40 kG. We also examine other asymmetries that develop between the leading and following sides of the emerging loops. Including all results, we find that field strengths of 40 - 50 kG produce emerging loops that best match the observed properties of solar active regions.

Monday, June 13, 2011, 1:40 PM - 3:40 PM
03
Lower Atmosphere
Oral
Exhibit Hall 1 - Las Cruces Convention Center

03.01

Analysis Of Sunspot Number Counts, Sunspot Area, And Sunspot Irradiance Deficit: 2002-2011

K. S. Balasubramaniam[1], T. Henry[2]
[1]USAF/AFRL, [2]National Solar Observatory.

1:40 PM - 1:55 PM
Exhibit Hall 1 - Las Cruces Convention Center

Sunspot numbers have been traditionally associated with strength of solar activity, and feed into a variety of space weather forecast models.
We present a detailed analysis of (i) sunspot number counts, (ii) sunspot area, (iii) their component umbral and penumbral intensities, and (iv) sunspot irradiance deficit as measured from 5-minute cadence true continuum images observed with the USAF/AFRL's Improved Solar Observing Optical Network (ISOON) prototype telescope. The data were acquired from December 2002 - present. These measures are obtained, semi-automatically.
We relate these observed measures to the daily NOAA/SWPC Sunspot Numbers, and International Sunspot Numbers, and trace the intra-day fluctuations in sunspot numbers to its component constituents. With higher data cadence of modern instruments, we relate the advantages and disadvantages of automating the process. We trace inherent fluctuations in sunspot numbers to the underlying solar activity, and relate them to the solar eruptive process.
This work was supported by the Air Force Office of Scientific Research (AFOSR)

03.02

An Observational Study of the Formation and Evolution of Sunspots

Sarah A. Jaeggli[1], H. Lin[1], H. Uitenbroek[2]
[1]Univ. of Hawaii, [2]National Solar Observatory.

1:55 PM - 2:10 PM
Exhibit Hall 1 - Las Cruces Convention Center

It is well known that the thermal-magnetic relation in sunspots can be non-linear. Previous investigations ascribe the non-linearity of the relation to changing geometrical height of the measurement due to radiative transfer effects (Wilson Depression) and the poorly determined magnetic field curvature force. However, the very coolest regions of some sunspots show a rapid increase in umbral magnetic field strength relative to temperature which cannot be explained by the simplified sunspot model with single-component ideal gas atmosphere which has been previously assumed. This represents a fundamental flaw in our understanding of the sunspot equilibrium problem. Existing multiple-component sunspot atmospheric models predict that a large amount of molecular hydrogen (H_2) exists in the sunspot umbra. The formation of molecules provides a mechanism for isothermal concentration of the umbral magnetic field which may explain the observed rapid increase in umbral magnetic field strength relative to temperature. We have characterized the equilibrium forces in sunspots using simultaneous visible and IR sunspot magnetic field survey observations of the highly sensitive Fe I lines at 6302 and 15650 Angstroms and nearby OH lines which have been conducted with the new Facility Infrared Spectropolarimeter (FIRS) at the Dunn Solar Telescope. We have performed detailed chemical equilibrium calculations with full consideration of radiative transfer effects to

establish OH as a proxy for H2, and demonstrate that a significant population of H2 exists in the coolest regions of large and more mature sunspots. We further point out that the formation of H2 can significantly alter the thermodynamic properties of the sunspot atmosphere and may play a significant role in sunspot evolution.

03.03

Spectropolarimetric Study Of Sea-serpent Penumbral Filaments And A Naked Sunspot.

Alberto Sainz Dalda[1], T. Tarbell[2], A. Title[2], S. Vargas Dominguez[3], L. R. Bellot Rubio[4]

[1]Stanford-Lockheed Institute for Space Research, [2]LMSAL, [3]MSSL-UCL, United Kingdom, [4]IAA, Spain.

2:10 PM - 2:25 PM

Exhibit Hall 1 - Las Cruces Convention Center

We present a spectropolarimetric study of the sea-serpent penumbral filaments in AR NOAA 10944 and of a naked sunspot (i.e. a sunspot-like feature without penumbra) in AR NOAA 10977. Both active regions were observed by Hinode-SOT/SP in the photospheric lines Fe I 6301 & 6302 \AA. The high spatial and temporal resolution combined with the high polarimetric sensitivity of these observations enables us to get a better understanding of the dynamics of the penumbra and the moving magnetic feature (herafter MMF) activity in and around both traditional and naked sunspots. Our results show how the temporal evolution of the sea-serpent filaments fits very well with the thin-tube flux model for the penumbra presented by Schlichenmaier (2003). In addition, the spectropolarmetric analysis of the naked sunspot addresses the issue posed by Zuccarello et al. (2009) about the existence of bipolar MMFs around naked sunspots even when they cannot be explained as an extension of the penumbral filaments.

03.04

The Observed Red Asymmetry in the Bisectors of the Chromospheric CaII 854.2 nm Line

Kaylan Burleigh[1], A. Tritschler[2], H. Uitenbroek[2]

[1]University of Arizona, [2]National Solar Observatory.

2:25 PM - 2:40 PM

Exhibit Hall 1 - Las Cruces Convention Center

The bisector analysis of chromospheric spatially and temporally unresolved Ca II atlas profiles reveals a red asymmetry of the Doppler core in form of an “inverse C” (Uitenbroek, 2005). The origin of this red asymmetry is yet unknown. We use spatially and temporally resolved 2D spectroscopic chromospheric (CaII 854.2 nm) observations of the quiet and more active sun obtained with the Dunn Solar Telescope's Interferometric BIdimensional Spectrometer (IBIS) to determine where the inverse C-shape appears with respect to granules, inter-granular lanes, and magnetic features. To this end we generate masks of the spatial location of the red asymmetry. We also examine the temporal behavior of profiles showing this red asymmetry. In the chromosphere, we find the red asymmetry most concentrated in dark region outside of magnetic networks; it avoids nearly all bright regions. It disappears almost entirely within magnetic networks which suggests magnetic activity “damps out” the red asymmetry. Relative to the underlying photosphere, the red asymmetry preferentially occurs over or just slightly offset from inter-granular lanes; very rarely does it occur over granules. The temporal behavior of at least one red asymmetry profile shows a periodicity near 3 min. We speculate that the red asymmetry forms from upward traveling acoustic shock waves.

This work was supported by the National Solar Observatory’s Research Experiences for Undergraduate (REU) program which is co-funded by the Department of Defense in partnership with the National Science foundation REU Program.

03.05

High-Resolution He I Spectropolarimetry of Chromospheric Fibrils

Thomas A. Schad[1], M. J. Penn[2]
[1]Department of Planetary Sciences, University of Arizona, [2]National Solar Observatory.
2:40 PM - 2:55 PM
Exhibit Hall 1 - Las Cruces Convention Center
Of spectral diagnostics for the magnetic field in the solar chromosphere, the He I triplet at 1083 nm offers a comparatively simple means to determine both the magnitude and direction of the field vector. The triplet forms over a narrow range of heights when compared to strong optical lines, and recently the mechanisms that influence its polarization have been well characterized, thus allowing inversions of the magnetic field from observed Stokes profiles. We discuss recent work with the Facility Infrared Spectropolarimeter (FIRS) at the Dunn Solar Telescope (DST), New Mexico, USA to measure and infer the magnetic field vector of chromospheric fibrils. FIRS is designed to perform fast diffraction-limited dual-beam spectropolarimetry simultaneously at visible and infrared wavelengths through the use of multiple slits and narrowband filters. It can be operated in congress with the High Order Adaptive Optics (HOAO) system of the DST as well as with the Interferometric BiDimensional Spectropolarimeter (IBIS). Here we present high-resolution FIRS observations of chromospheric fibrils which employ the HOAO system under great seeing. We calibrate these observations for the full effect of the FIRS-DST combined analysis system on the Stokes vector which allow us to define the observed Stokes geometry with respect to solar coordinates. Full inversions of our measurements incorporating the effects of atomic polarization, the Hanle effect, and the Zeeman effect will be presented showing support for chromospheric fibrils that are aligned with the magnetic field direction.

03.06
Propagating Transverse Wave In A Spicule Observed By The Hinode Sot
Yeon-Han Kim[1], S. Bong[1], K. Cho[1], Y. Park[1], I. Cho[1], J. Chae[2]
[1]KASI, Korea, Republic of, [2]Seoul National University, Korea, Republic of.
2:55 PM - 3:10 PM
Exhibit Hall 1 - Las Cruces Convention Center
We examined the wave signatures in a spicule observed by the Hinode SOT to present a quantitative and clear evidence of propagating transverse waves. Especially, we estimated the propagation wave speed in the spicule observed on 2008 June 3 in the north polar limb of the Sun. For this, we made time-slice stacks at different height of the spicule axis using time series images of the spicule. All time-slice stacks for 9 different heights show oscillation patterns with a period of about 130 s. We also investigated the cross-correlation among time-slice stacks to estimate the phase difference of the oscillation with height and its propagating speed. We found that the mean phase delay over the height difference of 3000 km is about 13 s. This result suggests that the oscillation is a propagating transverse wave and the propagating speed is about 220 km s^{-1}. In addition, we found that the estimated speeds increased from 100 to 230 km s^{-1} over 5000 km height range and this is well explained by the density variation along the spicule structure.

03.07
Explosive Event Rates in He II from MOSES Data
Lewis Fox[1], C. Kankelborg[2]
[1]National Solar Observatory, [2]Montana State University.
3:10 PM - 3:25 PM
Exhibit Hall 1 - Las Cruces Convention Center
Explosive events have been observed for years in many transition region lines across temperatures from 20,000 - 250,000 K. They are particularly well-known in lines of C IV (the 1550A doublet) and Si IV (1393A) at temperatures of 100,000 K. They are characterized by large non-thermal doppler broadening

of the order of 100 km/s, are usually small ~2000 km, and short-lived, 60 - 90 sec. Event rates have been measured on the order of 600 events per second over the visible surface of the Sun. In Fox, Kankelborg, and Thomas (2010) we showed the discovery of the first explosive event reported in the literature in the He II 304A line, at a temperature of 80,000 K (Andretta et. al., 2000), using data from the Multi-Order Solar EUV Spectrograph sounding rocket instrument. Explosive events in He II lines are seldom reported in the literature, and no event rates are given. We present here the first estimate of He II explosive event rates and compare to event rates for explosive events in other ions. This work supported by the NASA LCAS program, grant NAG5-10997 and NNX-07AG6G.

03.08

Spectropolarimetry Of The Footpoints Of A C-class Flare In The Chromosphere

Lucia Kleint[1], P. Judge[1]

[1]*HAO/NCAR.*

3:25 PM - 3:40 PM

Exhibit Hall 1 - Las Cruces Convention Center

Flares are well-known solar phenomena but have rarely been imaged in high resolution polarimetry and even less often in the chromosphere. We observed the declining phase of a C-class flare in NOAA 10940 on January 29, 2007 with the IBIS instrument (0.17"/px), taking quasi-simultaneous spectropolarimetric images in the chromosphere (8542 \AA) and in the photosphere (6302 \AA).

Only the inner wings and core of the chromospheric line are seen to brighten in IBIS, the underlying photosphere remaining undisturbed. TRACE images reveal the connectivity of the chromospheric flaring plasma to the overlying corona: IBIS fortuitously captured the chromospheric flares associated with both footpoints of a loop systems seen in TRACE.

Our hour-long image sequence shows the evolution and weakening of the chromospheric flare, and reveals unresolved opposite magnetic field components with large velocities with respect to the average Sun. In the chromosphere, we find redshifted components but in the photosphere we see observe blueshifts. We will present high resolution movies of the flaring plasma seen in both footpoints of the loop system. We will discuss the implications of these measurements for models of the storage and release of energy for this class of small flare, and possible connections to the formation of the penumbra that appears later at this location.

Monday, June 13, 2011, 4:00 PM - 4:40 PM

04

Special Lecture: The Coming Next-Gen Reusable Suborbital Era: New Capabilities for Solar Research

Oral

Exhibit Hall 1 - Las Cruces Convention Center

04.01

Special Lecture: The Coming Next-Gen Reusable Suborbital Era: New Capabilities for Solar Research

S. Alan Stern[1]

[1]*Blue Origin.*

4:00 PM - 4:40 PM

Exhibit Hall 1 - Las Cruces Convention Center

The era of routine human suborbital spaceflight will soon dawn with the advent of several new vehicles capable of carrying crew, experiments, and test subjects onto flights to apogees of 100-140 km. By 2013-2014, these vehicles are expected to launch hundreds of times each year--opening unprecedented opportunities for solar physics research, education, and technology testing. I will discuss the capabilities of the coming suborbital era and point out their potential for studying solar physics.
I will particularly concentrate on the capabilities of the Blue Origin New Shepard flight system.

Tuesday, June 14, 2011, 8:30 AM - 10:20 AM

05

Hale Prize and Upper Atmosphere I

Oral

Exhibit Hall 1 - Las Cruces Convention Center

05.02

Calculating Energy Storage Due to Topological Changes in Emerging Active Region NOAA AR11112

Lucas Tarr[1], D. Longcope[1]

[1]*Montana State University.*

9:20 AM - 9:35 AM

Exhibit Hall 1 - Las Cruces Convention Center

The Minimum Current Corona (MCC) model provides a way to estimate stored coronal energy using the number of field lines connecting regions of positive and negative photospheric flux. MCC assumes that the amount of flux connecting pairs of regions is fixed, even as the photospheric field evolves. As the fixed flux in each domain becomes increasingly different from a potential field configuration the system builds up magnetic free energy. We have developed a method for quantifying the field evolution by tracking photospheric magnetic sources measured with SDO/HMI, and therefore energy storage. In particular, we present an algorithm quantifying the flux evolution of each pair of regions due to submergence and emergence through the photosphere. We have applied this method to NOAA Active Region 11112, which underwent a GOES M--2.9 class flare around 19:00 on Oct. 16, 2010, and calculated a free magnetic energy buildup of $\sim 8x10^30 ergs over 3 days.

This work was supported NASA LWS.

05.03

Radiative Signatures of the Coronal Heating and Cooling Cycle

Stephen Bradshaw[1], J. Klimchuk[2]

[1]*Rice University,* [2]*NASA Goddard Space Flight Center.*

9:35 AM - 9:50 AM

Exhibit Hall 1 - Las Cruces Convention Center

The 'smoking gun' of small-scale, impulsive heating in the non-flaring solar corona is expected to be emission from plasma at temperatures greater than 5 MK. Recent studies, designed to strongly constrain the high temperature part of the emission measure distribution, have begun to provide evidence for such a hot component to the emission spectrum. However, it is significantly weaker than predicted by numerical models. We propose that the discrepancy can be resolved by dropping the common modeling assumption of ionization equilibrium.

The launches of Hinode and the Solar Dynamics Observatory (SDO) have brought the matter of the ionization state of the plasma, which lies at the interface between models and observations, firmly to the forefront.

We present detailed, quantitative predictions for the spectral emission that the instruments EIS and AIA would actually detect, for a broad range of impulsive heating scenarios, derived from a combination of numerical hydrodynamic and forward modeling.

We demonstrate that a nonequilibrium ionization state, as induced by small-scale, impulsive heating, leads to predictions for observable quantities that are consistent with what is actually observed.

05.04

Temperature Analysis of Coronal Loop Cross-Sections: Monolithic vs. Nanoflare Heating

Markus J. Aschwanden[1], P. Boerner[1]
[1]Lockheed Martin ATC.
9:50 AM - 10:05 AM
Exhibit Hall 1 - Las Cruces Convention Center
We present a first systematic study on the cross-sectional temperature structure of coronal loops using the six coronal temperature filters of the Atmospheric Imaging Assembly (AIA) instrument on the Solar Dynamics Observatory (SDO). We analyze a sample of 100 loop snapshots measured at 10 different locations and 10 different times in active region NOAA 11089 on 2010 July 24, 21:00-22:00 UT. The cross-sectional flux profiles are measured and a cospatial background is subtracted in 6 filters in a temperature range of $T \approx 0.5-16$ MK, and 4 different parameterizations of differential emission measure (DEM) distributions are fitted. We find that the reconstructed DEMs consist predominantly of narrowband peak temperature components with a thermal width of $\sigma_{log(T)} \le 0.11\pm0.02$, close to the temperature resolution limit of the instrument, consistent with earlier triple-filter analysis from TRACE by Aschwanden and Nightingale (2005) and from EIS/Hinode by Warren et al.~(2008) or Tripathi et al.~(2009). We find that 66\% of the loops could be fitted with a narrowband single-Gaussian DEM model, and 19\% with a DEM consisting of two narrowband Gaussians (which mostly result from pairs of intersecting loops along the same line-of-sight). The mostly isothermal loop DEMs allow us also to derive an improved empirical response function of the AIA 94 \ang\ filter, which needs to be boosted by a factor of $q_{94} = 6.7\pm 1.7$ for temperatures at $log(T) \lapprox 6.3$. The main result of near-isothermal loop cross-sections is not consistent with the predictions of standard nanoflare scenarios, but can be explained by flare-like heating mechanisms that drive chromospheric evaporation and upflows of heated plasma coherently over loop cross-sections of $w \approx 2-4$ Mm.

05.05
Wavefront Expansion and Dispersion of Coronal Bright Fronts
David Long[1], E. DeLuca[1], P. Gallagher[2]
[1]Harvard-Smithsonian Centre for Astrophysics, [2]Trinity College Dublin, Ireland.
10:05 AM - 10:20 AM
Exhibit Hall 1 - Las Cruces Convention Center
The true nature of Coronal Bright Fronts (CBFs; commonly called "EIT Waves") remains enigmatic despite more than ten years of research. High cadence contemporaneous observations from the Solar Dynamic Observatory (SDO) and Solar TErrestrial RElations Observatory (STEREO) spacecraft are used here to determine the kinematics and dispersion of a CBF pulse observed on 2010 August 14. The CBF exhibited clear deceleration with propagation, with lower initial velocity and weaker deceleration in STEREO observations compared to SDO. The kinematics of the CBF were found to be highly passband dependent, with the pulse exhibiting higher initial velocity and stronger deceleration in cooler passbands. Significant pulse broadening was also measured using both STEREO (~55 km/s) andSDO (~65 km/s) observations. The dispersion rate of the pulse was derived by modeling the CBF as a linear superposition of sinusoidal waves within a Gaussian envelope. These results imply that the observed CBF is a fast-mode magnetoacoustic wave, and allowed the quiet coronal magnetic field strength to be estimated at ~1-2 G.

Tuesday, June 14, 2011, 11:00 AM - 12:30 PM

06

Big Bear Solar Observatory

Oral

Exhibit Hall 1 - Las Cruces Convention Center

06.01

The New Solar Telescope in Big Bear

Philip R. Goode[1]

[1]*Big Bear Solar Obs..*

11:00 AM - 11:15 AM

Exhibit Hall 1 - Las Cruces Convention Center

The 1.6 m clear aperture, off-axis solar telescope (the “NST”) in Big Bear Lake enjoyed first light in January 2009. In the Summer of 2009, high resolution, speckle corrected observations were made in TiO and Halpha. In the Summer of 2010, adaptive optics were implemented and the first magnetograms were obtained. The NST is first new U.S. facility class solar telescope in a generation. The NST has an off-axis Gregorian configuration consisting of a parabolic primary, heat-stop, elliptical secondary and diagonal flats. The focal ratio of the primary mirror is f/2.4, and the final ratio is f/50. The working wavelength range covers from 0.4 to 1.7 microns in the Coude Lab beneath the telescope and all wavelengths including the far infrared before the entrance window to the Coude Lab.
Observational results will be introduced including revealing granular-scale chromospheric jets with their origin in the dark intergranular lanes, revealing bright lanes in granules, demonstration of equipartition between photospheric magnetic fields and plasma flow, and some unexpected results in the evolution of bright points.

06.02

Utilizing Nst Data To Look For Connection Between Photospheric Dynamics And Small-scale Chromospheric Activity

Vasyl B. Yurchyshyn[1]

[1]*Big Bear Solar Obs..*

11:15 AM - 11:30 AM

Exhibit Hall 1 - Las Cruces Convention Center

The largest ground-based solar telescope, the new solar telescope (NST) of Big Bear Solar Observatory now allows us to address many important issues of coupling between the photosphere and chromosphere by means of simultaneous observations of photospheric granulation with well resolved bright points (BPs) and associated dynamics in the low chromosphere, as seen in H-alpha spectral line. Excellent seeing conditions, augmented with an adaptive optics system and speckle-reconstruction applications produce diffraction limited images. We use these data to search for any possible connection between typical dynamics of bright points (collision, clustering and rapid motions) and chromospheric activity, such as jets that are visible on all scales down to the smallest resolved features. In this presentation we will highlight the most important findings, which include the following. 1) In mostly unipolar coronal holes, the majority of colliding/interacting BPs are not associated with any detectable chromospheric activity. This means that the component reconnection, presumably occurring when the same polarity BPs interact, may not be very effective in producing chromospheric flows. We speculate that interaction of opposite polarity BPs may be more effective in generating up-flows. 2) NST/TiO images further reveal the hidden structure of plasma vortex tubes, previously predicted by Steiner et al. Besides the bright granular lane, a vortex tube structure also includes rapidly developing bright grain co-

spatial with the tube's axis. Finally, some vortex tube events, detected in a CH data set, are co-spatial with small-scale chromospheric jets, which suggests that they may be associated with new magnetic flux emerging within a granule.

06.03

New View on Quiet-Sun Photospheric Dynamics Offered by NST Data

Valentyna Abramenko[1], V. Yurchyshyn[1], P. R. Goode[1]
[1]*Big Bear Solar Observatory.*

11:30 AM - 11:45 AM

Exhibit Hall 1 - Las Cruces Convention Center

Recent observations of the quiet sun photosphere obtained with the 1.6 meter New Solar telescope (NST) of Big Bear Solar observatory (BBSO) delivered new information about photospheric fine structures and their dynamics, as well as posing new questions. The 2-hour uninterrupted data set of solar granulation obtained under excellent seeing conditions on August 3, 2010 (with cadence of 10 sec) was the basis for the study. Statistical analysis of automatically detected and tracked magnetic bright points (MBPs) showed that the MBPs population monotonically increases as their size decreases, down to 60-70 km. Our analysis shows that if the smallest magnetic flux tubes exist, their size is still smaller that 60-70 km, which impose strong restrictions on the modeling of these structures. We also found that the distributions of the MBP's size and lifetime do not follow a traditional Gaussian distribution, typical for random processes. Instead, it follows a log-normal distribution, typical for avalanches, catastrophes, stock market data, etc. Our data set also demonstrated that a majority (98.6 %) of MBPs are short live (<2 min). This remarkable fact was not obvious from previous studies because an extremely high time cadence was required. The fact indicates that the majority of MBPs appear for a very short time (tens of seconds), similar to other transient features, for example, chromospheric jets. The most important point here is that these small and short living MBPs significantly increase dynamics (flux emergence, collapse into MBPs, and magnetic flux recycling) of the solar surface magnetic fields.

06.04

NST and Photospheric Fine -scale Structures Indicating the Small Scale Flux Emergence in an Active Region

Eunkyung Lim[1], V. Yurchyshyn[1], V. Abramenko[1], P. Goode[1], K. Ahn[1]
[1]*Big Bear Solar Observatory.*

11:45 AM - 12:00 PM

Exhibit Hall 1 - Las Cruces Convention Center

We have studied very small-scale flux emergence events on granular scales in a solar active region. The New Solar Telescope of Big Bear Solar Observatory made it possible to clearly observe the photospheric signature of flux emergence with a very high spatial (0”.034/pixel) and temporal (15s) resolution. From the TiO observations, we found several elongated thread-like granules protruding from the penumbral filaments of a sunspot at a relatively high speed of over 4km s-1. A slender arched darkening protrudes from the tip of the penumbral filament, then quickly stretches its length along the intergranular lane with a slight bright point developing at the previously shaded leading edge. The size of such granules is approximately 0”.5 wide and 3” long, and their stretching lasts for several minutes before contacting other magnetic structures nearby. Magnetograms from HMI/SDO and IRIM/BBSO show that such elongated granules are photospheric indicators of small-scale flux emergence. The cancellation process is also described in detail for two events that show different chromospheric signatures, such as brightenings and jets during the cancellation. We speculate that subsurface connectivity and the depth of the roots of magnetic field are the main keys to determining different cancellation phenomena.

06.05

From Bright Points, Throughout The Substructures Of The Pore, To The Umbral Dots
Aleksandra Andic[1]
[1]Big Bear Solar Observatory.
12:00 PM - 12:15 PM
Exhibit Hall 1 - Las Cruces Convention Center
The NST resolution of 0.09” in the TiO spectral line unveiled new information about small structures in the photosphere. We observed how movement of the granulation pushes BPs into the small pore and made the BP an integral part of the pore. Also, we observed small structures inside the pore that behave as umbral dots, indicating that umbral dots come into existence before the spot itself is formed. We present the statistical nature and survey of the behavior; comparisons among the behavior of BPs surrounding the pore, BPs that are pushed into the pore, small structures inside the pore, and the umbral dots from the spot.

06.06
Near-infrared Imaging Spectropolarimeter For The Nst
Wenda Cao[1], K. Ahn[1], N. Gorceix[1], S. Shumko[1], R. Coulter[1], P. Goode[1]
[1]Big Bear Solar Obs..
12:15 PM - 12:30 PM
Exhibit Hall 1 - Las Cruces Convention Center
The NST Near-Infrared Imaging Spectropolarimeter is one of the first imaging solar spectro-polarimeters working in the near infrared (NIR). It has been installed and commissioned in the Coude Lab of the 1.6-meter NST at Big Bear Solar Observatory (BBSO). This innovative system, which includes a 2.5 nm interference filter, a unique 0.25 nm birefringent Lyot filter, and a Fabry-Perot etalon, is capable of providing a bandpass as low as 0.01 nm over a field-of-view (FOV) of 50" in a telecentric configuration. An NIR waveplate rotates ahead of M3 in the NST as the polarimeter modulator, and ahead of it a calibration unit is located to reduce polarization cross-talk induced by subsequent oblique mirrors. Dual-beam differential polarimetry is employed to minimize seeing-induced spurious polarization. Based on the unique advantages in IR window, the very capable NST with adaptive optics, it will provide unprecedented solar spectro-polarimetry with high Zeeman sensitivity ($10^{-3}I_c$), high spatial resolution (0.2"), and high cadence (15s). In this presentation, we discuss the design, fabrication, and calibration, as well as showing the results of the first light observations.

Wednesday, June 15, 2011, 8:30 AM - 10:20 AM
07
Parker Lecture II and Upper Atmosphere II
Oral
Exhibit Hall 1 - Las Cruces Convention Center

07.02
Dimming of the 17th Century Sun
Peter V. Foukal[1], A. Ortiz[2], R. Schnerr[3]
[1]Heliophysics, Inc., [2]University of Oslo, Norway, [3]Stockholm Observatory, Sweden.
9:20 AM - 9:35 AM
Exhibit Hall 1 - Las Cruces Convention Center
Reconstructions of total solar irradiance (TSI) rely mainly on linear relations between TSI variation and indices of facular area. When these are extrapolated to the prolonged 15th - 17th century Spörer and Maunder solar activity minima, the estimated solar dimming is insufficient to explain the mid- millennial climate cooling of the Little Ice Age. We draw attention here to evidence that the relation departs from linearity at the lowest activity levels. Imaging photometry and radiometry indicate *an increased TSI contribution per unit area from small network faculae* by a factor of 2-4 compared to larger faculae in and around active regions. Even partial removal of this more TSI - effective network at prolonged minima could enable climatically significant solar dimming, yet be consistent with the weakened but persistent 11- yr cycle observed in Be 10 during the Maunder Minimum. The mechanism we suggest would not alter previous findings that increased solar radiative forcing is insufficient to account for 20th century global warming. This work was supported at Heliophysics, Inc. by NASA grants NNX09AP96G and NNX10AC09G.

07.03
Formation and Evolution of a Multi-Threaded Prominence with Different Heating Scenarios
Manuel Luna Bennasar[1], J. Karpen[2], C. R. DeVore[3]
[1]UMD/GSFC, [2]NASA/GSFC, [3]Naval Research Laboratory.
9:35 AM - 9:50 AM
Exhibit Hall 1 - Las Cruces Convention Center
Solar prominences are cool and dense plasma suspended in the million-degree solar corona. Recent observations reveal that prominences are composed of fine and highly dynamic threads aligned with the local magnetic field. We have constructed a 3D time-dependent model of a prominence combining a magnetic field structure with 1D independent simulations of many flux tubes. The 3D magnetic field is taken from an adaptive MHD simulation of a sheared double-arcade filament channel. Using the thermal non-equilibrium model we study different parametrization of their heating function and influence on the evolution of the plasmas. With the results of our simulations we produce synthetic emission images of the filament channel and the overlying loops. We show the evolving properties of our model and compare the results with data from the AIA instrument onboard the recently launched SDO satellite.

07.04
Three-dimensional Mapping of the Lower Corona and Transition Region
Samuel D. Tun[1], D. E. Gary[1]
[1]NJIT.
9:50 AM - 10:05 AM
Exhibit Hall 1 - Las Cruces Convention Center

Numerous studies have shown that temperature in the solar atmosphere rises abruptly from chromospheric to coronal values through a spatially thin transition region. Through the use of a novel method by which to obtain three-dimensional temperature and magnetic field strength maps of the lower corona and transition region from microwave observations [Tun, Gary & Georgoulis, 2011, ApJ 728, 1], a region of relatively cool material is found to extend to greater heights over the sunspot's umbra than in surrounding regions. While previous studies have occasionally pointed toward the existence of such material, this mapping represents a direct observation of this feature and of its three dimensional distribution above the sunspot. This distribution, in turn, has a direct application to the investigation of heat distribution in the higher corona, as evidence is presented that temperatures in different loop systems are correlated to the location of their footpoints in the sunspot. The mapping method itself also represents a test of the accuracy of magnetic field extrapolations.
This work was supported in part by NSF grants AGS-0961867, AST-0908344, and NASA grants NNX10AF27G and NNX11AB49G to New Jersey Institute of Technology.

07.05

The Evolution and Space Weather Effects of Solar Coronal Holes

Larisza Krista[1], P. Gallagher[2]

[1]NOAA/University of Colorado, [2]Trinity College Dublin, Ireland.

10:05 AM - 10:20 AM

Exhibit Hall 1 - Las Cruces Convention Center

As solar activity is the foremost important aspect of space weather, the forecasting of flare and CME related transient geomagnetic storms has become a primary initiative. Minor magnetic storms caused by coronal holes (CHs) have also proven to be important due to their long-lasting and recurrent geomagnetic effects. In order to forecast CH related
geomagnetic storms, the author developed the Coronal Hole Automated Recognition and Monitoring (CHARM) algorithm to replace the user-dependent CH detection methods commonly used. CHARM uses an intensity thresholding method to identify low intensity regions in EUV or X-ray images. Since CHs are regions of "open" magnetic field and predominant polarity, magnetograms were used to differentiate CHs from other low intensity regions. The Coronal Hole Evolution (CHEVOL)
algorithm was developed and used in conjunction with CHARM to study the boundary evolution of CHs. It is widely accepted that the short-term
changes in CH boundaries are due to the interchange reconnection between the CH open field lines and small loops. We determined the magnetic reconnection rate and the diffusion coefficient at CH boundaries in order to test the interchange reconnection model. The author also
developed the Minor Storm (MIST) package to link CHs to high-speed solar wind (HSSW) periods detected at Earth. Using the algorithm the relationship between CHs, the corresponding HSSW properties, and geomagnetic indices were studied between 2000-2009. The results showed a strong correlation between the velocity and HSSW proton plasma temperature, which indicates that the heating and acceleration of the solar wind plasma in CHs are closely related, and perhaps caused by the same mechanism. The research presented here includes analysis of CHs on small and large spatial/temporal scales, allowing us to further our
understanding of CHs as a whole.

Wednesday, June 15, 2011, 11:00 AM - 12:30 PM

08

Advanced Technology Solar Telescope

Oral

Exhibit Hall 1 - Las Cruces Convention Center

08.01

The Advanced Technology Solar Telescope - Constructing The World's Largest Solar Telescope

Thomas R. Rimmele[1], S. Keil[1], J. Wagner[1], ATST Team

[1]*National Solar Observatory.*

11:00 AM - 11:15 AM

Exhibit Hall 1 - Las Cruces Convention Center

The 4m Advance Technology Solar Telescope (ATST) will be the most powerful solar telescope and the world's leading ground-based resource for studying solar magnetism that controls the solar wind, flares, coronal mass ejections and variability in the Sun's output. The ATST shall provide high resolution and high sensitivity observations of the dynamic solar magnetic fields throughout the solar atmosphere, including the corona at infrared wavelengths. With its 4 m aperture, ATST will resolve features at 0."03 at visible wavelengths and obtain 0."1 resolution at the magnetically highly sensitive near infrared wavelengths. A high order adaptive optics system delivers a corrected beam to the initial set of five state-of-the-art, facility class instrumentation located in the coude laboratory facility. Coronal magnetometry and spectroscopy will be performed by two of these instruments at infrared wavelengths.

In January 2010 the ATST project transitioned from design and development to the construction phase. The project has awarded contracts for major subsystems, including the 4m primary mirror, architectural and engineering services related to the Support Facilities, Enclosure construction design, Telescope Mount Assembly, and Facilities Thermal System construction design. The State of Hawai'I Board of Land and Natural Resources approved the Conservation District Use Permit submitted by the University of Hawai'I at their December 6, 2010 meeting in Honolulu, HI.

A brief overview of the science goals and observational requirements of the ATST will be given, followed by a summary of the project status of the telescope and discussion of the approach to integrating instruments into the facility.

08.02

Filament and Prominence Research with the Advanced Technology Solar Telescope

Thomas Berger[1]

[1]*Lockheed Martin Adv. Tech. Ctr..*

11:15 AM - 11:30 AM

Exhibit Hall 1 - Las Cruces Convention Center

Recent advances in our understanding of solar filaments on the disk and prominences off the limb have come primarily from the Hinode/Solar Optical Telescope (SOT) and the Solar Dynamics Observatory/Atmospheric Imaging Assembly (AIA). These moderate spatial and temporal resolution instruments offer the huge advantage of seeing-free, low-scattering, observations from space. However they are limited in their abilities to provide spectral and/or polarimetric information. In contrast, the ATST will provide extremely high spatial and temporal resolution images of both filaments and prominences in a wide variety of spectral lines and polarimetric modes. We review recent SOT and AIA research as well as the current science questions regarding the formation and dynamics of filaments and prominences and their role in active and quiet-region coronal mass ejections. We then discuss key

measurements that the ATST is expected to make and how these measurements will significantly advance our understanding of these enigmatic markers of magnetic energy storage in the solar corona.

08.03

Coupling The Dynamics Of The Outer Atmosphere With Atst

Scott W. McIntosh[1]

[1]*National Center for Atmospheric Research.*

11:30 AM - 11:45 AM

Exhibit Hall 1 - Las Cruces Convention Center

ATST will permit the detailed observation of the physical processes that drive the relentlessly violent energy release in the engine room of the outer solar atmosphere. We will discuss the outstanding questions that require the uniquely detailed observations that ATST's large aperture and the first light instrumentation will make possible. We will use contemporary observational cues to illustrate the potential for discovery and understanding.

08.04

Magnetic Fields: Modeling And ATST Observations

Robert F. Stein[1], D. Georgobiani[1], A. Nordlund[2], A. Lagerfjard[3]

[1]*Michigan State Univ.,* [2]*Niels Bohr Institute, Denmark,* [3]*Copenhagen University, Denmark.*

11:45 AM - 12:00 PM

Exhibit Hall 1 - Las Cruces Convention Center

We have performed magneto-convection simulations starting from snapshots of hydrodynamic convection with initial conditions both of uniform vertical magnetic field and with minimally structured (uniform, untwisted), horizontal magnetic field advected into the computational domain from a depth of 20 Mm. One clear result is that while the magnetic field can collect into large-scale concentrations - pores and sunspots - most of the magnetic flux is in small concentrations with steep horizontal gradients in the field and plasma properties. Furthermore, the field strength distribution is a power law with slope between -1 and -2, so most of the field at the surface is weak. A large aperture telescope, such as ATST, is needed both to collect sufficient photons to measure the ubiquitous weak fields and to resolve the small-scale magnetic features.

We present results on flux emergence, pore formation, and Stokes spectra as they would appear in Hinode and ATST compared with the raw simulation.For those interested in analyzing the simulation data, it is available online at steinr.pa.msu.edu/~bob/data.html. There are slices of the velocity and magnetic field vectors at continuum optical depths of 1, 0.1, and 0.01 and the emergent intensity have been saved at 1 minute intervals. Four hour averages, with 2 hour cadence for the 3D cube for variables: velocity, magnetic field, density, temperature, sound speed, and internal energy have been computed. Stokes spectra have been computed for the Hinode FeI 630 nm lines, processed with the Hinode annular mtf, the slit diffraction and frequency smoothing.

This work has been supported by NASA grants NNX07AO71G, NNX07AH79G and NNX08AH44G and NSF grant AST0605738. The simulations where performed on the Pleiades cluster of the NASA Advanced Supercomputing Division at the Ames Research Center.

08.05

The Visible Spectro-Polarimeter (ViSP) for the ATST: Science Objectives and Design Concepts

Roberto Casini[1]

[1]*High Altitude Observatory.*

12:00 PM - 12:15 PM

Exhibit Hall 1 - Las Cruces Convention Center

(this presentation is for the special ATST session of the SPD meeting)
The ViSP will be the slit-based spectro-polarimeter for the ATST. It is designed to be a wavelength versatile research instrument, multi-line capable (up to three lines simultaneously) between 380 and 900 nm, and providing high spectral, spatial, and temporal resolution, and large FOV, to satisfy the science needs of the solar community. The design effort has emphasized the high throughput of the instrument necessary for precision polarimetry science, and automated configurability, in order to increase the scientific opportunities of the instrument during daily operations. In this talk we present the design characteristics of the instrument, its expected performance, and an example of instrument configuration for a typical science case.

08.06

The Visible Tunable Filter and the Science it will do

Wolfgang Schmidt[1]

[1]*Kiepenheuer-Institut, Germany.*

12:15 PM - 12:30 PM

Exhibit Hall 1 - Las Cruces Convention Center

With the Visible Tunable Filter (VTF) of the ATST we will measure the solar magnetic field and its interaction with the constantly moving plasma in the atmosphere with hitherto unseen precision and resolution. Observations with the two-dimensional spectro-polarimeter VTF will unveil those physical processes that are relevant to understand solar magnetic activity on length scales between 20 km and 40,000 km.
The VTF is a narrowband tunable filter system for imaging spectroscopy based on Fabry Perot interferometers. It will operate in the visible spectral range with access to a host of magnetically sensitive lines at highest spatial resolution. Its multi-line capability, together with fast detectors, a field of view of one arc minute, and the ability to measure polarization states of the incoming light allow to probe the solar atmosphere from the photosphere to the chromosphere within a couple of seconds. The instrument is capable to vary the spectral sampling, the signal-to noise ratio, and the temporal cadence over a wide range without changing or compromising the opto-mechanical setup. This versatility gives unique possibilities to deal with a variety of science questions and to apply different measurement schemes. Here are two examples:
We will observe short-lived processes on sub-granular scales down to 20 km to understand how small-scale vortex flows transport and redistribute mechanical energy at the solar surface. Simultaneous magnetic field measurements at the same resolution will show how the interaction of magnetized and non-magnetized material.
The length scales of thermal and magnetic structures in sunspots span three orders of magnitude, from the spot diameter down to the resolution limit of the ATST. With the VTF we will measure the processes that accompany the formation, development and decay of sunspots in order to understand the governing physical mechanisms.

Wednesday, June 15, 2011, 1:40 PM - 3:40 PM

09

Solar Dynamics Observatory

Oral

Exhibit Hall 1 - Las Cruces Convention Center

09.01

SDO/HMI - The First Year

Philip H. Scherrer[1]

[1]*Stanford Univ..*

1:40 PM - 1:55 PM

Exhibit Hall 1 - Las Cruces Convention Center

The Solar Dynamics Observatory (SDO) science operations phase began a year ago. During that time the Helioseismic and Magnetic Imager (HMI) team has made significant progress in developing calibration and data processing procedures. The new view of the Sun provided by SDO/HMI allows direct viewing of dynamic processes both in the interior and photospheric magnetic fields and brightness features. The extended team is now spending as much or even more time exploring the Sun than developing calibration and processing codes. Some highlights of the former and a quick status of the latter will be presented.

09.02

First Year Of Science Results From Solar Dynamics Observatory (SDO) Extreme Ultraviolet Variability Experiment (EVE)

Rachel Hock[1], T. N. Woods[1], F. G. Eparvier[1], A. R. Jones[1], L. Didkovsky[2]

[1]*University of Colorado LASP,* [2]*University of Southern California.*

1:55 PM - 2:10 PM

Exhibit Hall 1 - Las Cruces Convention Center

The Extreme ultraviolet Variability Experiment (EVE) onboard Solar Dynamic Observatory (SDO), part of NASA's Living With the Star (LWS) program launched on 11 February 2010. Normal science operations began 1 May 2010 and have continued uninterrupted since then. The EVE instruments measure the solar extreme ultraviolet (EUV) irradiance from 0.1 to 105 nm with unprecedented spectral resolution (0.1 nm), temporal cadence (10 sec minimum), and accuracy (20% or better). Here, we present a review of the first year of EVE observations and initial science results presented at the LWS/SDO-1 Workshop held 1-5 May 2011 in Squaw Valley, CA. Much of the initial science from EVE has focused on the changes in the EUV irradiance due to solar flares. In the first eleven months of science operations, EVE observed over 350 C-class flares, 43 M-class flares, and 2 X-class flares. The location of a solar flare is important for understanding the EUV irradiance. ESP data is available in near-real time and uses a quadrant detector to determine the location of a solar flare. Preliminary location results are presented and compared to the location provided by both NOAA and AIA through the Heliophysics Events Knowledgebase (HEK). From EVE observations, we have noticed that flares of similar GOES class can have significant differences in the amount and timing of the increase of EUV irradiance due to the flare. From this, we have classified flares based on the topology in AIA observations to explore the implications for modeling the EUV irradiance of solar flares. In some solar flares, certain lines such as Fe IX (17.1 nm) actually decrease due to the ejection of material. The use of EVE spectral irradiance measurements as diagnostics of coronal mass ejections (CMEs) is explored.

09.03

Energetics And Heating In A Solar Plasma Ejection Observed By RHESSI And AIA

Lindsay Glesener[1], S. Krucker[1], H. M. Bain[1], R. P. Lin[1]
[1]*University of California, Berkeley.*
2:10 PM - 2:25 PM
Exhibit Hall 1 - Las Cruces Convention Center
For the past nine years, hard X-ray observations by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) have provided remarkable insight into the locations and spectra of energetic flare particles. With the advent of high-cadence, multiwavelength observations by the Atmospheric Imaging Assembly (AIA) aboard the Solar Dynamics Observatory, it is now possible to study the dynamic structures among which these energetic particles move. On November 3, 2010, a C4.9 solar flare emerged from behind the eastern limb of the Sun, accompanied by a coronal mass ejection. Because the bright flare footpoints were occulted by the solar disk (by about 12 degrees), the coronal X-ray sources can be studied in detail without contamination by the footpoints. Extreme ultraviolet (EUV) images from AIA show a mass of plasma ejected from the solar surface. Isothermal analysis using multiple EUV filters shows that this erupting plasma reaches a high temperature of 11 MK. Meanwhile, RHESSI X-ray images reveal a large, diffuse hard X-ray source that matches the location and shape of the ejecting plasma, suggesting the presence of nonthermal electrons magnetically trapped in the region. Using RHESSI spectroscopy and AIA temperature analysis, we will test the hypothesis that nonthermal electrons in the erupting plasma are responsible for heating the plasma to this high temperature via collisional heating.

09.04

Insights into Filament Eruption Onset from Solar Dynamics Observatory Observations

Alphonse C. Sterling[1], R. L. Moore[2], S. L. Freeland[3]
[1]*NASA's MSFC, Japan,* [2]*NASA's MSFC,* [3]*Lockheed Martin.*
2:25 PM - 2:40 PM
Exhibit Hall 1 - Las Cruces Convention Center
We examine the buildup to and onset of an active region filament confined eruption of 2010 May 12, using EUV
imaging data from the Solar Dynamics Observatory (SDO) Atmospheric Imaging Array and line-of-sight magnetic
data from the SDO Helioseismic and Magnetic Imager. Over the hour preceding eruption the filament undergoes
a slow rise averaging ~3 km/s, with a step-like trajectory. Accompanying a final rise step ~20 minutes prior
to eruption is a transient preflare brightening, occurring on loops rooted near the site where magnetic field had canceled over the previous 20 hr. Flow-type motions of the filament are relatively smooth with speeds ~50 km/s prior to the preflare brightening and appear more helical, with speeds ~50-100 km/s, after
that brightening. After a final plateau in the filament's rise, its rapid eruption begins, and concurrently an outer shell "cocoon" of the filament material increases in emission in hot EUV lines, consistent with heating in a newly formed magnetic flux rope. The main flare brightenings start ~5 minutes after eruption
onset. The main flare arcade begins between the legs of an envelope-arcade loop that is nearly orthogonal to
the filament, suggesting that the flare results from reconnection among the legs of that loop. This progress
of events is broadly consistent with flux cancellation leading to formation of a helical flux rope that subsequently erupts due to onset of a magnetic instability and/or runaway tether cutting. A full description of this work appears in ApJ Letters 2011, 731, L3.

NASA supported this work through its Solar Physics Supporting Research and Technology, Sun-Earth Connection Guest Investigator, and Living With a Star Targeted Research & Technology programs.

09.05

Cme Cavity, Core And Flux Rope: New Insights From Sdo And Stereo Observations

Jie Zhang[1], X. Cheng[1]

[1]*George Mason Univ..*

2:40 PM - 2:55 PM

Exhibit Hall 1 - Las Cruces Convention Center

In white light coronagraph images, the brightness morphology of a CME often has a 3-part structure: a semi-circular-shaped bright leading front, a dark cavity enclosed by the leading front, and a blob-like core inside the cavity. It is believed that the underlying magnetic structure of a CME is a flux rope that consists of helical field lines wrapping around the central axis. Nevertheless, the relationship between the flux rope and CME cavity and core is poorly understood. We look into these issues using recent SDO observations. CME cavity and immediate leading front are observed in AIA passbands of low coronal temperatures (AIA 171 Å, 193 Å, 211 Å and 335 Å), while CME core can be observed as an elongated hot channel in the AIA passbands of hot temperatures (AIA 94 Å and 131 Å). The hot channel initially appears in the shape of a sigmoid as viewed from the top, and a low lying central-dipped structure as viewed from the sides. Later, the hot channel starts to rise slowly and separates from the sigmoid. This slow-rise phase can last tens of minutes. In the meantime, the entire overlying arcade field starts to expand and develops into the cavity structure. As it rises, the hot channel appears closer to be a semi-circular loop, resembling the envisioned flux-rope shape. In this phase, these features are illuminated by EUV emissions, without apparent signature in GOES X-ray. However, this phase is followed by a sudden fast acceleration of the hot channel, strong expansion of the cool cavity, and the onset of the GOES X-ray flare (also flaring in EUV and other EM wavelengths). Based on the early examination of a limited number of eruptive events, we conclude that the flux rope exists before CME eruption, and later becomes the core of CME.

09.06

SDO/AIA Observations of a Global EUV Disturbance Traveling into a Coronal Cavity and Its Subsequent Oscillations: New Evidence of Fast Mode MHD Waves

Wei Liu[1], M. J. Aschwanden[2], L. Ofman[3], N. V. Nitta[2], T. D. Tarbell[2]

[1]*Stanford-Lockheed Institute for Space Research,* [2]*Lockheed Martin Solar and Astrophysics Laboratory,* [3]*Catholic University of America and NASA Goddard Space Flight Center.*

2:55 PM - 3:10 PM

Exhibit Hall 1 - Las Cruces Convention Center

We report new SDO/AIA observations of a global EUV disturbance that propagates at ~600 km/s and sweeps through a coronal cavity, instigating its bodily transverse oscillations. The high temporal resolution and large FOV of AIA allow us to clearly see, for the first time, the timing coincidence between the onsets of the oscillations and the arrival of the disturbance at increasing distances covering 300 Mm in the neighborhood of the cavity. There is a time delay of the oscillations from the near side to the far side of the cavity, which is consistent with the travel time of the global perturbation. In addition, we find a fine structure consisting of evenly spaced pulses of periods 100-120 s within the global disturbance. In contrast, the CME loop expansion falls behind the global disturbance at a smaller velocity of ~200 km/s. These observations suggests that this global disturbance is a real fast mode MHD wave that continues propagating into the cavity, rather than an apparent wave caused by CME expulsion that is not expected to penetrate through a topological separatrix, including the flux rope cavity boundary here. The cavity and its hosted prominence have oscillation amplitudes of ~20 km/s and periods of 20-30

minutes. Such unusually long periods, compared with a few minutes commonly observed in coronal loops, likely reflect kink mode oscillations of the long cavity flux rope of a large length (a fraction of the solar radius).

09.07

Euv Imaging Of Shock Formation In The Low Corona With Sdo/aia

Angelos Vourlidas[1], S. Patsourakos[2], T. Kouloumvakos[3]

[1]NRL, [2]University of Ioaninna, Greece, [3]University of Athens, Greece.

3:10 PM - 3:25 PM

Exhibit Hall 1 - Las Cruces Convention Center

Shock generation in the low corona has long been inferred by spectral observations of drifting so-called type-II radio emission in the metric wavelengths. Type-IIs occur with coronal mass ejections (CMEs) and/or flares but not consistently. Therefore, the exact relationship has been difficult to pin down, mostly because of the lack of radio imaging capability and of the low cadence of EUV observations in the low corona during the flare/CME formation. The advent of ultra-high observations from the AIA imagers has changed all that. In this talk, we present several direct observations of shock formation in the EUV and their association to the accompanying type-IIs. We will show that the coronal expansion driven by the formation of the CME ejecta is responsible for both EUV and radio emissions.

09.08

3d Mhd Simulation Of Sympathetic Eruptions On 1 August 2010

Tibor Torok[1], O. Panasenco[2], V. Titov[1], Z. Mikic[1], K. Reeves[3], M. Velli[4], J. Linker[1], G. de Toma[5]

[1]Predictive Science, Inc., [2]Helio Research, [3]Harvard-Smithsonian Center for Astrophysics, [4]Jet Propulsion Laboratory, California Institute of Technology, [5]HAO/NCAR.

3:25 PM - 3:40 PM

Exhibit Hall 1 - Las Cruces Convention Center

Apart from single eruptions originating in localized source regions, the Sun sometimes produces so-called sympathetic events, which consist of several individual eruptions occurring almost simultaneously in different source regions. The close temporal vicinity of the individual eruptions in such events indicates the existence of a causal link between them, but the mechanisms by which one eruption can trigger another one remain largely a mystery. A particularly beautiful example of a global sympathetic event was recently observed by the Solar Dynamics Observatory (SDO) on 1 August 2010. It included a small filament eruption and CME that was closely followed by the eruptions of two large adjacent (twin) filaments, indicating that these three eruptions were physically connected. A coronal potential field extrapolation revealed that the twin filaments were located in the lobes of a so-called pseudostreamer prior to their eruptions. Here we present a 3D MHD simulation of the successive eruption of two magnetic flux ropes in such a pseudostreamer configuration. The two eruptions are triggered by the simulated eruption of a third flux rope in the vicinity of the pseudostreamer. The simulation qualitatively reproduces the CME and subsequent twin filament eruption on 1 August 2010 and suggests that these events were indeed physically connected. Furthermore, it provides a generic scenario for the frequently observed twin filament eruptions in coronal pseudostreamers and suggests a mechanism by which such eruptions can be triggered in the first place. Our results thus provide an important step for a better understanding of sympathetic eruptions.

Wednesday, June 15, 2011, 4:00 PM - 4:40 PM

10

Harvey Prize Lecture

Oral

Exhibit Hall 1 - Las Cruces Convention Center

10.01

Numerical Simulations of Sunspots: From the Scale of Sine Structure to the Scale of Active Regions

Matthias D. Rempel[1]

[1]*High Altitude Obs. / NCAR..*

4:00 PM - 4:40 PM

Exhibit Hall 1 - Las Cruces Convention Center

Over that past five years magneto-convective sunspot models have seen a dramatic improvement to the point at which simulations of entire sunspots with sufficient detail for resolving sunspot fine structure are possible. After a brief review of recent developments I will focus on three different classes of numerical sunspot models. 1.) Sunspot simulations at the highest currently affordable resolution that focus on details of sunspot fine structure: I will highlight the magneto-convective processes that are responsible for the energy transport, filamentation and driving of the Evershed flow in sunspot penumbrae. 2.) Sunspot models at lower resolution that can be evolved for time scales of several days in computational domains with horizontal extents beyond 50 Mm: These models start to address the subsurface field and flow structure
of sunspots and their surroundings as well as processes related to sunspot decay. In addition these simulations are used as a testbed for helioseismic inversion methods. 3.) Sunspot models on the scale of active regions: These models capture the last stages of the flux emergence and sunspot formation process in the upper most 10 to 20 Mm of the convection zone. After the initial flux dispersal due to the strong expansion of emerging flux a re-amplification of flux into ~3 kG sunspots is found as a robust result.

The National Center for Atmospheric Research is sponsored by the National
Science Foundation.

Thursday, June 16, 2011, 8:30 AM - 10:20 AM

11

Parker Lecture III and Solar Flares I

Oral

Exhibit Hall 1 - Las Cruces Convention Center

11.02

Impulsive High-Energy Particle Acceleration in the SOL2010-06-12T00:57 M2 X-ray Flare

Gerald H. Share[1], M. S. Briggs[2], D. Gruber[3], F. Longo[4], R. J. Murphy[5], N. Omodei[6], R. A. Schwartz[7], S. M. White[8], A. J. Tylka[5], Fermi LAT Collaboration, Fermi GBM Collaboration

[1]University of Maryland, [2]University of Alabama, [3]Max Planck Institute for Extraterrestrial Physics, Germany, [4]Universit`a di Trieste, Italy, [5]Naval Research Laboratory, [6]Stanford University, [7]Catholic University, [8]AFGL.

9:20 AM - 9:35 AM

Exhibit Hall 1 - Las Cruces Convention Center

The GOES M2-class solar flare, SOL2010-06-12T00:57, was modest in many respects yet exhibited remarkable acceleration of energetic particles. While both radio and SDO/AIA UV/EUV images indicate a compact flare with foot-point separation of just 10 arc sec, this small region produced an ~70 sec burst of hard X-and gamma-ray emission up to at least 200 MeV observed by the Fermi GBM and LAT experiments. The gamma-ray line and >300 keV bremsstrahlung fluences from this flare were about ten times higher than that typically observed from this modest GOES-class of X-ray flare. Analysis of the combined nuclear line and high-energy gamma-ray emissions suggests that the accelerated proton spectrum at the Sun softened significantly above ~50 MeV. We compare these observations with measurements of solar energetic protons to determine whether the particle populations at the Sun and in space may have a common origin. The 34 and 80 GHz microwave emissions are very bright and well correlated with the few hundred keV X-ray emission, but with small time lags suggesting mild trapping of electrons in the corona.

11.03

Fermi-LAT Observation Of >100 MeV Gamma-rays Of March 7-8, 2011 Solar Flares

Vahe Petrosian[1], A. Allafort[1], N. Gigliotto[2], F. Longo[1], N. Omodei[1], G. Share[3], Y. Tanaka[4], Q. Chen[1], A. Tylka[5], and Fermi Collaboration

[1]Stanford Univ., [2]INFN and Politecnico di Bari, Italy, [3]NASA Goddard, [4]ISAS- JAXA, Japan, [5]NRL.

9:35 AM - 9:50 AM

Exhibit Hall 1 - Las Cruces Convention Center

Fermi-LAT has detected >100 MeV emission beginning 2011 March 7 and extending over several hours following (and somewhat overlapping with the decay phase of) the M3.7 flare at 19:50 UT, which was observed up to at least 300 keVby RHESSI and the Fermi GBM during the ~7 minute impulsive phase. There was no evidence of detection of nuclear-line emission by RHESSI during this flare and during the time interval from March 7 20 hr UT to March 8 4 hr UT of the Fermi-LAT observations. The Fermi-LAT emission coincides with several other smaller flares seen both in RHESSI and GOES light curves, with SEP electrons and protons and a prominent CME. There is also some indication of microwave emission from Noboyama observatory. The long duration and relatively hard spectrum of the Fermi-LAT gamma-rays pose a challenge to theoretical modeling. We shall discuss the hard X-ray and gamma-ray characteristics

of these events and evaluate several scenarios for acceleration of particles and production of these radiation, including leptonic and hadronic origin from either the flare site or the CME shock region.

11.04

On the Relation of Above-the-loop-top and Footpoint Hard X-ray Sources in Solar Flares

Shin-Nosuke Ishikawa[1], S. Krucker[1], T. Takahashi[2], R. P. Lin[1]

[1]University of California, Berkeley, [2]Institute of Space and Astronautical Science, Japan.

9:50 AM - 10:05 AM

Exhibit Hall 1 - Las Cruces Convention Center

We report on the most prominent example of an above-the-loop-top hard X-ray source in the extensive solar flare data base of the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). The limb flare of 2003 October 22 around 20UT shows a coronal source in the 40-100 keV range that is significantly above the thermal flare loop top, similar as seen in the famous Masuda flare. The above-the-loop-top source is only visible during one of the four hard X-ray peaks, highlighting the rare occurrence of above-the-loop-top sources that are equally bright as footpoint sources. The chromospheric emissions for the peak with above-the-loop-top source shows a single footpoint, with the second footpoint occulted. The relative timing between the above-the-loop-top and footpoint source shows that the coronal source peaks about 10 s before the footpoint source and decays during the time the footpoint source is most prominent.

Thanks to the good energy resolution of RHESSI, this is the first time to obtain accurate spectra of both above-the-loop-top and footpoint sources. Photon indices of the above-the-loop-top and the footpoint sources are 4.8±0.4 and 3.7±0.5, respectively. These difference of indices 1.1±0.6 suggests that these emission are from the same components of electrons through thin- and thick-target bremsstrahlung. The large intensity of the above-the-loop-top source and the absence of thermal emission in the above-the-loop-top region suggests that the electrons within above-the-loop-top source are purely non-thermal. Based on this assumption, we estimate the number of the accelerated electrons and time scale. We discuss on the relation of the above-the-loop-top and footpoint sources and a possible model to explain this event.

11.05

The Origin Of High Density In Loop-top X-ray Sources

Dana Longcope[1], S. Guidoni[1]

[1]Montana State Univ..

10:05 AM - 10:20 AM

Exhibit Hall 1 - Las Cruces Convention Center

Super-hot looptop sources, detected in some large solar flares, are compact sources of HXR emission with spectra matching thermal electron populations exceeding 30 megakelvins. High observed emission measure, as well as inference of electron thermalization within the small source region, both provide evidence of high densities at the looptop; typically more than an order of magnitude above ambient. Some investigators have suggested such density enhancement results from a rapid enhancement in the magnetic field strength. It seems unlikely, however, that the spontaneous decrease in magnetic energy powering the flare would increase the field strength by more than a factor of ten. We propose an alternative model, based on Petschek reconnection, whereby looptop plasma is heated and compressed by slow magnetosonic shocks generated self-consistently through flux retraction following reconnection. Under steady conditions such shocks can enhance density by no more than a factor of four. These steady shock relations (Rankine-Hugoniot relations) turn out to be inapplicable to Petschek's model owing to transient thermal conduction. The actual density enhancement can in fact exceed a factor of ten over the entire length of the reconnection outflow. An ensemble of flux tubes retracting following reconnection at an ensemble of distinct sites will have a collective emission measure proportional to the rate of flux tube production. This rate, distinct from the local reconnection rate within a single tube, can be measured separately through observations of flare ribbon motion. Typical flux transfer rates and loop parameters yield emission measures comparable to those observed in super-hot sources.

Thursday, June 16, 2011, 11:00 AM - 12:30 PM

12

Solar Flares II

Oral

Exhibit Hall 1 - Las Cruces Convention Center

12.01

The Magnetic and Dynamic Properties of Flaring Active Regions

Fraser Watson[1], L. Fletcher[1]

[1]*University of Glasgow, United Kingdom.*

11:00 AM - 11:15 AM

Exhibit Hall 1 - Las Cruces Convention Center

As solar cycle 24 begins, the return of active regions and solar flares provides new opportunities for the study of the sun, particularly with the recently launched Solar Dynamics Orbiter. This allows these regions to be studied in more detail than has previously been possible. We have developed a magnetic segmentation algorithm that allows us to examine magnetic structures within active region magnetograms and track their evolution in space and time. With this, we can build up a picture of the photospheric properties of the active region before and after solar flares. We can then examine the structures for changes that occur around the time of flaring and compare these with changes seen in other active regions at times of emergence, flaring and decay. We present the findings of a study of flaring active regions, most of which come from SOHO/MDI data and two use data from SDO/HMI. These two regions observed by HMI include two of the strongest flares seen during the beginning of solar cycle 24 whilst the MDI regions are very active regions from the peak of solar cycle 23. In this way we can also compare any changes observed between the two cycles.

12.02

SDO And RHESSI Observations Of Flares

Steven Christe[1]

[1]*400 Massachusetts Ave. NW.*

11:15 AM - 11:30 AM

Exhibit Hall 1 - Las Cruces Convention Center

We present the statistics of flares with simultaneous observations in both hard X-ray (HXR) and ultraviolet (UV/EUV) observations by RHESSI and SDO/AIA, respectively. The flares were chosen from the RHESSI flare list and range from GOES M class to GOES A class (though most are GOES B class). Identifying the flare region using RHESSI imaging, we compare the HXR (thermal) light curves and images with those observed by AIA in every available UV/EUV channels. Many events show complex morphologies with multiple flaring loops observed in AIA images though only a simple morphology is observed by RHESSI images. We find that at least 75% of events show significant UV/EUV flux at the same location as the RHESSI HXR source. The high temperature AIA channels (131 $\AA$, 91 $\AA$) are well correlated with the RHESSI thermal HXRs (4-10 keV) though not the 193 $\AA$, another high temperature channel. We find little to no time lag between the different AIA channels. We further compare the temperature response as derived from the AIA images to that derived from RHESSI.

12.03

Detection of the Acceleration Site in a Solar Flare

Gregory D. Fleishman[1], E. P. Kontar[2], G. M. Nita[1], D. E. Gary[1]

[1]*NJIT,* [2]*University of Glasgow, United Kingdom.*

11:30 AM - 11:45 AM

Exhibit Hall 1 - Las Cruces Convention Center
We report the observation of an unusual *cold, tenuous solar flare* (ApJL, v. 731, p. L19, 2011), which reveals itself via numerous and prominent non-thermal manifestations, while lacking any noticeable thermal emission signature. RHESSI hard X-rays and 0.1-18 GHz radio data from OVSA and Phoenix-2 show copious electron acceleration (10^{35} electrons per second above 10 keV) typical for GOES M-class flares with electrons energies up to 100 keV, but GOES temperatures not exceeding 6.1 MK. The HXR footpoints and coronal radio sources belong, supposedly, to a single magnetic loop, which departs strongly from the corresponding potential loop (obtained from a photospheric extrapolation) in agreement with the apparent need of a non-potential magnetic field structure to produce a flare. The imaging, temporal, and spectral characteristics of the flare have led us to a firm conclusion that the bulk of the microwave continuum emission from this flare was produced directly in the acceleration region. We found that the electron acceleration efficiency is very high in the flare, so almost all available thermal electrons are eventually accelerated. However, given a relatively small flaring volume and rather low thermal density at the flaring loop, the total energy release turned out to be insufficient for a significant heating of the coronal plasma or for a prominent chromospheric response giving rise to chromospheric evaporation. Some sort of *stochastic acceleration* process is needed to account for an approximately energy-independent lifetime of about 3 s for the electrons in the acceleration region.
This work was supported in part by NSF grants AGS-0961867, AST-0908344, and NASA grants NNX10AF27G and NNX11AB49G to New Jersey Institute of Technology. This work was supported by a UK STFC rolling grant, STFC/PPARC Advanced Fellowship, and the Leverhulme Trust, UK. Financial support by the European Commission through the SOLAIRE and HESPE Networks is gratefully acknowledged.

12.04
Pulsations In Two-ribbon Flares: Waves, Reconnection Or Both?
Andrew Inglis[1], B. Dennis[1]
[1]*NASA GSFC.*
11:45 AM - 12:00 PM
Exhibit Hall 1 - Las Cruces Convention Center
Pulsations in flares, commonly observed simultaneously in hard X-rays and radio waves, are normally considered in the context of two alternate mechanisms: either a process of bursty reconnection, or a signature of periodic wave behaviour. However, observationally distinguishing between these mechanisms remains a challenging objective. By studying large two-ribbon flares with RHESSI, SOHO and now SDO, we attempt to discriminate between these two mechanisms by focusing on expected observable characteristics.
In particular, we focus on the recent slow wave model proposed by Nakariakov & Zimovets (2011). According to this model, slow waves propagate obliquely along the arcade, reflect from the chromosphere, and trigger reconnection in the corona due to constructive interference. Hence a discontinuous motion of footpoints along ribbons is expected, while the interval between pulses would be a function of footpoint separation. Additionally, gaps would be expected along the arcade in areas where magnetic reconnection was not triggered by waves and loops were not heated. The size of these gaps can be estimated from the preferential propagation angle of slow waves. We test for consistency with this model using observations of several flares, including from 9th November 2002 and 19th January 2005.
ARI is supported by the NASA Postdoctoral Programme, administered by Oak Ridge Associated Universities through a contract with NASA.

12.05
Heating of Flare Loops During a Two-ribbon Flare on 2005 May 13

Jiong Qiu[1], W. Liu[1], D. W. Longcope[1]
[1]*Montana State Univ..*
12:00 PM - 12:15 PM
Exhibit Hall 1 - Las Cruces Convention Center
Many eruptive flares exhibit two extended ribbons in the lower-atmosphere outlining the feet of the post-flare coronal arcade. High-cadence high-resolution UV observations by TRACE reveal that a flare ribbon consists of small patches sequentially brightened along the ribbon, suggesting that reconnection takes place sequentially forming individual post-flare loops along the arcade, as often seen in coronal observations in the EUV wavelengths. These reconnection events and formation of new loops continue into the decay phase. Our recent study (Qiu et al. 2010) further shows that the spatially resolved UV brightness at the foot-points of individual loops grows rapidly on timescales of ~1 minute, followed by a long decay on timescales of more than 10 minutes. The rapid rise of UV radiation is correlated with the hard X-ray light curve during the impulsive phase, hence is most likely a direct response of instantaneous heating in the reconnection formed flux tubes. In this study, we utilize the spatially resolved UV brightness time profiles to reconstruct instantaneous heating functions of individual flux tubes, and compute evolution of each flux tube using the EBTEL model (Klimchuk et al. 2008). To build the heating function, we take into account the scaling between the total UV peak count rate, the hard X-ray energy flux derived from RHESSI spectral analysis during the impulsive phase, and as well the reconnection rate that persists from the pre-impulsive phase to the decay phase. The sum of the computed coronal radiation in all the flux tubes compares favorably with the gross coronal radiation observed by GOES. This study presents the first effort to constrain heating functions of flare loops directly using all available observables, and provides a method to examine physics of heating discrete flux tubes formed by reconnection events throughout the flare. The work is supported by NSF grant ATM-0748428.

12.06

The Time-Extended Phase of Solar Flares at MM-SUBMM Wavelengths

Jean-Pierre Raulin[1], G. Trottet[2], C. G. Giménez de Castro[1], T. Luthi[3], A. Caspi[4], C. H. Mandrini[5], M. L. Luoni[6], P. Kaufmann[7]
[1]*CRAAM/EE/UPM, Brazil,* [2]*LESIA/Observatoire de Paris, France,* [3]*Leica Geosystem AG, Switzerland,* [4]*Space Sciences Laboratory, UC Berkeley,* [5]*IAFE, CONICET-UBA, Argentina,* [6]*FCEN, UBA, Argentina,* [7]*CRAAM/EE/UPM and CCS/UNICAMP, Brazil.*
12:15 PM - 12:30 PM
Exhibit Hall 1 - Las Cruces Convention Center
We give a brief overview of the observations of the few flare which exhibit a slowly-varying and time-extended phase lasting for tens of minutes after the impulsive phase, and which are detected in radio up to submillimeter wavelengths. We present a detailed analysis of the 2003 October 27 event at 12:30 UT, which shows such a gradual phase. The radio, UV/EUV, X-ray and optical observations of the gradual phase are consistent with thermal bremsstrahlung from coronal material at two temperatures which is optically thick below 8 GHz and optically thin at higher frequencies. At 345 GHz there is a flux density excess with respect to the optically-thin emission which arises from the chromosphere. We show that these findings constitute a challenge for the modeling of the chromospheric response to energy deposition during solar flares.

Thursday, June 16, 2011, 1:40 PM - 3:40 PM

13

CME's

Oral

Exhibit Hall 1 - Las Cruces Convention Center

13.01

Partial Torus Instability in Initiating Coronal Mass Ejections

Oscar Olmedo[1], J. Zhang[1]

[1]*George Mason University.*

1:40 PM - 1:55 PM

Exhibit Hall 1 - Las Cruces Convention Center

We have been studying the balance between internal and external Lorenz forces of an idealized flux rope and the role of the external overlying (strapping) magnetic field in triggering the torus instability. It has been theorized that the flux rope is the magnetic configuration of an erupting coronal mass ejection. The role of the overlying field is to maintain the flux rope in equilibrium, but it may eventually become unstable and erupt as the flux rope gradually rises up. We analyze the semi-circular flux rope model as proposed by Chen and others, which pre-supposes the existence of a flux rope in the corona. It is found that this model predicts a critical index of the overlying field that dictates the stability of the flux rope. This index is a function of the arc length of the loop, and we argue that this function is a generalized form of the torus instability. We have coined our finding the partial torus instability. We continue the research by looking for observational evidences of this instability. We use observations from SOHO, STEREO, and SDO, and compare the kinematics of eruptive prominences with extrapolated coronal magnetic fields. These results are in qualitative agreement with the theorized partial torus instability. Our comprehensive results of this study will be presented.

13.02

Cme Onset And Take-off

Spiro K. Antiochos[1], J. T. Karpen[1], C. R. DeVore[2]

[1]*NASA GSFC,* [2]*NRL.*

1:55 PM - 2:10 PM

Exhibit Hall 1 - Las Cruces Convention Center

For understanding and eventually predicting coronal mass ejections/eruptive flares,
two critical questions must be answered: What is the mechanism for eruption onset, and what is the mechanism for the rapid acceleration? We address these questions in the context of the breakout model using 2.5D MHD simulations with adaptive mesh refinement (AMR). The AMR capability allowed us to achieve ultra-high numerical resolution and, thereby, determine the influence of the effective Lundquist number on the eruption. Our calculations show that, at least, for the breakout model, the onset of reconnection external to the highly-sheared filament channel is the onset mechanism. Once this reconnection turns on, eruption is inevitable. However, as long as this is the only reconnection in the system, the eruption remains slow. We find that the eruption undergoes an abrupt "take-off" when the flare reconnection below the erupting plasmoid develops significant reconnection jets. We conclude that in fast CMEs, flare reconnection is the primary mechanism responsible for both flare heating and CME acceleration. We discuss the implications of these results for SDO observations and describe possible tests of the model.

This work was supported, in part, by the NASA TR&T and SR&T Programs.

13.03

An MHD Model of the December 13 2006 Eruptive Flare

Yuhong Fan[1]

[1]*HAO/NCAR.*

2:10 PM - 2:25 PM

Exhibit Hall 1 - Las Cruces Convention Center

We present a 3D MHD simulation that qualitatively models the coronal magnetic field evolution of the eruptive flare occurred on December 13, 2006 in the emerging delta-sunspot region NOAA 10930 observed by the Hinode satellite. The simulation is set up where we drive the emergence of a twisted magnetic flux rope at the lower boundary into a pre-existing coronal potential field derived based on the MDI full-disk magnetogram at 20:51:01 UT on December 12, 2006. The resulting coronal flux rope embedded in the ambient coronal magnetic field first settles into a stage of quasi-static rise, and then undergoes a dynamic eruption, with the front of the flux rope cavity accelerating to a steady speed of about 900 km/s. The pre-eruption coronal magnetic field shows morphology that is similar to that seen in the Hinode soft X-ray observation of the region in both the magnetic connectivity as well as the development of a central inverse-S shaped X-ray sigmoid due to the formation of a current sheet underlying the flux rope. We examine the properties of the erupting flux rope and also the accompanying reconnections and the post-reconnection loops, and compare them with observations.

13.04

Dynamics of Coronal Mass Ejection Origins

Suli Ma[1], J. Lin[1], L. Golub[2]

[1]*Yunnan Astronomical Observatory, Chinese Academy of Sciences, China,* [2]*Harvard-Smithsonian Center for Astrophysics.*

2:25 PM - 2:40 PM

Exhibit Hall 1 - Las Cruces Convention Center

Coronal mass ejections (CMEs) are massive eruptions of magnetised plasma that is believed to be originated from the solar corona. CMEs are known to play a significant role in driving disastrous space weather. This thesis focuses on understanding the dynamics of CMEs source regions with the observations made by STEREO, the Solar Terrestrial Relations Observatory.

The successful launch of STEREO provides us with the first-ever stereoscopic measurements to study the 3D structures of CMEs. With the data from Extreme Ultra-Violet Imager (EUVI) and coronagraphs COR1 and COR2 onboard both STEREO Ahead (A) and STEREO Behind (B) and the data from other instruments, we studied of the initiation of a CME and its associated phenomena. The CME occurs on 2007 December 7, during which the separation angle of STEREO A with B is about 42.4°. This offers us a good opportunity to study the initiation of the CME stereoscopically. Using the data from both STEREO A and B, we made a detailed comparison for the morphologies and kinematics of its associated “EIT wave”. The results indicate that the nascent CME seems to affect the morphology of the EIT wave, vise verse, i.e., the morphology of EIT wave reflects the morphology of the CME.

Taking the advantage of the two viewpoints of the STEREO spacecrafts from January 1 to August 31, 2009, we identified 34 CMEs that originated from almost one quarter of the Sun which faces the Earth. It is found that about 33% of them had no distinct low coronal signature (such as coronal dimming, coronal wave, filament eruption, post-eruptive arcade). It might be a new challenge for our present models of CME origination.

13.05

The Coronal Imprints of Eruptive Prominences and CMEs as Revealed by the Total Solar Eclipse Observations of 11 July 2010

Shadia R. Habbal[1], M. Druckmuller[2], H. Morgan[1], A. Ding[3], J. Johnson[4], H. Druckmullerova[2], A. Daw[5], M. B. Arndt[6]
[1]Univ. of Hawaii at Manoa, [2]Brno University of Technology, Czech Republic, [3]Institute of Technical Physics, Germany, [4]Electricon, [5]NASA/GSFC, [6]Bridgewater State University.
2:40 PM - 2:55 PM
Exhibit Hall 1 - Las Cruces Convention Center
Total solar eclipses continue to provide unique opportunities for observing the corona, due primarily to the exceptional diagnostic capabilities offered by emission from forbidden lines. Such observations span the heliocentric distance range of 1 - 3 solar radii, providing information that is currently inaccessible to any space-borne or ground-based observatory. Taking advantage of such an opportunity, the most ambitious multi-wavelength observations to date were made simultaneously in broadband white light, H alpha 656.3 nm, Fe IX 435.9 nm, Fe X 637.4 nm, Fe XI 789.2 nm, Fe XIII 1074.7 nm, Fe XIV 530.3 nm and Ni XV 670.2 nm, during the total solar eclipse of 11 July 2010 from Tatakoto, an atoll in French Polynesia. A number of curious coronal structures, namely ripples, streaks and a structure in the shape of a hook, were detected in the images. The ripples were most prominent in emission from spectral lines associated with temperatures around 10^6 K. The most prominent streak was associated with a conical-shaped void in the emission from the coolest line of Fe IX and from the hottest line of Ni XV. A prominence, which erupted prior to totality, produced the hook in the cooler lines of Fe X and Fe XI, spanning 0.5 Rs in extent, centered at 1.3 Rs, with a complex trail of hot and cool twisted structures connecting it to the solar surface. These observations show for the first time how the passage of CMEs and eruptive prominences through the corona leave complex density trails with distinct temperatures.

13.06
Plasma Heating During a Coronal Mass Ejection Observed by SOHO
Nicholas Arnold Murphy[1], J. C. Raymond[1], K. E. Korreck[1]
[1]Harvard-Smithsonian Center for Astrophysics.
2:55 PM - 3:10 PM
Exhibit Hall 1 - Las Cruces Convention Center
Several recent observational results suggest that coronal mass ejection (CME) plasma is heated even after leaving the flare site. The source of the heating is probably the magnetic field, but the mechanisms that convert magnetic to thermal energy during these events are not well understood. We perform a time-dependent ionization analysis of a CME observed by SOHO/UVCS on 2000 June 28 to constrain plasma heating at distances of up to several solar radii. The most strongly constrained feature shows cumulative plasma heating comparable to or greater than the kinetic energy, whereas features observed early in the event showed plasma heating comparable to or less than the kinetic energy. We use these results to assess the efficacy of several candidate mechanisms, including heating by the CME current sheet, small-scale reconnection, MHD instabilities, thermal conduction, energetic particles, and wave heating.

13.07
Simultaneous Observations of Hα Moreton Waves and EUV Waves
Stephen M. White[1], K. S. Balasubramanian[1], E. W. Cliver[1]
[1]Air Force Research Laboratory.
3:10 PM - 3:25 PM
Exhibit Hall 1 - Las Cruces Convention Center
The first period of major solar activity in the current cycle, due to AR 11158 in mid February 2011, produced a sequence of solar flares exhibiting both Moreton waves in H-alpha images and "EIT-waves" seen in EUV images. Given the rarity of Moreton waves, this offers an excellent opportunity to compare

the properties of the two phenomena with simultaneous observations. We analyze several events and compare the speeds and locations of the disturbances using high-cadence H-alpha data from both the ISOON telescope at Sunspot, NM, and the GONG network, together with EUV images in several wavelengths from the SDO/AIA telescope, and interpret the results in light of current models for such disturbances.

13.08

The Evolution Of Coronal Mass Ejections And Large Solar Wind Structures

Tim A. Howard[1], C. E. DeForest[1], A. A. Reinard[2]

[1]Southwest Research Institute, [2]University of Colorado / NOAA.

3:25 PM - 3:40 PM

Exhibit Hall 1 - Las Cruces Convention Center

Processing of STEREO/HI-2 heliospheric image data has reached a level where extremely faint structures can be tracked through their entire trajectory to 1 AU. This enables detailed comparison with auxiliary datasets allowing an unambiguous identification of solar wind transient structures from the Sun to 1 AU and beyond. These transients are in the scale range from large CMEs to "puffs" only a few hundred Mm across. For events that impact in-situ spacecraft, we are able to make quantitative measurements of these transients without the confusion involving the identification of heliospheric image features. We present results utilizing a new processing pipeline of HI-2 data developed by DeForest et al. (2011) that link transient features observed by white light coronagraphs with in-situ datasets near 1 AU. The results include attempts of three-dimensional reconstruction, trajectory and kinematic evolution of these features, along with a detailed in-situ analysis of the magnetic field and plasma comprising each of the features.

Thursday, June 16, 2011, 4:00 PM - 5:30 PM
14
Solar Wind, SEPs and Heliosphere
Oral
Exhibit Hall 1 - Las Cruces Convention Center

14.01
The 3D Reconstruction of Heliospheric Density Using Thomson-Scattering Observations - Current Progress and Future Prospects
Bernard V. Jackson[1], J. M. Clover[1], A. Buffington[1], P. P. Hick[1]
[1]*UC, San Diego.*
4:00 PM - 4:15 PM
Exhibit Hall 1 - Las Cruces Convention Center
Three-dimensional reconstructions using Thomson-scattering observations from the Air Force/NASA Solar Mass Ejection Imager (SMEI) provide a determination of density in the inner heliosphere and allow its forecast from these remote-sensing heliospheric data. Here we describe our recent progress in providing density from this technique, and our current success in this endeavor. We would like to provide the best possible remote determinations of this heliospheric parameter. Here we explore this possibility with the copious data available from the SMEI imagery that can now be cleaned of auroral signals such that as many as 10,000 lines of sight can be available on each 102-minute orbit. We speculate on the degree to which these methods and results could be used on future heliospheric missions, should such instruments on such missions provide images as finely-calibrated as those from SMEI.

14.02
Imaging The Solar Wind At 1 AU. With Stereo/hi-2
Craig DeForest[1], T. Howard[1], J. Tappin[2]
[1]*Southwest Research Inst.,* [2]*National Solar Observatory.*
4:15 PM - 4:30 PM
Exhibit Hall 1 - Las Cruces Convention Center
The STEREO/HI-2 wide-field imagers have demonstrated the importance of heliospheric imaging to understanding CMEs and the solar wind, but the difficulty of background subtraction has precluded full exploitation of this rich resource: current results are based mainly on morphological studies of running difference movies and time-elongation “J-plots”. With a combination of several commonly used image processing techniques, we have developed a pipeline to extract quantitative wind imagery from HI-2 at elongation angles as high as 70 degrees from the Sun and brightness ranges 3-4 orders of magnitude fainter than the background.
The processed data reveal to direct view a surprising menagerie of features in the solar wind: voids within CMEs, remnant loop structures, disconnected plasmoids, current sheets, interacting streams, and compressive wave fronts. Despite motion blur of 1-3 degrees in the HI-2 instrument, in some cases the images are clear enough to reveal striated “tracer” structures that appear to follow the magnetic field, just as in the solar corona. We will briefly summarize the reduction pipeline, demonstrate its output with spectacular movies of Earth-directed events and “quiet Sun”, and present preliminary results from examination of the quantitative data. This work was supported in major part by NASA’s SHP-GI program.

14.03
Interchange Slip-running Reconnection and Sweeping SEP Beams

Sophie Masson[1], G. Aulanier[2], E. Pariat[2], K. Klein[2]
[1]NASA/GSFC, [2]LESIA-Observatoire de Paris, France.
4:30 PM - 4:45 PM
Exhibit Hall 1 - Las Cruces Convention Center
We present a new model to explain how particles, accelerated at a reconnection site that is not magnetically connected to the Earth, could eventually propagate along the well-connected open flux tube. Our model is based on the results of a low beta resistive MHD simulation of a 3D line-tied and initially current-free bipole, that is embedded in a non-uniform open potential field. The topology of this configuration is that of an asymmetric coronal null-point, with a closed fan surface and an open outer spine. When driven by slow photospheric shearing motions, field lines initially anchored at both feet below the fan dome reconnect at the null point, and jump to the open magnetic domain. This is the standard interchange mode as sketched and calculated in 2D. The key result in 3D is that, after the interchange, and just as found earlier in non-open null-point reconnection, reconnected open field lines located in the vicinity of the outer spine keep reconnecting continuously, across an open quasi-separatrix layer. The apparent slipping motion of these field lines leads to forming an extended narrow magnetic flux tube at high altitude. Because of the slip-running reconnection, we conjecture that if energetic particles would be traveling through, or be accelerated inside, the diffusion region, they would be successively injected along continuously reconnecting field lines, that are connected farther and farther from the spine. At the scale of the full Sun, owing to the super-radial expansion of field lines below 3 Rs, such energetic particles could easily be injected in field lines slipping over significant distances, and could eventually reach the distant flux tube that is well connected to the Earth.

14.04
A Two-temperature Solar Wind Model: Validation And Two-temperature CMEs
Bart Van Der Holst[1], M. Jin[1], J. Gruesbeck[1], R. Oran[1], W. Manchester[1], R. Frazin[1], A. Vasquez[2], T. Gombosi[1]
[1]University of Michigan, [2]Institute of Astronomy and Space Physics, University of Buenos Aires, Argentina.
4:45 PM - 5:00 PM
Exhibit Hall 1 - Las Cruces Convention Center
We have performed a multi-spacecraft validation study for the recently developed 3D, two-temperature, Alfven wave driven global solar wind model (B. van der Holst et al., 2010) of the Space Weather Modeling Framework (SWMF). We compare the proton state (density, temperature, and velocity) and magnetic field for solar minimum CR2077 as predicted by this model with the in-situ observations from STEREO A/B, ACE/WIND, and Venus Express. Near the Sun, we validate this model with the electron density obtained from Solar Rotational Tomography on LASCO C2 white-light images of SOHO as well as with the electron density and temperature from the Differential Emission Measure Tomography (DEMT) applied to the STEREO A/B EUVI images. Moreover, we compare ion charge state (C, O, Si, Fe) observed in-situ by ACE/SWICS with that predicted by our solar wind model. This validation study demonstrates that most of the model results for CR2077 are in range with observations. A preliminary two-temperature simulation of the December 12, 2008 coronal mass ejection (CME) is demonstrated. The heat transport is significantly different from one-temperature models.

14.05
Magnetohydrodynamic Modeling of the Origin and Evolution of Corotating Interaction Regions
Jon A. Linker[1], P. Riley[1], R. Lionello[1], Z. Mikic[1], M. Stevens[2]
[1]Predictive Science Inc, [2]Harvard-Smithsonian Center for Astrophysics.
5:00 PM - 5:15 PM
Exhibit Hall 1 - Las Cruces Convention Center

Recurrent geomagnetic activity at Earth is closely associated with corotating interaction regions (CIRs), which form when fast solar streams catch up to and interact with slow solar wind. CIRs are most often associated with the declining phase of the solar cycle. In the classic picture of the formation of CIRs, fast solar wind streams emanating from the polar coronal holes encounter and compress the slow solar wind in the ecliptic because of the overall tilt of the Sun's magnetic axis during this phase of the cycle. This picture fits well with Ulysses observations near the end of solar cycle 22. In the most recent solar minimum, recurrent fast solar wind streams at Earth were frequently observed, but these streams were associated with isolated equatorial coronal holes, rather than the extended polar coronal holes of the previous minimum. This time period would seem ideal for testing models of coronal and heliospheric structure, which were first developed and tested against observations at the end of cycle 22. We have developed MHD models of the corona and solar wind for Carrington rotation 2060 (Aug. 14 - Sept. 10, 2007), when prominent fast solar wind streams were present. We discovered that the model predictions varied significantly depending on which solar observatory was used to develop the boundary conditions, and that the models systematically underestimated the strength of B in the solar wind. We discuss our results thus far in identifying the underlying causes of these discrepancies and some of the implications for providing routine models of the corona and solar wind.
Research supported by NASA and NSF.

14.06

Dependence Of Solar Proton Events On Flare And Cme Parameters
Jinhye Park[1], Y. Moon[1]
[1]School of Space Research, Kyung Hee University, Korea, Republic of.
5:15 PM - 5:30 PM
Exhibit Hall 1 - Las Cruces Convention Center
In this study we have examined the probability of solar proton events (SEPs) and their peak fluxes depending on flare (intensity, longitude and impulsive time) and CME parameters (linear speed and angular width). For this we used the NOAA SPE events and their associated flare data from 1976 to 2006 and CME data from 1997 to 2006. From this study, we found that about only 3.5% (1.9% for M-class and 21.3% for X-class) of the flares are associated with the proton events. It is also found that this fraction strongly depends on longitude; for example, the fraction for 30W° < L < 90W° is about three times larger than that for 30°E < L < 90°E. The occurrence probability of solar proton events for flares with long duration (≥ 0.3 hours) is about 2 (X-class flare) to 7 (M-class flare) times larger than that for flares with short duration (< 0.3 hours). In the case of halo CMEs with V ≥ 1500km/s, 36.1% are associated with SPEs but in the case of partial halo CME (120° ≤ AW < 359°) with 400 km/s ≤ V < 1000 km/s, only 0.9% are associated with SPEs. The relationship between X-ray flare peak intensity and proton flux as well as its correlation coefficient strongly depends on longitude and impulsive time. It is also noted that the relationship between CME speed and proton flux depends on longitude as well as direction parameter.

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