Contents

1 Wednesday Session 1: 08:30 - 10:00

1.1 Welcome

Blue Heron Ballroom

08:30: **Meeting opening and welcome**

1.2 Plenary 1: Measuring the Coronal Magnetic Field

Chair: Angelos Vourlidas

08:45 - 09:30: **Measuring the Coronal Magnetic Field**

Steve Tomczyk

09:30 - 09:45: **Probing the magnetic structure of coronal cavities**

Laurel Rachmeler, Sarah Gibson

In order to understand the initiation mechanism of a CME, we must first know the initial magnetic field configuration. Measuring this field can be quite challenging. Linear polarization measurements of the corona can give us valuable information about the magnetic field above the solar limb. Coronal cavities are seen on the limb, are quasi-stable, aligned with our line-of-sight, and are known to regularly erupt as CMEs. Thus, they provide an ideal target for polarization studies. We use this polarization data, in conjunction with forward modeling, to study coronal cavities. Our work focuses on determining the magnetic morphologies of these cavities, learning what the pre-initiation structure is, and finding the properties that point to cavities which are more likely to erupt.

09:45 - 10:00: **Dynamically Measuring Coronal Magnetic Fields in Flaring Loops with Microwave Imaging Spectropolarimetry**

Dale E. Gary, Gregory Fleishman

The theory of gyrosynchrotron (GS) emission in the microwave radio range is well known, and clearly demonstrates the promise of measuring magnetic field strength and direction in flaring loops. For decades, observations have exploited this theoretical understanding to confirm the feasibility of such measurements, using both radio imaging at a few frequencies and spectra with modest or no imaging, in situations where reasonable simplifying assumptions could be made. However, the true exploitation of the diagnositic power of microwave imaging spectropolarimetry requires simultaneous, excellent dual-polarization imaging at many frequencies over a broad band with 1 s or better time resolution. Anticipating that instruments with the required capabilities will soon be available, we model GS emission from flaring loops and use the resulting data cube to investigate the methods needed to obtain 2D maps of physical parameters, including coronal magnetic field, through forward fitting. We quantitatively compare the results with the model, and investigate systematic errors due to effects such as frequency-dependent spatial resolution, and spatial variation along the line of sight. We also discuss ways to address the latter through forward fitting with 3D models.

10:00 - 10:30 **Coffee Break**

1.3 Plenary 2: Connections to, and Reactions of, the Large-Scale Corona

Chair: Angelos Vourlidas

10:30 - 11:15: **Coronal restructuring on large-scales**

Manuela Temmer

11:15 - 11:30: **Connections between Active Region Subsurface Flows and Solar Flares**

Junwei Zhao,

This presentation summarizes our recent efforts in deriving solar interior flow fields by use of newly available SDO/HMI observations, and the study of connections between solar flares and subsurface flow fields. Solar subsurface flow fields are now routinely calculated by the HMI time-distance data-analysis pipeline, and readily available to world-wide users. Using these flow fields, we try to look for connections between flows beneath active regions and solar flares occurring in these regions. We analyzed the evolution of subsurface vorticity and kinetic helicity before and after some major solar flares, and found that some rapid change of kinetic helicity was often associated with solar flares. This demonstrates that the subsurface flow fields may contribute to the energy build-up that leads to solar flares.

11:30 - 12:45 **Lunch**

1.4 Plenary 3: Large-Scale Magnetic Connectivity of Active Regions

Chair: Frank Eparvier

12:45 - 13:30: **Large-Scale Magnetic Connectivity of Active Regions**

Karel Schrijver

The high-cadence, global view of the solar corona by the combined coverage with the SDO/AIA and STEREO/SECCHI instruments reveals an abundance of events that are widely separated in space while either overlapping in time or occurring in rapid succession. In particular, coronal mass ejections often appear to be composite events in which the assumption that there is a single, relatively compact source region is a misleading simplification. In many cases, sets of coronal events can be seen to be causally related, while in many other instances indirect evidence exists that is based either on global field models or inferred from the timing of repeating sets of near-synchronous events. We use a series of case studies to highlight the various coupling processes that include large-scale flows, flux dispersal, flux emergence, eruptions, and large-scale waves. The frequent occurrence of near-synchronous, apparently disjoint events within the global corona demonstrates that many coronal mass ejections involve multiple events within the coronal field, regardless whether their respective destablizations are causally connected. Understanding and quantifying the coupling of eruptive flares with destabilizations of the magnetic field in other active or quiet solar regions is crucial to the prediction of space weather resulting from coronal mass ejections, that will require high-quality global observations and advanced global modeling.

13:30 - 13:45: **Spectrally-resolved X-Ray and Extreme Ultraviolet Irradiance Variations during Solar Flares**

Tom Woods, SDO EVE Team

In spite of lower activity during solar cycle 24, there have been several episodes of intense and frequent solar storms during the Solar Dynamics Observatory (SDO) mission. Understanding the time variations of the hard X-ray (HXR), soft X-ray (SXR), and extreme ultraviolet (EUV) emissions can reveal the energy transfer throughout a solar flare event. The SXR and EUV irradiance observations by SDO EUV Variability Experiment (EVE), as enabled by 10 sec cadence and 0.1 nm spectral resolution in the 6-105 nm range, are providing new insights into flare energetics and dynamics over a broad range of corona, transition region, and chromosphere temperatures. Most of the EVE flare observations can be decomposed into four distinct characteristics. Firstly, the emissions that dominate during the flares impulsive phase are the transition region emissions, such as the He II 30.4 nm. Secondly, the hot coronal emissions above 5 MK dominate during the gradual phase and are highly correlated with the GOES X-ray. A third flare characteristic is coronal dimming, seen best in the cool coronal EUV emissions such as the Fe IX 17.1 nm. The coronal dimming appears to be related to coronal mass ejections (CMEs), thus representing a new way to possibly estimate CME events from SDO observations. As the post-flare loops reconnect and cool, many EUV coronal emissions peak a few minutes after the GOES X-ray peak. One interesting variation of the post-eruptive loop reconnection is that warm coronal emissions (e.g., Fe XVI 33.5 nm) sometimes exhibit a second large peak separated from the primary flare event by many minutes to hours, with EUV emission originating not from the original flare site and its immediate vicinity, but rather from a volume of higher loops. We refer to this second peak as the EUV late phase. The characterization of many flares during the SDO mission is provided, including quantification of the spectral irradiance from the coronal dimming and EUV late phase that cannot be inferred from GOES X-ray diagnostics.

13:45 - 14:00: **Global Energetics of Solar Eruptive Events**

Brian Dennis

1.5 Plenary 4: Transfer of Energy to, and Storage of Energy in, the Corona

Chair: Frank Eparvier

14:00 - 14:45: **Numerical Studies of the Transfer of Energy to, and Storage of Energy in, the Corona**

Mark Linton, James Leake, Peter Schuck

The source of the solar coronal magnetic field, and therefore of the energy released in flares and coronal mass ejections, comes from magnetic fields generated in or just below the solar convection zone. How this magnetic energy is transferred into and stored in the corona is a key question which must be studied if the magnetic activity of the corona is to be well understood. We will present a review of what numerical simulations of magnetic flux emergence tell us about how magnetic energy is transferred from the solar convection zone into the corona. We will focus on issues raised by these simulations, which show how difficult it can be to emerge flux from the photosphere through the intervening chromosphere into the corona. We will then review potential solutions to these issues, such as modeling three dimensional and arched field geometries, including chromospheric ion-neutral diffusion, and including the effects of convective turbulence. While such convection zone to corona simulations of flux emergence can tell us much about the dynamics of magnetic energy transfer into the corona, they cannot be used to reproduce the state of the true corona at any given time. We will therefore then focus our discussion on methods for modeling the actual corona, based on high cadence vector magnetogram observations of the photosphere such as those now being provided by SDO/HMI. These methods, varying from static models, such as nonlinear force free field extrapolations, to dynamical models, such as magnetofrictional or even full magnetohydrodynamical simulations, will allow one to simulate and analyze the coronal magnetic field and its energetic state, based on data driving photospheric observations. We will focus on the challenges each of these models face, review potential solutions to these issues, and discuss the future prospects for using these models to reproduce and study the magnetic and energetic state of the corona.

14:45 - 15:00: **Magnetic Point-Charge Modeling of the Transfer of Energy to, and Storage of Energy in, the Corona**

Richard Canfield, Maria Kazachenko

In flares and CMEs, free energy for energetic particles, thermal and non-thermal radiation, and large-scale mass motions is stored in stressed current-carrying magnetic fields within the corona, and the free energy is converted into radiation and mass motion (large-scale flows and energetic particles) by processes associated with magnetic reconnection. Hence, it is imperative to model this storage and release of energy by specifically treating magnetic topology, in order to determine how much free energy is accessible through reconnection, and how much is not. Observations of the emergence of magnetic flux through the photosphere compellingly demonstrate the transfer of free energy and helicity into the corona. This flux is fragmented on scales from sunspots down to the smallest observable features, which suggests representation of photospheric magnetogram sequences using moving magnetic point charges. In the last few years, local correlation tracking and point-charge modeling have been applied to a small number of major eruptive flare events using the Minimum Current Corona model (Longcope 1996), which quantifies the magnetic free energy that is stored on magnetic separators, and hence is accessible to release via magnetic reconnection. Quantitative comparisons of the predictions of the MCC model to estimated flare energy loss through radiation, conduction, and enthalpy flux (Kazachenko et al 2012) suggest that the MCC model captures the most important mechanisms for flare energy and CME helicity transfer to, and storage in, the corona. However, these comparisons also imply that for such major events 1) the time frame for which energy emergence must be tracked is a serious observational challenge and (2) a more sophisticated treatment of the energetics is needed for events to which the MCC can be applied.

15:30 - 16:00 **Coffee Break**

1.6 Plenary 5: Bob Lin and his Vision for Solar Physics

Chair: Gerry Share

16:00: *Gerry Share*
16:10: *Hugh Hudson*
16:25: *Gordon Holman*
16:35: *Nicole Vilmer*
16:45: *Gordon Hurford*
16:55: *David Smith*
17:05: *Dick Mewaldt*
17:25: *Albert Shih*

2 Thursday Session 1: 08:30 - 10:00

2.1 Working group 1: Energy Transfer: Electron Acceleration

Marina Overlook (Business Center)

08:30: **Non-thermal electron rate at loop-top and foot-point sources of solar flares: implications for electron acceleration**

Paulo Simoes, Eduard Kontar

Spatially resolved observations of solar flares often demonstrate the presence well separated sources of bremsstrahlung emission, so-called coronal and foot-point sources. The interrelation of hard X-ray emitting sources and the underlying physics of electron acceleration and transport presents one of the major questions in the high energy solar flare physics. Using spatially resolved X-ray observations by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) and recently improved imaging techniques, we investigate in detail the electron distributions in a few well observed solar flares. The selected flares can be interpreted as having a standard geometry with chromospheric sources (Hard X-ray (HXR) footpoints) related to thick-target X-ray emission, while the coronal sources are normally characterized by a combination of thermal and thin-target bremsstrahlung. Using imaging spectroscopy technique, we deduce the characteristic electron rates and spectral indices required to explain the coronal and foot-points X-ray sources. We found that, during the impulsive phase, the electron rate for energies above 20 keV is a few times higher at the loop-top than at the foot-points. We discuss these results in terms of magnetic trapping, pitch-angle scattering and injection properties. The results are consistent with the electron acceleration source approximately co-spatial with the thermal source and subsequent electron transport towards the chromosphere. These findings put strong constraints on the particles transport for the models of particle acceleration requiring faster acceleration rate than scattering.

08:50: **Quasi-periodic Emission and Time delay at the Footpoints of a Solar Flare**

Gan, W .Q., Li, Y. P.

Using both NORH and RHESSI data, we analyzed the quasi-periodic emissions at the footpoints of the flare on 2005 August 22. The phase difference and time delay among 17 GHz, 34 GHz, and 25-50 keV are spatially compared. The explanations to the results are discussed.

09:10: **Combining X-ray and Radio to diagnose spatial aspects of flare acceleration regions**

Hamish Reid, Nicole Vilmer, Eduard Kontar

For a variety of solar flares, we have used X-ray and radio wavelengths to infer properties about accelerated electron beams. We then use these properties to deduce the spatial characteristics of solar flare acceleration regions. Events are found from the RHESSI flare catalogue and the Phoenix 2 catalogue of type III bursts. We use events where the X-ray and radio emission overlap in time. We find that some events show a very good anti-correlation between the X-ray spectral index and the starting frequency of the type III burst. Through a derived analytical relation we can then constrain the distance an electron beam must travel before it becomes unstable to the generation of Langmuir waves. Assuming a background density model we can then infer both the height and vertical extent of a variety of different solar flare acceleration regions. We also use images from RHESSI and the Nançay Radioheliograph to check the spatial connection between the two wavelengths.

09:30: **Particle Acceleration and Plasma Heating in Bi-directional Reconnection Outflows Revealed by SDO/AIA and RHESSI Observations**

Wei Liu, Qingrong Chen, Vahé Petrosian

Magnetic reconnection is widely believed to be the primary energy release mechanism during solar flares, but how and where the released energy is transformed to heat the plasma and accelerate particles remain unclear. In a recent M-class flare occurring on the limb, SDO/AIA observed cusp-shaped flare loops. Bi-directional plasma blobs (plasmoids) are ejected from the cusp upward and downward at typical velocities of 200-500 and 100-200 km/s, respectively. Downward contracting loops, with initial velocities up to 900 km/s, rapidly descend and decelerate to 5 km/s throughout the course of the flare. The bi-directional plasmoids and contracting loops are evidence of reconnection outflows at Alfvenic velocities. RHESSI X-ray sources appear both below and above the cusp with higher energy emission approaching each other, further suggestive of a reconnection site near the cusp between those sources. We find that the brightest X-ray and Nobeyama microwave emissions are always associated with these contracting loops, far below their original heights near the presumed reconnection site. This suggests that the primary locus of particle acceleration and plasma heating is in the reconnection outflow region, rather than the reconnection site itself. This conclusion supports acceleration mechanisms associated with reconnection outflows by, e.g., stochastic turbulence, MHD shocks, and/or collapsing traps (betatron), but does not favor other mechanisms including acceleration by the DC electric field within the reconnection region.

10:00 - 10:30 **Coffee Break**

2.2 Working group 2: Achievements and Goals

Caspian Tern (4th floor)

08:30: **Achievements**

Gordon Emslie

09:15: **Goals**

Brian Dennis

10:00 - 10:30 **Coffee Break**

2.3 Working group 3: Flare Signatures from the lower atmosphere

Golden Eagle (Business Center)

08:30: **Characterization of white light, SXR and HXR kernels emissions in white light flares observed by SDO/HMI and RHESSI.**

Juan S. Castellanos-Duran, Julian D. Alvarado-Gomez, Juan C. Martinez Oliveros, Juan C. Buitrago-Casas, Benjamin Calvo-Mozo.

Solar Fares are explosive processes in the solar atmosphere due to the sudden release of magnetic energy. They are characterized by brightness increases in the optical- and radio-wavelengths, movement of vast amounts of solar mass, generation of X-rays and (gamma)-rays and also, of cosmic rays. In particular, some solar flares show an increase in white-light emission as was shown by Carrington in 1859. We analyzed the white light emission and its correlation with X-rays (soft and hard) kernels using SDO/HMI and RHESSI data. We restrict our analysis to flares which have a GOES classification larger than M 1.0, in the period between 1 October 2010 and 31 July 2012.

09:00: **He I D3 Emissions And Black-Light Flares**

Chang Liu, Yan Xu, Na Deng, and Haimin Wang

Distinct from the Halpha line with a wide sensitivity to the chromosphere, the D3 line at 5876 Å, the strongest He line in the visible spectrum, shows a unique response often better for discriminating high-energy phenomena. The only high-resolution helium observations were taken in D3 at Big Bear Solar Observatory (BBSO) and recorded on films. Part of these film data have recently been digitized, which allows a detailed study of the historic D3 observations. Our main interest lies in the rarely observed, so-called black-light flares (BLFs), which show "negative intensity" or dark features in contrast to brightenings in ordinary flares. The first imaging evidence of BLFs was presented by Zirin (1980) using BBSO D3 observations for an M8 flare on 1978 July 10, in which a shell-like D3 source first darkened before the subsequent brightening. Here we present another prominent D3 BLF on 1984 May 22. This M6 flare begins with darkening and then brightening in a region presumably above the magnetic neutral line, and the emission subsequently grows to become a ridge-like structure. Meanwhile, a bright kernel starts to be seen at the edge of the main sunspot umbra. Both the bright ridge and kernel features in D3 further extend in the same direction, and apparently evolve into two long dark ribbons mirroring the two long bright ribbons in Hα. We discuss the implications of these observations for understanding the characteristics and process of the flare.

09:30: **Small-scale photospheric magnetic fields in solar flares**

Mykola Gordovskyy, Vsevolod Lozitsky

Magnetographic observations suggest that photospheric magnetic field is very inhomogeneous at sub-telescopic scale (<1 arcsec) with intense magnetic fluxtubes embedded into a weak ambient field. In the present study we examine the magnetic field in flaring photosphere using echelle spectra with high spectral resolution. This is done by comparing magnetic field strengths measured using different spectral lines as well as by examining the fine structure of I+/-V Stokes profiles. Analysis of synthetic spectral line profiles allows to estimate the strength of different field components. In addition, we discuss implications of sub-telescopic magnetic field structure for magnetographic measurements.

10:00 - 10:30 **Coffee Break**

2.4 Working group 4: Flare Energetics

Pelican (Business Center)

08:30: **CME-flare relationship**

Astrid Veronig, S. Berkebile-Stoiser, B. M. Bein, M. Temmer

We investigate the relationship between the main acceleration phase of coronal mass ejections (CMEs) observed by STEREO and the particle acceleration in the associated flares observed by RHESSI. Both the CME peak velocity and CME peak acceleration yield distinct correlations with various parameters characterizing the flare-accelerated electron spectra. The highest correlation coefficient is obtained for the relation of the CME peak velocity and the total energy in accelerated electrons (c = 0.85). Flares with hard electron spectra tend to be associated with CMEs erupting at low coronal heights, i.e., in regions of stronger magnetic fields (c = -0.8). As for the relative timing, we find that the flare hard X-ray peaks occur well synchronized with the peak of the CME acceleration profile (in 75% of the cases they occur within $\pm$5 min). In 80% of the events under study, the non-thermal flare emission starts after the CME acceleration (on average 6 min), which corresponds to a mean current sheet length at the onset of magnetic reconnection of 21 $\pm$ 7 Mm. Our findings provide evidence for a tight coupling of the CME dynamics and the particle acceleration in the associated flare in impulsive events, with the total energy in accelerated electrons being closely correlated with the peak velocity (and thus the kinetic energy) of the CME, whereas the number of electrons accelerated to high energies is decisively related to the CME peak acceleration and the height of the pre-eruptive structure.

08:55: **Observations of a Plasmoid-Looptop Collision and Resulting Particle Acceleration During CME Initiation**

Ryan Milligan, James McAteer, Brian Dennis, Alex Young

There have been an increased number of studies recently which combine RHESSI observations with those from coronal imaging instruments to investigate the intimate relationship between solar flares and and their associated CMEs. The standard flare model states that the primary release of energy occurs when magnetic field lines converge and reconnect along a current sheet in the corona, thereby accelerating both the CME and in situ particles. In some cases multiple reconnection sites can develop resulting in the formation of plasmoids, or 'magnetic islands', along the current sheet. In this talk I will present observations of the first downward-moving plasmoid observed by RHESSI, which occurred during the acceleration phase of the associated CME as observed by STEREO. As the plasmoid collided with the top of the underlying flare loop, enhanced HXR and radio emission was detected signaling that additional particle acceleration took place. The study of these kinds of events can reveal important details on the flare-CME relationship and the associated energy release processes.

09:20: **The Magnetic Nature of a Homologous Eruption Series with Coronal Null**

Xudong Sun, Todd Hoeksema, Yang Liu, Qingrong Chen, Keiji Hayashi

We study several homologous non-radial eruptions from NOAA active region (AR) 11158 that are strongly modulated by the local magnetic field as observed with the Solar Dynamic Observatory. A small bipole emerged in the sunspot complex and subsequently created a quadrupolar flux system. Nonlinear force-free field extrapolation from vector magnetograms reveals its energetic nature: the fast-shearing bipole accumulated about 2e31 erg free energy (10% of AR total) over just one day despite its relatively small magnetic flux (5% of AR total). During the eruption, the ejected plasma followed a highly inclined trajectory, over 60 degrees with respect to the radial direction, forming a jet-like, inverted-Y-shaped structure in its wake. Field extrapolation suggests complicated magnetic connectivity with a coronal null point, which is favorable of reconnection between different flux components in the quadrupolar system. Indeed, multiple pairs of flare ribbons brightened simultaneously, and coronal reconnection signatures appeared near the inferred null. Part of the magnetic setting resembles that of a blowout-type jet; the observed inverted-Y structure likely outlines the open field lines along the separatrix surface. Owing to the asymmetrical photospheric flux distribution, the confining magnetic pressure decreases much faster horizontally than upward. This special field geometry likely guided the non-radial eruption during its initial stage.

09:45: *Discussion*

10:00 - 10:30 **Coffee Break**

2.5 Working group 5: Shocks

Avocet (Business Center)

08:30: **On the dynamics of shocks in the solar corona - Insights from MHD simulations**

Jens Pomoell, Rami Vainio

The nature of shock waves in the solar corona is a key topic in our effort to understand the physics behind eruption-associated phenomena such as solar energetic particle (SEP) events, EUV waves and metric type II radio bursts. The task at hand is, however, made complicated by the fact that many of the parameters needed in order to test current theories of the phenomena are generally not directly attainable from observations. For instance, in order to assess the viability of diffusive shock acceleration of ions at shocks driven by coronal mass ejections (CMEs) as a mechanism to explain gradual SEP events, a detailed knowledge of the compression ratio and obliquity angle of the shock as a function of time would be needed. A viable path to overcome this difficulty is to construct numerical models capable of simulating the coronal dynamics. Embarking on such a journey, we have employed magnetohydrodynamic (MHD) simulations to study the dynamics of shocks in various solar coronal environments caused by the on-set of a CME. The results show that a dynamically intricate global shock front degenerating to a fast-mode MHD wave towards the surface of the Sun is an essential and natural part of the eruption complex that plays a key role in the generation of eruption-related transient phenomena. For instance, the close resemblance between the on-disk signatures produced by the fast-mode wave and EUV waves suggest a wave interpretation of the latter. This implies that observations of EUV waves can serve as important diagnostics for the magnetic connections between coronal shocks and the observer at 1 AU. The simulations also reveal that a highly non-trivial evolution of the shock properties on coronal field lines occurs even for simple coronal conditions, highlighting the need for more sophisticated models of particle acceleration than generally used so far.

08:55: **Global Numerical Modeling of SEP Acceleration by a CME in the Solar Corona and Transport to 1 AU**

Kamen A. Kozarev, Rebekah M. Evans, Nathan A. Schwadron, Maher A. Dayeh, Merav Opher, Bart van der Holst

Solar energetic particles (SEP) may gain most of their energy at coronal mass ejections (CMEs) relatively close to the Sun. Rapid changes occur in the ejected plasma structures and there is a great abundance of charged seed particles close to the Sun relative to the interplanetary populations. However, the details of the acceleration process have remained largely hidden due to the lack of in situ observations in the corona. As the next generation of solar exploratory missions (Solar Probe Plus and Solar Orbiter) gets ready to probe the plasma and particle conditions near the Sun directly, a better understanding of SEP acceleration processes in the corona is necessary. We have developed a comprehensive model for studying proton acceleration and global interplanetary transport. It consists of a three-dimensional magnetohydrodynamics (MHD) model of the solar corona and interplanetary space (part of the Space Weather Modeling Framework), which we use to simulate the corona, solar wind, and a CME; and a global energetic particle acceleration and transport kinetic model (the Energetic Particle Radiation Environment Module), which uses the results from the MHD simulation to model the time-dependent behavior of protons. We show that a CME may efficiently accelerate suprathermal protons to hundreds of MeV energies during its transit between 2 and 8 solar radii. We find that the resulting SEP spectra vary greatly depending on the location of their guiding field lines relative to the shock and CME.

09:20: **On the Detection of Suprathermal Ions in the Solar Corona and their Role as Seeds for Solar Energetic Particle Production**

J. Martin Laming, J. Dan Moses, Yuan-Kuen Ko, Chee K. Ng, Cara Rakowski, Allan J. Tylka

Large Solar Energetic Particle (SEP) events associated with coronal mass ejections (CME) pose a major radiation hazard to space-borne instrumentation and astronauts, but their intensities are difficult to predict, spanning 3 orders of magnitude at any given shock speed of the CME. Many lines of indirect evidence point to the pre-existence of suprathermal seed particles for injection into the acceleration process as a key ingredient limiting the SEP intensity of a given event. This talk will outline the observational and theoretical basis for the belief that a suprathermal particle population is present prior to large SEP events, explores various scenarios for generating seed particles and their observational signatures, and explains how such suprathermals could be detected through spectroscopic measurements of the wings of the H I Ly-α line.

09:45: *Discussion*

10:00 - 10:30 **Coffee Break**

2.6 Working group 6: Flows vs Waves; Does it Matter?

Northern Harrier (4th floor)

09:00** *(note later start time)* **Hi-C observations of small scale dynamics: antiparallel flows**

Robert Walsh, Caroline Alexander, Jonathan Cirtain

On 11th July 2012, the High Resolution Coronal Imager (Hi-C) flew on a NASA sounding rocket. During this brief flight, the telescope captured 620 seconds of 193 Angstrom data at a cadence of approximately 5 seconds and with a spatial resolution near five times better than NASA's SDO AIA. Hi-C focused on a large active region on the Sun near sunspot NOAA 1520 located close to the center of the solar disc. One important issue concerning structures observed in coronal lines is whether we have up to now resolved the fundamental scales relating to their basic properties. We will show examples of small scale dynamics along features observed at Hi-C resolving scales and examine the possible origin of these "flows". The amalagamation of these individual strands as viewed at coarser resolutions will be shown. In particular, the presence of antiparallel flows on neighbouring strands at the highest spatial scale will be demonstrated.

09:20: **High Resolution Mass Flows in the Solar Corona as seen by the High Resolution Coronal (HI-C) Imager Sounding Rocket**

Kelly Korreck, Hi-C Team

We examine plumes and outflows (or waves) in the high resolution (0.2 arcsecond) Hi-C Rocket data. Recent work by Tian et al. described the ubiquitous nature of the plume-like structures over the solar disk. The five minutes of Hi-C flight data shows evidence of this. Comparing the Hi-C data to that of XRT and AIA, we discuss the various parameters seen in the flows and implications for the need for high resolution, high cadence observations to aid in the waves/flows determinations.

09:40: **Coronal outflows from active region boundaries and CME-induced dimming regions**

Hui Tian, Scott W. McIntosh

X-ray and EUV imaging observations often reveal high-speed (100 km/s) quasi-periodic propagating disturbances (PDs) along the fan-like structures at edges of active regions. Meanwhile EUV spectroscopic observations of active region boundaries usually reveal a blue shift of the order of 20 km/s and no periodicity. We think that the key to solve these discrepancies is the asymmetry of the emission line profile. The ubiquitous presence of blueward asymmetries of EUV emission line profiles suggests at least two emission components: a primary component accounting for the background coronal emission and a weak secondary component associated with high-speed (100 km/s) upflows. Through jointed imaging and spectroscopic observations, we have demonstrated that the PDs are responsible for the secondary component of line profiles and suggested that they may be an efficient means to provide heated mass into the corona and solar wind. The intermittent nature of these high-speed outflows (fine-scale jets) suggests that the mass supply to the corona and solar wind is episodic rather than continuous. Similar spectroscopic signatures have also been found in CME-induced dimming regions, suggesting high-speed outflows or possible solar wind streams from dimming regions. It is unclear whether these outflows can impact the kinematics of the associated CMEs or not.

10:00 - 10:30 **Coffee Break**

2.7 Working group 7: How much particle acceleration occurs in nanoflares

American Kestrel (4th floor)

08:30: **Introduction**

Iain Hannah & Nicoleen Viall

09:00: **Particle Acceleration Versus Direct Heating in Nanoflares**

James Klimchuk,

It is traditionally assumed that all of the magnetic energy released during nanoflares causes direct heating of the plasma, yet there is no reason to rule out the possibility that much of the energy accelerates particles, as in a full-scale flare or microflare. The evolution of the loop plasma (variation of temperature and density with time) can vary substantially depending on the relative amounts of particle acceleration and direct heating. This affects observed quantities that are based on the differential emission measure distribution, such as the ratio of intensities detected by spectrometers or broad-band imagers. I will describe these differences and hopefully initiate a discussion of how we might determine, or place upper limits on, the particle acceleration in nanoflares.

09:30: **The Focusing Optics X-ray Solar Imager (FOXSI)**

Steven Christe

10:00 - 10:30 **Coffee Break**

3 Thursday Session 2: 10:30 - 12:00

3.1 Working group 1: Energy Transfer: Electron Acceleration continued

Marina Overlook (Business Center)

10:30: **Determination of Fermi Acceleration Model Characteristics and Application to RHESSI Solar Flare Observations**

Qingrong Chen, Vahe Petrosian

Fermi processes by plasma wave turbulence and shocks through resonant wave-particle interactions lead to efficient acceleration of particles in many astrophysical circumstances. Here we demonstrate that, under the quasilinear theory and given the volume-averaged spectra of the accelerated particles and escaping particles from the accelerator that are inferred from observations, one can derive the energy dependence of the escape time, pitch-angle scattering rate, and energy diffusion and acceleration rates of particles by turbulence in the accelerator. Such direct and non-parametric inversion of the turbulence acceleration and scattering processes has considerable advantage over conventional forward-fitting methods. In particular, we apply the method to solar flare suprathermal electrons, which produce bremsstrahlung hard X-ray emission along the flare loop, in many cases mostly at the looptop and thick-target footpoints. We present results obtained from analysis of a few outstanding RHESSI flare events based on either the regularized electron or the traditional hard X-ray imaging spectroscopy. We further discuss the implication of the results to theoretical models of stochastic Fermi acceleration of particles by turbulence. We will also briefly discuss potential application of the method to particle acceleration by shocks in supernova remnants.

10:50: **Model selection for energy loss rate and injection mechanisms by means of electron maps and electron continuity equation.**

Gabriele Torre, Nicola Pinamonti, A. Gordon Emslie, Jingnan Guo, Anna Maria Massone, Michele Piana, Anna Codispoti

We apply the electron continuity equation to electron maps of extended solar flare sources deduced from RHESSI hard X-ray visibilities. We study the consistency of this framework with respect to different models for the energy loss rate and for the injection term describing the way electrons are injected into the emission region. In particular, we show that accounting for return currents notably increases the reliability of the fitting process.

11:10: **Properties Of The Acceleration Regions In Loop-Structured Solar Flares**

Jingnan Guo, A. Gordon, Emslie, Michele Piana

Using RHESSI hard X-ray imaging spectroscopy observations, we analyze electron flux maps for a number of extended coronal loop flares. For each event, we fit a collisional model with an extended acceleration region (either tenuous or dense) to the observed variation of loop length with electron energy E, resulting in estimates of the plasma density in, and longitudinal extent of, the acceleration region. These quantities in turn allow inference of the number of particles within the acceleration region and hence the filling factor f, the ratio of the emitting volume to the volume that encompasses the emitting region(s). Further, coupling information on the number of particles in the acceleration region with information on the total rate of acceleration of particles above a certain reference energy (obtained from spatially-integrated hard X-ray data) also allows inference of the specific acceleration rate (electrons s^{-1}) per ambient electron). A comparison of the results obtained from the tenuous model and the dense model suggests that in some flares, as expected, the dense model provides more consistent explanations of the acceleration processes; however in other flares the tenuous model fits the data better. We explain this by pointing out that the tenuous acceleration model, although at first sight an artificially simple construct, is actually a good approximation of a model on which the loop density increases from the looptop towards the footpoints.

11:30: *Discussion*

12:00 - 1:30 **Lunch**

3.2 Working group 2: Flare Energies

Caspian Tern (4th floor)

10:30: **The Thermal Properties Of Solar Flares Over Three Solar Cycles Using Goes X-Ray Observations**

Daniel Ryan, Ryan Milligan, Peter Gallagher, Brian Dennis, Kim Tolbert, Richard Schwartz, Alex Young

Solar flare X-ray emission results from rapidly increasing temperatures and emission measures in flaring active region loops. Since the mid-1970s, observations from the X-Ray Sensor (XRS) onboard the Geostationary Operational Environmental Satellite (GOES) have been used to derive these properties making it an ideal instrument for conducting large-scale statistical studies. Although such studies are vital for determining the characteristic behavior of solar flares, they have been limited by a number of factors, including the lack of a consistent background subtraction method capable of being automatically applied to large numbers of flares. In this talk, we describe an automated temperature and emission measure-based background subtraction method (TEBBS), which aims to make large-scale statistical studies easier and more accurate. Our algorithm ensures that the derived temperature is always greater than the instrumental limit and pre-flare background temperature, and that the temperature and emission measure are increasing during the flare rise phase, thus preserving the characteristic evolution of those properties. TEBBS was successfully applied to over 50,000 solar flares occurring over nearly three solar cycles (1980-2007), and used to create an extensive catalog of the solar flare thermal properties. We found that TEBBS performed more suitable background subtractions than more naive methods. In doing so, we confirmed that the peak emission measure and total radiative losses scale with background subtracted GOES X-ray flux as power-laws, while the peak temperature scales logarithmically. The TEBBS catalog is publicly available on SolarMonitor.org/TEBBS/.

10:50: **Turbulent plasma energies in flares**

Kenneth J. H. Phillips,

A well-known phenomenon at the flare onset, coincident in time with the impulsive phase seen in hard X-rays and cm-wave radio wavelengths, is the broadening of soft X-ray lines, commonly attributed to turbulence. If this is truly plasma turbulence, it is important to estimate its energy to see if it is an important contributor to the total flare energy budget. I will give new estimates based on archived Yohkoh BCS data for some flares which could be provided for flares to be discussed in WG2. These estimates will be compared with thermal energies. I will also discuss the nature of the line broadening, including other possible mechanisms, and why the line broadening decreases after the flare impulsive phase but never seems to reach zero in the later thermal stages of flares.

11:10: **Particle acceleration and MHD turbulence energetics in flares**

Eduard Kontar

Many solar flare models require presence of plasma turbulence which can effectively accelerate or scatter energetic particles. However, there is little or next to nothing known about MHD turbulence in the solar flares. Using the older and recent observations I will discuss the evidences and estimates for the MHD turbulence level. The energetics of MHD turbulence, which is currently missing from the flare energy budgets, will be addressed.

11:30: *Discussion*

12:00 - 1:30 **Lunch**

3.3 Working group 3: Interactions between corona and chromosphere

Golden Eagle (Business Center)

10:30: **Chromospheric and coronal plasma parameters in a white light solar flare measured with RHESSI and SDO/AIA**

Marina Battaglia, Eduard P. Kontar

We present combined RHESSI and AIA observations of the coronal and chromospheric plasma parameters during a white light limb flare as a function of height above the photosphere. RHESSI soft X-ray images and spectra provide the emission measure, temperature, and density of the coronal source while the chromospheric density is found using RHESSI visibility analysis of the hard X-ray footpoints. A regularized inversion technique is applied to AIA images of the flare to find the differential emission measure DEM(T) along the loop. Such combination of RHESSI and simultaneous SDO/AIA observations makes it possible for the first time to determine the density, temperature, and emission profile of the solar atmosphere during a flare, using two independent methods. The observations suggest that the density in the loop leg decreases with increasing height. The hottest plasma is found near the coronal loop top source while the temperature along the legs of the loop is constant within uncertainties.

10:50: **Tracing Transient Chromospheric Features in Flare Eruptions**

Michael Kirk, Jason Jackiewicz, R. T. James McAteer

Erupting chromospheric flares are connected to the adjacent solar atmosphere through magnetic field lines. Observing these dynamic features at multiple heights and temperatures creates a more complete picture of the origin and evolution of flares. To make these multi-layer observations, ground-based and space-based images need to be analyzed simultaneously. We utilize an automated technique for identifying and tracking chromospheric bright features embedded in and adjacent to eruptions. The meta-data produced in this tracking process is then culled using complementary data to isolate trends and anomalies in chromospheric eruptions. We employ ground-based H-α images and extend these detections vertically into the corona and photosphere by pairing them with complementary AIA images and HMI magnetograms. Through a multi-instrument, multi-layer approach to automated analysis, we are able to constrain the origin of eruptions and postulate an evolution of flares from the chromosphere through the corona.

11:10: **The influence of coronal emission lines on prominence plasma**

Gerrard Brown, Nicolas Labrosse, Lyndsay Fletcher

Prominences, also known as filaments, are cool, high density structures located in the corona. They are influenced by the corona due to the coronal radiation illuminating these structures. Several strong emission lines are found in the coronal spectrum, and the impact of these lines on the radiative transfer processes of the prominence is examined. A one dimensional model is used to model the radiative transfer processes of the prominence. Previous modelling did not include the coronal lines. In this talk work is presented on adding the influence of coronal emission lines to a prominence. These additional lines affect the ionisation degree and level populations of the prominence plasma and so the intensity of the emitted hydrogen lines and the prominence radiative energy budget.

11:30: *Discussion*

12:00 - 1:30 **Lunch**

3.4 Working group 4: Radio Signatures

Pelican (Business Center)

10:30: **Radio imaging of synchrotron emission associated with a CME on the 14th of August 2010**

Hazel Bain, Sam Krucker, Claire Raftery, Pascal Saint-Hilaire

Radio observations can be used to identify sources of electron acceleration within flares and CMEs. In a small number of events, radio imaging has revealed the presence of synchrotron emission from nonthermal electrons in the expanding loops of the CME (Bastian et al. (2001), Maia et al. (2007) and (mathrmDacuteemoulin) et al. (2012)). Events in which the synchrotron emission is sufficiently bright to be identified in the presence of plasma emission from radio bursts, which are prevalent at meter wavelengths, are infrequent. Using radio images from the Nancay Radioheliograph (NRH) we present observations of synchrotron emission associated with a CME which occurred on the 14th of August 2010. Using context observations from the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory, the SWAP instrument onboard Proba2, the LASCO coronograph onboard SOHO and the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI), we follow the propagation of the CME out to 2-3 solar radii and characterize the associated electron distribution. We find that the synchrotron emission is cospatial with the CME core.

10:55: **Break-out reconnection observed in meter wave radio emission**

Henry Aurass, G. Holman

Based on combined radio spectroscopy and imaging, in the last years several papers were published on the significance of meter wave radio emission for tracing activated magnetic connections in the complex structures of the coronal magnetic field. Minor energy release accelerating a small amount of electrons may indicate coronal break-out reconnection. We describe this effect for two different X-class flares - one on the disk, the other at the limb - and find a surprising amount of coincidence. Faint radio features in space and time are highly reminiscent with each other and well in phase with the hard X-ray flare in both (different) active regions.

11:20: **Radio Evidence for Breakout Reconnection in the 2003 November 3 Solar Eruptive Event**

Gordon Holman, Henry Aurass

Breakout reconnection resulting from the interaction of a developing magnetic arcade and flux rope with overlying magnetic field is an integral part of many numerical simulations of solar eruptive events. While considerable progress has been made in identifying and characterizing the reconnection region above the flare arcade and below the erupting flux rope (CME), breakout reconnection has been more difficult to identify. We present and discuss a combination of radio and X-ray observations that provide evidence for breakout reconnection, as well as for the vertical current sheet above the flare arcade, in the well-studied 2003 November 3 (09:49 UT) solar eruptive event.

11:45: *Discussion*

12:00 - 1:30 **Lunch**

3.5 Working group 5: Flares

Avocet (Business Center)

10:30: **On the role of slow-mode shocks in the reconnection region for generating energetic electrons during solar flares**

Gottfried Mann, Henry Aurass, Hakan Oenel, and Alexander Warmuth

A flare is a sudden enhancement of the emission of electromagnetic radiation of the Sun covering a broad range of the spectrum from the radio up to the gamma-ray range. That indicates the generation of energetic electrons during flares. Flares are a manifestation of magnetic reconnection. According to this model, the inflow region of the reconnection region is separated from the outflow one by pairs of slow-mode shocks. At these shocks magnetic field energy is efficiently transferred into a strong heating of the plasma in the outflow region. It is investigated in which way these slow-mode shocks are able to generate energetic electrons needed for the emission of hard X-ray radiation during flares. The slow-mode shocks are studied in terms of the Rankine-Hugoniot relationships. Especially, the jump of the temperature and the magnetic field across these shocks is evaluated to study the heating of the plasma in the outflow region. Due to the strong heating of the plasma at the slow-mode shocks, electrons with energies ¿ 30keV are generated in the outflow region. The theoretically obtained fluxes of energetic electrons agree well with those measured by RHESSI during X-class flares.

10:55: **A classification scheme for turbulent acceleration during solar flares**

Nicolas Bian, G. Emslie, E. Kontar

We establish a classification scheme for stochastic acceleration models involving low-frequency plasma turbulence in a strongly magnetized plasma. This classification takes into account both the properties of the accelerating electromagnetic field, and the nature of the transport of charged particles in the acceleration region. We group the acceleration processes as either resonant, non-resonant, or resonant-broadened, depending on whether the particle motion is free-streaming along the magnetic field, diffusive, or a combination of the two. Stochastic acceleration by moving magnetic mirrors and adiabatic compressions are addressed as illustrative examples. We obtain expressions for the momentum-dependent diffusion coefficient D(p), both for general forms of the accelerating force and for the situation when the electromagnetic force is wave-like, with a specified dispersion relation = (k).¿ Finally, for models considered, we calculate the energy-dependent acceleration time, a quantity that can be directly compared with observations of the time profile of the radiation field produced by the accelerated particles, such as those occurring during solar flares.

11:20: **Observational signatures of particle acceleration in reconnecting twisted coronal loops**

Mykola Gordovskyy, Eduard Kontar, Philippa Browning, Nicolas Bian

We examine magnetic reconnection and particle acceleration in twisted coronal loops. In this scenario, a potential field above a bipolar magnetic region is twisted by photospheric rotation, yielding an unstable, nearly force-free magnetic loop with strong field convergence near the foot-points. The ideal kink instability results in a drastic increase of the peak current density, leading to magnetic reconnection. The consequent appearance of a strong electric field with very fragmented structure results in particle acceleration distributed throughout the flaring loop (Gordovskyy & Browning 2011). This 3D time-dependent MHD model is employed to study proton and electron motion using the relativistic guiding-centre motion equations, taking into account Coulomb collisions (Gordovskyy et al. 2012). Based on the developed theoretical model, we derive spectral and spatial distribution of HXR emission and perform detailed comparison with the RHESSI data, with emphasis on the fine structure of HXR sources and their temporal evolution (Kontar et al. 2010). The results will be discussed, focusing on the effects of large-scale loop curvature (loop bending), atmospheric stratification and the choice of a non-uniform threshold for anomalous resistivity.

11:45: *Discussion*

12:00 - 1:30 **Lunch**

3.6 Working group 6: Flows vs Waves; Does it Matter?

Northern Harrier (4th floor)

10:30: **Enhanced Up-Flows Observed on the Solar Granules**

Gordon A. MacDonald, Johann Hirzberger, Sami Solanki, Debi Prasad Choudhary

This study is the result from a survey of 572 Enhanced Up-Flows (EUF) observed on granules in the solar photosphere using the Imaging Magnetograph eXperiment (IMaX) on board the Sunrise balloon-borne observatory. EUFs are features with line-of-sight (LOS) speeds in excess of 1.8 kms^{-1}. They occur in the bright centers of small decaying granules which do not fragment and on the bright edges of large granules which do fragment. The EUFs are most commonly found about 0.1 arcsec from the granule edge, towards granule center. The probability distributions of EUF area and lifetime give a mean area of 0.028 Mm^2 and mean lifetime of about 2.3 minutes, respectively. The maximum area an EUF grows to during its lifetime correlates strongly with the length of its lifetime. The similarities between these results and those found in various observations and numerical simulations of granular dynamics are discussed.

10:50: *Discussion*

12:00 - 1:30 **Lunch**

3.7 Working group 7: Observational signatures of nanoflares

American Kestrel (4th floor)

10:30: **Are there accelerated electrons in non-flaring active regions?**

Iain Hannah

RHESSIs hard X-ray (HXR) observations have shown that active region flares of all magnitudes, from A-class microflares to the largest X-class events, accelerate electrons. But are there accelerated electrons present in active regions when there are no flares? To try and determine the HXR spectrum of a non-flaring active region we use the offpointing technique (Hannah et al. 2007a) adopted for the RHESSI quiet Sun observations. This time-modulates the solar signal with predictable peaks twice per RHESSI rotation. For the quiet Sun periods no signal was detected and upper limits were placed on the HXR spectrum (Hannah et al. 2007b,2010). We repeat this analysis during off-pointing times with flaring and non-flaring active regions to determine whether a HXR signal is detectable.

11:00: **Investigating Nanoflare Heating by Comparing SDO/AIA Observations with Modeled Light Curves**

Nicholeen Viall, James Klimchuk

An important signature of nanoflare heated coronal plasma is the sudden appearance of the plasma at hot temperatures, followed by a comparatively slow cooling and draining phase. This is due to the impulsive nature of nanoflare heating and the heat conduction and mass exchange between the corona and chromosphere. Identifying such nanoflare signatures in active regions or the quiet Sun is complicated by the fact that the corona is optically thin: many thousands of flux tubes which are heated completely independently are contributing to the total emission along a given line of sight. One approach has been to analyze isolated features; however diffuse emission between isolated features and the emission from the quiet Sun are both crucial to understanding coronal heating. In this study we move beyond isolated features and analyze all of the emission in an entire active region and quiet Sun area. We investigate SDO/AIA light curves, systematically identifying nanoflare signatures. We compare the observations with a model of the corona as a line-of-sight integration of many thousands of completely independently heated flux tubes. We consider that the emission from these flux tubes may be due exclusively to impulsive nanoflare bursts, it may be due to quasi-steady heating, or a mix of both, depending on the cadence of heat release. We demonstrate that despite the superposition of randomly heated flux tubes, different distributions of nanoflare cadences produce distinct signatures in light curves observed with multi-wavelength and high time cadence data, such as those from SDO/AIA. We discuss the quiet Sun and active region emission in the context of these predicted nanoflare signatures.

11:30: **Nanoflare heating in multi-stranded loops: reproducing observed red and blue-shifts**

Robert Walsh, Stephane Regnier

Hinode EIS has revealed a broad distribution of red and blue doppler-shifts in active regions; red predominantly near the core, blue near the edges. Another significant observation demonstrates that the distribution of dopplershifts depends on the peak formation temperature of formation of the spectral lines. A nanoflare heated, multi-strand model is employed to examine and reproduce observed dopplershifts. It is found that red-shifts/downflows dominate cool spectral lines (OV to Si VII) while blue-shifts/upflows dominate in hotter lines (from Fe XV to Ca XVII). When comparing spectral lines over a broad range of temperature, the ratio of blueshift to redshift gives an estimate of the coronal loop temperature. A typical EIS raster is modelled and the consequences of the temporal smearing of an evolving plasma structure on the resulting observations is examined.

12:00 - 1:30 **Lunch**

4 Thursday Session 3: 13:30 - 15:30

4.1 Working group 1: Joint WG1/WG3: Beam Propagation

Blue Heron Ballroom

13:30: **The effects of density gradients on Langmuir waves and electron beam propagation**

Heather Ratcliffe, Nicolas H Bian, Eduard P Kontar

The number and energy of electrons in a flare accelerated beam may be estimated from the hard X-rays (HXR) they emit using the collisional thick target model, which assumes the emitting electrons are modified only by collisions. However the Langmuir waves produced by the beam are strongly affected by density gradients, and so these are an important factor. We consider the treatment of Langmuir wave evolution in a plasma with long length-scale density fluctuations using a diffusive approximation, and calculate the diffusion coefficients. We use 1-D simulations to follow the time-evolution of the Langmuir waves and the subsequent effects on the electron beam for a broad range of beam and plasma parameters, and find a significant acceleration effect on the electrons, increasing the number at high energies in the time-integrated distribution. This effect may therefore be important in the interpretation of HXR observations of non-thermal electrons, as the increased number of electrons at high energies could lead to an overestimate of the total number and energy of the originally accelerated electrons.

13:50: **A Thick-Target Interpretation of Downward-Moving Hard X-ray Sources**

Aidan O'Flannagain, Peter Gallagher, John Brown, Ryan Milligan, Gordon Holman

Solar flare hard X-rays (HXR) are thought to be produced by nonthermally accelerated electrons braking in the dense chromosphere, with strong evidence that the release of energy required occurring high in the corona. However, the mechanism by which this energy is transferred to the chromosphere, and where acceleration occurs, remains unclear. Many competing models have been put forward to explain this missing link in flare initiation, such as beamed electrons and the propagation of torsional Alfven waves. In this presentation, one such model known as the Collisional Thick Target Model (CTTM) is used to interpret a unique observation of an 'early impulsive flare', where apparently nonthermal HXR sources appear to descend to the chromosphere before the impulsive X-ray peak of the flare. Locations of peak HXR emission as observed by RHESSI are compared with CTTM predictions in order to verify whether this model can adequately explain how the distribution of HXR emission should evolve during this rarely observed phase of the flare. It is found that hardening of the injected electron spectrum at the corona is enough to cause this descent as per the CTTM, and it is suggested that early impulsive flares provide us with an important opportunity to compare predictions of the many different and contradictory energy transport models.

14:10: **How Lorentz force affects particles and how this is diagnosed in flares**

Valentina Zharkova, S.Zharkov, S. Matthews and L. Green

In this talk we will discuss the differences between MHD and full kinetic approaches with respect to magnetic reconnection and particle acceleration. In particular we will explore the effects of Lorentz force on particles in the both approaches and will trace the resulting disturbances throughout the whole atmosphere from the corona to the photosphere and the solar interior. In this respect we also explore possible agents delivering the energy and momentums to the solar photosphere and beneath and their possible implications for generation of seismic responses in a few recent flares observed with SDO.

14:30: *Discussion*

15:30 - 16:00 **Coffee Break**

4.2 Working group 2: Flare Ions

Caspian Tern (4th floor)

13:30: **Ion energetics in solar eruptive events**

Albert Shih

I'd like to talk about estimating the energy content in accelerated ions using RHESSI and/or Fermi/GBM. Past RHESSI events can have more constrained energy estimates by determining the ion spectral indices. Unfortunately, recent RHESSI observations will be hampered by limited gamma-ray sensitivity. Estimates for smaller events can be obtained by making use of the observed correlation between ions and relativistic electrons.

14:00: **Imaging Spectroscopy of Energetic Ions and the 2003 October 29 flare**

Nicole Duncan, Albert Shih, Gordon Hurford, Robert Lin

Flares are efficient particle accelerators; up to half the energy released during an eruption is transferred into energetic particles. This particle energy is roughly equipartitioned between ions and electrons. Since higher energy particles undergo interactions which yield fewer photons, RHESSI can only detect the bremsstrahlung of relativistic electrons and the rich gamma-ray line structure from ions in the largest of flares. HXR and gamma-ray flare analysis is typically limited by low count rates and high background. To date, RHESSI has resolved gamma-ray line spectra in only a small number of flares. From this small data set, it has been shown that there is a high correlation between the energy content in relativistic electrons and ions. This relationship makes relativistic electron observations a valuable tool when ion emission is difficult to observe. To characterize the role of energetic ions in flares it is necessary to expand the small set of these highly energetic flares. To extract spectra from flares that are obscured by high background counts, we employ the method of imaging spectroscopy. We examine the validity of extending the imaging spectroscopy method into this high energy regime by conducting a comparative study between imaging spectroscopy and traditional spectroscopy for all large gamma-ray line flares in the RHESSI catalog. After exploring the benefits and limitations of this method in the HXR/ gamma-ray regime, we use this method to analyze the energetics of the 2003 October 29 flare.

14:30: *Discussion*

15:30 - 16:00 **Coffee Break**

4.3 Working group 3: Joint WG1/WG3: Beam Propagation

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14:30: *Discussion*

15:30 - 16:00 **Coffee Break**

4.4 Working group 4: Radio Signatures continued/Instabilities and Initiation Signatures

Pelican (Business Center)

13:30: CME buid-up, shock formation: Contribution of EUV and radio imaging observations

Monique Pick

This presentation will discuss recent contributions of EUV and radio imaging observations to our understanding on the initiation and the fast development of CMEs in the low corona. We shall discuss more precisely i) how radio and EUV observations can trace the regions of CME interaction with the surrounding medium ii) the origin of the shocks.

13:55: On the nature of successive CMEs from the same active regions

Yuming Wang, Lijuan Liu, Caixia Chen, Chenglong Shen

A CME is a process of releasing a huge amount of free magnetic energy stored in the corona. Sufficient amount of free magnetic energy is a necessary condition for an active region (AR) to produce a CME. Our statistical study of waiting times of CMEs during 1998 - 1999 [Chen, Wang, et al., JGR, 116, A12108, 2011] reveals that successive CMEs from the same ARs tend to be produced at a pace of about 8 hours, and there were no two fast CMEs within 15 hours. Since the accumulation speed of free energy in the coronal magnetic field is typically longer than 8 hours, our results suggest that, for a group of successive CMEs, (1) the free energy they required is not newly injected, and (2) except the first CME, all the other CMEs should be caused due to the instability triggered by the preceding ones. Now the study is being extended to all the super-ARs in the last solar cycle, and a more robust result is expected to be obtained.

14:20: New insight into CME processes revealed by CoMP observations

Hui Tian, Scott W. McIntosh, S. Tomczyk, C. Bethge, L. Sitongia

CoMP measures not only the polarization of coronal emission, but also the full radiance profiles of coronal emission lines. For the first time, CoMP observations provide high-cadence image sequences of the coronal intensity, Doppler shift and line width simultaneously. The image sequence of Doppler shift can be used to infer information of the background coronal Alfven wave and magnetic field before and after solar eruptions. By studying the Doppler shift and line width we can also explore more of the physical processes at the onset of solar eruptions such as CMEs. Here we present a list of CMEs observed by CoMP. Our preliminary analysis shows that CMEs are usually associated with greatly increased Doppler shift and enhanced line width. The linear polarization in CMEs measured by CoMP has also been investigated. These new observations present not only valuable information to constrain CME models, but also a cheap and low-risk means of space weather forecasting.

14:45: **Solar Filaments As Indicators Of Cme Probability**

Boris Filippov

The onset of a CME is not preceded by any specific form of activity that could be recognized several days before the event. The cause of eruption is more likely in properties of coronal magnetic field equilibrium, possibly in the rapid growth of instability. The most probable initial magnetic configuration of a CME is a flux rope consisting of twisted field lines which fills the whole volume of the dark cavity stretched in the corona along the photospheric polarity inversion line. A coronal cavity is well recognized in coronal images only when its axis is directed along the line-of-sight; otherwise it is screened by surrounding bright coronal loops. Cold dense prominence matter accumulates in the lower parts of helical flux tubes, which serve as magnetic traps in the gravitation field. So, prominences and filaments are good tracers of the flux ropes in the corona long before the beginning of eruption. A twisted flux rope is held by the tension of field lines of photospheric sources until parameters of the system reach critical values and catastrophe happens. The flux rope height above the photosphere is one of these parameters and it is revealed by the height of the filament. There is a critical height in the given coronal magnetic field that the flux rope cannot exceed being in stable equilibrium. We found that many eruptive prominences were near the limit of stability a few days before eruptions. We believe that a comparison of the measured heights of filaments with the calculated critical heights could be a basis for predicting filament eruptions and following CMEs.

15:10: *Discussion*

15:30 - 16:00 **Coffee Break**

4.5 Working group 5: Flares continued

Avocet (Business Center)

13:30: **Stochastic Particle Acceleration in Nonpotential Magnetic Loops**

Gregory D. Fleishman, Igor N. Toptygin

Modern X-ray and radio observations favor a stochastic (Fermi) acceleration mechanism of fast particles produced in flares, which implies that an accelerating turbulence must somehow be generated by the primary flare energy release. We point out that the turbulence needed to drive the particle acceleration is generated in nonpotential, twisted magnetic structures, which results in nonzero kinetic helicity of the turbulence. This helicity, in its turn, produces a nonzero mean DC electric field on top of stochastic turbulent fields driving the main stochastic acceleration; thus, acceleration by helical turbulence combines properties of the standard stochastic acceleration with some features of acceleration in DC electric fields. We find that this induced large-scale DC electric field can be comparable with the electron and estimated effective ion Dreicer fields, which has an immediate effect on (runaway) charged particle extraction from the thermal pool. This particle runaway process, through formation of a seed particle population available for stochastic acceleration process, can control the thermal-to-nonthermal partition of the flare energy, which is known to vary strongly from event to event. To conclude, we discuss other useful properties of acceleration by helical turbulence, e.g., formation of electron beams, enrichment of the seed population by rare ions (e.g., He-3 rich events), and charge-dependent direction of particle diffusion (gamma-ray emission sites in flares).

13:55: **Loss Cone Evolution and Particle Escape In Collapsing Magnetic Trap Models**

Solmaz Eradat Oskoui, Thomas Neukirch

Collapsing Magnetic Traps (CMTs) have been suggested as one possible mechanism responsible for the acceleration of high-energy particles during solar flares. It has been predicted on the basis of simple CMT models that the majority of the particles should escape towards the end of the trap collapse. This, however, is not seen in the study of particle orbits in more sophisticated trap models, which show that in particular the highest-energy particles remain trapped at all times. It is shown that this apparent contradiction can be resolved by a comparison of the assumptions made in the different CMT models.

14:20: **Fragmentation cascade in the magnetic reconnection of solar flares**

Marian Karlicky, Miroslav Barta, Joerg Buchner

Magnetic field reconnection is now generally accepted as the key mechanism for energy release in solar flares and other eruptive events in astrophysical and space plasmas. However, direct application of magnetic-reconnection theory to the physics of solar flares (and other large-scale events) faces a crucial issue for a long time: All known micro-physical processes leading to the change of magnetic field topology (i.e. the reconnection) require very thin current sheets (10 m in the solar corona). On the other hand, the typical flare current-layer width, estimated either from observations or from the dimensional considerations, is about six orders of magnitude larger. It is thus clear that some mechanisms of consecutive fragmentation of the current density (and corresponding magnetic field) structure have to play a role. In this contribution we aim at identifying all such possible processes and studying some of them in more detail. In order to cover a large range of scales we use high-resolution MHD simulations combined with large-scale kinetic (PIC) modelling. Our recent research has shown that the cascade towards small scales is the result of mutual positive feedback between the Lorentz-force driven instabilities (such as tearing and the fragmenting coalescence), and their flow- and pressure-field driven counterparts (typically Kelvin-Helmholtz).

14:45: **Stochastic acceleration by multi-island contraction during turbulent magnetic reconnection**

Nicolas Bian, E.Kontar

The acceleration of charged particles in magnetized plasmas is considered during turbulent multi-island magnetic reconnection. The particle acceleration model is constructed for an ensemble of islands which produce adiabatic compression of the particles. The model takes into account the statistical fluctuations in the compression rate experienced by the particles during their transport in the acceleration region. The evolution of the particle distribution function is described as a simultaneous first and second-order Fermi acceleration process. The acceleration efficiency associated with the second-order process involves both the Eulerian properties of the compression field and the Lagrangian properties of the particles. The stochastic contribution to the acceleration is non-resonant and can dominate the systematic part in the case of a large variance in the compression rate. The model addresses the role of the second-order process, how the latter can be related to the large-scale turbulent transport of particles and explains some features of the numerical simulations of particle acceleration by multi-island contraction during magnetic reconnection.

15:10: *Discussion*

15:30 - 16:00 **Coffee Break**

4.6 Working group 6: Flows vs Waves; Does it Matter?

Northern Harrier (4th floor)

14:00** *(note later start time)*: **Propagating Disturbances in Coronal Loops: A Detailed Analysis of Propagation Speeds**

Greg Kiddie, Ineke De Moortel, Giulio Del Zanna, Scott McIntosh, Ian Whittaker

Quasi-periodic disturbances have been observed in the outer solar atmosphere for many years. Although first interpreted as upflows (Schrijver *et al.*, 1999) they have been widely regarded as slow magneto-acoustic waves, due to their observed velocities and periods. However, recent observations have questioned this interpretation, as periodic disturbances in Doppler velocity, line width, and profile asymmetry were found to be in phase with the intensity oscillations (De Pontieu and McIntosh, 2010, Tian, McIntosh, and De Pontieu, Astrophysics, J.Lett. (2011)), suggesting that the disturbances could be quasi-periodic upflows. Here we conduct a detailed analysis of the velocities of these disturbances across several wavelengths using the *Atmospheric Imaging Assembly* (AIA) onboard the *Solar Dynamics Observatory* (SDO). We analysed 41 examples, including both sunspot and non-sunspot regions of the Sun. We found that the velocities of propagating disturbances (PDs) located at sunspots are more likely to be temperature dependent, whereas the velocities of PDs at non-sunspot locations do not show a clear temperature dependence. This suggests an interpretation in terms of slow magneto-acoustic waves in sunspots but the nature of PDs in non-sunspot(plage) regions remains unclear. We also considered on what scale the underlying driver is affecting the properties of the PDs. Finally, we found that removing the contribution due to the cooler ions in the 193 Å wavelength suggests that a substantial part of the 193 Å emission of sunspot PDs can be attributed to the cool component of 193 Å.

14:20: **Slow Magneto-acoustic Waves Observed above Quiet-Sun Region in a Dark Cavity**

Jiajia Liu, Zhenjun Zhou,Yuming Wang, Rui Liu, Bin Wang, Chijian Liao, Chenglong Shen, Huinan Zheng, Bin Miao, Zhenpeng Su, and S. Wang

Waves play a crucial role in diagnosing the plasma properties of various structures in the solar corona and coronal heating. Slow magneto-acoustic (MA) waves are one of the important magnetohydrodynamic waves. In past decades, numerous slow MA waves were detected above the active regions and coronal holes, but rarely found elsewhere. Here, we investigate a 'tornado'-like structure consisting of quasi-periodic streaks within a dark cavity at about 40–110 Mm above the quiet-Sun region on 2011 September 25. Our analysis reveals that these streaks are actually slow MA wave trains. The properties of these wave trains, including the phase speed, compression ratio, kinetic energy density, etc., are similar to those of the reported slow MA waves, except that the period of these waves is about 50 s, much shorter than the typical reported values (3–5 minutes).

14:40: *Discussion*

15:30 - 16:00 **Coffee Break**

4.7 Working group 7: Power Law statistics of flares

American Kestrel (4th floor)

13:30: **AIA Statistics from Nanoflares to Giant Flares and Self-Organized Criticality**

Markus Aschwanden,

With AIA we are for the first time capable to gather statistics from nanoflares, microflares, to giant flares, with the same instrument, wavelength ranges, and cadences. We present statistics of observed and derived physical parameters over the entire range of 8 orders of magnitude in energy. We analyze the spatio-temporal evolution of flares, the fractal geometry, and the occurrence frequency distributions. We compare the results with the theoretical predictions of the fractal-diffusive self-organized criticality model and discuss the underlying physical scaling laws.

14:00: **The flare productivity of active regions**

Natsuha Kuroda, Steven Christe

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 investigate the relationship between the slope of the microflare size distribution and the magnetic properties of source active regions. For each flare we obtain the relevant MDI magnetogram to determine properties such as the area of the source active region and total unsigned magnetic flux. These properties are then compared to properties of the associated microflares such as peak flux and microflare size distribution. We find that, for both the Mount Wilson Magnetic Classification and the Zurich/McIntosh Sunspot Classification, the slopes of the microflare size distribution tend to get harder as a function of magnetic complexity. For example, in Mount Wilson Magnetic Classification the slope for α regions was 1.66 and the slope for $\beta\gamma\delta$ region was 1.51.This suggests that $\beta\gamma\delta$ regions are 50% more likely to produce X class flares than α regions.

14:30: **The Power-law Deviation at the Lower End of the Flare Frequency Distribution**

Li, Y. P., Gan, W. Q.

A new model to fit the frequency distribution of HXR peak counts is proposed. With an assumption that there exists noise fluctuations for all measured data, we prove that the power-law distribution can be kept for all events. The deviation at the lower end can be explained by the noise fluctuations. The power law index, noise level, and lower cutoff can be obtained by the new fitting method.

15:00: **Spatially resolved event distribution analysis in MHD simulations of coronal heating**

LiWei Lin, Chung-Sang Ng, Amitava Bhattacharjee

In a recent numerical study [Ng et al., ApJ 747 109, 2012], with a three-dimensional model of coronal heating using reduced magnetohydrodynamics, we have obtained scaling results of heating rate versus Lundquist number based on a series of runs in which random photospheric motions are imposed for hundreds to thousands of Alfvn time in order to obtain converged statistical values. The heating rate found in these simulations saturate to a level that is independent of the Lundquist number. This scaling result was also supported by an analysis with the assumption of the Sweet-Parker scaling of the current sheets, as well as how the width, length and number of current sheets scale with Lundquist number. In order to test these assumptions, we have implemented an automated routine to analyze thousands of current sheets in these simulations and return statistical scalings for these quantities [Lin et al. Astronum 2012 submitted]. We now extend this analysis to investigate the distribution of energy release events which are now spatially resolved. We report preliminary findings and compare to results obtained using only time-series analysis.

15:00: *Discussion*

15:30 - 16:00 **Coffee Break**

5 Thursday Session 4: 16:00 - 17:30

5.1 Working group 1: Joint WG1/WG3: Atmospheric Effects

Blue Heron Ballroom

16:00: **Characterizing the Atmospheric Response to Electrons Accelerated in Solar Flares**

Gordon Holman, Joel Allred

Observations have indicated that the energy contained in accelerated electrons is sufficient to provide most if not all of the heating of flare plasma. It is likely, however, that more direct heating of this plasma, perhaps associated with the same physical mechanism responsible for the accelerated electrons, plays a significant role. Therefore, obtaining an understanding of plasma heating and particle acceleration in flares requires a thorough understanding of the plasma response to heating by the accelerated electrons. Considerable progress has been made in deducing the electron distribution and its evolution, as well as the expected plasma response and properties of its radiation. We will describe some recent results and a developing project to model the coupled evolution of plasma and accelerated electrons for direct application to flare data.

16:20: **The emission measure distribution of impulsive phase flare footpoints**

David Graham, Iain Hannah, Lyndsay Fletcher, Ryan Milligan

The temperature distribution of emitting plasma in flare footpoints is an essential constraint on studying models of flare energy deposition. Studies of this kind have been difficult in the past without the spectral and imaging capabilities needed to separate footpoint and loop emission during the impulsive phase. We use high spectral and spatial resolution observations from Hinode/EIS in conjunction with a regularized inversion method to present the first footpoint emission measure distributions (EMDs) from six events. All of the events share very similar characteristics of the EMD: a peak temperature of 8 MK, peak emission measures between (10^{28}) - (10^{29} rm cm^{-5}), and an EMD gradient of EM(T) (sim T), indicating a substantial presence of plasma at coronal temperatures. Previous theoretical work on EMD gradients suggests that this is consistent with injected flare energy only directly heating the top of the flare chromosphere, with deeper layers being heated by thermal conduction and loosing energy via radiative losses. These EMDs can also be used for better estimating synthetic footpoint spectra, useful for line identification in SDO/EVE observations for example, or the forthcoming IRIS mission.

16:40: **Observations of the Neupert Effect with SDO, RHESSI, and GOES**

Sam Schonfeld, Phillip Chamberlin

The Neupert Effect is an empirically observed correlation between the hard X-rays (HXR) and the time derivative of soft X-rays (SXR) emitted during the impulsive phase of a solar flare. According to standard models of magnetic reconnection driven flares, accelerated electron beams are responsible for creating the HXR Bremsstrahlung radiation in the Transition Region and upper Chromosphere. This energy input should also heat the relatively low-temperature Chromospheric plasma, increasing the intensity of extreme ultraviolet (EUV) emission lines. The launch of the Extreme Ultraviolet Variability Experiment (EVE) on board the Solar Dynamics observatory (SDO) has for the first time provided measurements of the solar irradiance spectra with 0.1 nm spectral resolution over the range 6.5-37 nm at 10-second cadence and nearly 100% duty cycle. Comparisons were made using the EUV spectral data from EVE, SXR measured by the X-Ray Spectrometer (XRS) on the Geostationary Operational Environmental Satellites (GOES), and HXR recorded with the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). The first focus of the investigation looked at the timing of the HXR, time derivative of soft X-ray, and the Helium-II 304 doublet. The second focus compared He II images taken by the Atmospheric Imaging Assembly (AIA) (also on SDO) to x-ray images taken by RHESSI to compare the spatial location and area of the lower atmospheric energy emissions. We investigated all M class and above flares between May 1st 2010 and June 1st 2011 with complete coverage by all three instruments totaling 31 events. Of these, 77% (24) showed the expected Neupert Effect with 70% (17) of these events also displaying He-II profiles consistent with the electron beam heating model. This collaboration was organized through the SESI internship program at GSFC and funded by the Catholic University of America.

17:00: **Modeling the Solar Atmospheric Response to Flare-Accelerated Ion Beams**

Joel Allred,

In the standard flare model, both electrons and ions in the corona are accelerated to high energies and travel down magnetic field lines where they impact on the denser plasma producing chromospheric evaporation and causing numerous emission lines to dramatically brighten. Electron beams and their effects have been extensively studied. However, little work has been done modeling flare-accelerated ion beams. Here, I will discuss my recent simulations which model the atmospheric response to ion beams. There are several key differences between how ion and electrons beams affect the solar atmosphere. For example, ion beams carry significantly more momentum than do electron beams. Accounting for this is important for understanding velocities measured during flares. My simulations also include detailed chromospheric radiative transfer allowing me to model how line and continuum transitions respond to flare heating. Of particular interest are emission lines in the EUV and the mechanism for producing white light continuum.

17:20: *Discussion*

18:00 - 19:30 **Debate**

5.2 Working group 2: Flares and CMEs

Caspian Tern (4th floor)

16:00: **Connectivity of a major erupting filament to preceding new active regions and subsequent coronal cloud prominences**

Sara Martin, Olga Panasenco, Joan Feynman

The major filament eruption on 31 August 2012 serves as a prime example of events which reveal physical evidence linking the eruption of a filament to structural changes between its overlying coronal fields and one or more new and growing active regions. In this case four new active regions form within 3 days prior to the eruption and within 10 heliographic degrees of some part of the filament. We show changing interconnections between the active regions and the coronal structure around the filament using SOHO, STEREO and SDO images that appear to serve as contributors to initiation of the filament eruption and its associated CME and flare. We investigate these interactions also to understand why the filament mass was ejected and seen successively in several directions: to the east, north and west of its filament channel. As known to be common for eruptive events, some filament mass falls back to the Sun from both low heights and great heights. To understand both the build-up to eruption and what happens to the returning mass, we reconstruct a time-series of the global coronal magnetic configurations of the complex source region and adjacent complexes of active regions. In this way we can determine the relative importance of the emerging flux regions and the possible sites, where the erupting filament plasma, when falling back to the surface, can be temporarily captured to form the coronal cloud prominences. We provide speed and timing evidence that part or all of the coronal cloud prominences on the east limb are a consequence of mass falling from the major preceding event.

16:30: **Details of magnetic reconnection in the solar corona**

Yang Su

Magnetic field reconnection is believed to be a fundamental process for energetic phenomena in laboratory plasma, fusion plasma, the magnetosphere, solar flares, coronal heating and astrophysical systems. Although many pieces of indirect evidence for features that could be related to magnetic reconnection have been found in solar atmosphere, direct, detailed observations of the process are missing due to limited observational ability. Here we present the details of a non-steady, non-uniform, and unsymmetrical reconnection process between interacting coronal loops imaged by the SDO/AIA in UV, EUV and the RHESSI in X-rays. The results strongly support the idea that solar flares could be produced by magnetic reconnection. The observed speeding, expanding inflow loops and the high reconnection rate provide the first solid evidence in space for a Sonnerup-like or flux-pile-up reconnection, neither Sweet-Parker nor Petschek reconnection which are currently the focus of flare studies. The findings could provide new insights into flare and reconnection theories.

17:00: *Discussion*

18:00 - 19:30 **Debate**

5.3 Working group 3: Joint WG1/WG3: Atmospheric Effects

Blue Heron Ballroom

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17:20: *Discussion*

18:00 - 19:30 **Debate**

5.4 Working group 4: Instabilities/initiation signatures

Pelican (Business Center)

16:00: **Coronal Cavities, Prominences, and CMEs: convective transport and the evolution to eruptive states**

Thomas Berger, *Wei Liu*, B.C. Low

We review Hinode/SOT and SDO/AIA observations that suggest coronal cavity flux ropes - the largest coherent magnetic structures in the solar atmosphere - support a form of convective transport that drives their evolution to eruption as CMEs. Convective upflows are evidenced by the so-called (*prominence bubbles*) discovered by Hinode/SOT and shown by SDO/AIA to be comprised of hot plasma at temperatures of at least log T = 6.2 K. We hypothesize that the source of the bubbles is rapidly heated emerging flux at or near the polarity inversion line below coronal cavities. Further SDO/AIA observations, as well as new theoretical calculations, show that hot coronal cavity plasma can undergo (*thermal collapse*) to rapidly condense into cross-field downflows that manifest as quiescent prominences. Taken together, the hot upflows and cool downflows comprise the convective system that presumably feeds magnetic flux and helicity into coronal cavities while returning condensed plasma back to the lower atmosphere. Observations of the (*slow rise phase*) of early CME initiation show that the final drainage of prominence mass from the cavity precedes the initial acceleration of the structure into interplanetary space. The observations are consistent with hydromagnetic theories of CME initiation that posit loss of confinement due to accumulation of magnetic flux and helicity in non-potential magnetic structures (e.g., Zhang & Low 2005). While convective transport has thus far only been observed in quiescent coronal cavity systems (slow CMEs), it may be a general mechanism that applies to the more complex and explosive active region (fast) CMEs.

16:25: **The CORIMP CME Catalog: Automatically Detecting and Tracking CMEs**

Jason P. Byrne, Huw Morgan, Shadia R. Habbal, Peter T. Gallagher

Studying 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 amount of data available from the SOHO and STEREO missions also makes manual cataloguing of CMEs tedious, and so a robust method of detection and analysis is required. Here, we present the development of a new CORIMP (coronal image processing) CME detection and tracking technique that overcomes many of the drawbacks of current catalogs. It works by first employing a dynamic CME separation technique to remove the static background, and then characterizing CMEs via a multiscale edge-detection algorithm. This allows the inherent structure of the CMEs to be revealed in each image, which is usually subject to spatiotemporal crosstalk as a result of traditional image-differencing techniques. Thus the kinematic and morphological information on each event is resolved with higher accuracy than previous possible, revealing CME acceleration and expansion profiles otherwise undetected, and enabling a determination of the varying speeds attained across the span of the CME. This is of huge importance to understanding the forces that govern CME eruption and propagation through the heliosphere.

16:50: **Tracking the momentum flux of a CME to better understand its influence on GICs at Earth**

Neel Savani, A. Vourlidas, A. Pullkinen, L. Simpson, T. Nieves-Chinchilla, N.R. Sheeley

We investigate a CME propagating towards Earth on 29 March 2011.This event is specifically chosen for the northward directed magnetic field, so that the influence from the momentum flux on Earth can be isolated. We use a forward modeling technique to estimate the shape and orientation of the CME and use it to implement a semi-automated method for estimating the mass of the CME until 30Rs.We use the large fields of view from the white light cameras on STEREO to continually track the CME until it passes over the Earth. The mass images are converted into mass J-maps and compared to the established tracking techniques from total brightness J-maps. The mass tracks on these J-maps correspond to sheath region between the CME and its associated shock front as seen by in situ measurements from L1. The in situ measurements are used as inputs into a 3D magnetospheric space weather simulation from CCMC. These simulations display a sudden compression of the magnetosphere from the large momentum flux at the leading edge of the CME and predictions are made for the time-derivative of the magnetic field (dB/dt) on the ground. The predicted dB/dt were then compared with observations from specific ground stations to show promising results. This study of the momentum of a CME from the Sun down to its influence on magnetic ground stations on Earth is presented as preliminary proof of concept, such that future attempts may try to use remote sensing to create a density time-series as inputs to magnetospheric simulations.

17:15: *Discussion*

18:00 - 19:30 **Debate**

5.5 Working group 5: Flares continued/Shocks, Flares or Both?

Avocet (Business Center)

16:00: **Energetic particles at the Sun and in the Interplanetary medium: Spatially resolved observations of flares at X-rays and radio**

Nicole Vilmer, Rosa Rodriguez-Gasen, K.L. Klein, SEP Server consortium

We shall present here preliminary results of a study based on protons events in the interplanetary medium (subset of events from a list provided by the SEPServer consortium) for which hard X-ray observations from RHESSI and radio observations from the Nançay Radioheliograph are available for the presumably associated flare. We shall investigate the spatial and temporal evolution of hard X-ray and radio emissions in the flare, searching for evidence of long duration coronal signatures of energetic particles in these events. We shall briefly examine whether these observations may provide information on the origin of the longitudinal spread of energetic proton events as well as indications of long duration particle energy release in the corona.

16:25: **Study of Solar Eruptive Events and their Association with Sustained >100 MeV Gamma-Ray Flares Observed by Fermi**

Gerald Share, Ronald Murphy, Richard Schwartz, Albert Shih, Kim Tolbert, and Allan Tylka

We have compiled a list of 96 high-energy solar eruptive events from June 2008 until early June 2012, covering the first four years of the Fermi mission. This study was prompted by the detection of ¿100 MeV gamma-ray emission in the hours following three M-class flares in 2011 and 2012 reported in three ATELs by the Fermi Team. These events fall into a class known as Long Duration Gamma Ray Flares that was discussed by Ryan (2000). The three Fermi events were associated with fast/broad CMEs, flares with hard X-ray emission ¿100 keV, and solar energetic proton events. We therefore used the following search criteria to develop the list of SEEs: 1. CME speed ¿800 km/s and angular width ¿90 degrees, or 2. impulsive phase hard X-ray emission ¿100 keV, or 3. SEP proton flux ¿1 pfu. 70 of the 96 SEEs meeting one of these three criteria were associated with flares on the solar disk. Of these disk events 42 were associated with ¿800 km/s CMEs, 44 were associated with hard X-ray flares ¿100 keV, and 32 with SEP events ¿1 pfu. We identify 16 SEEs with broad ¿800 km/s CMEs and impulsive hard X-rays ¿100 keV that are candidates for sustained ¿100 MeV gamma-ray emission detectable by Fermi. We discuss constraints on the possible origins for this time-extended high-energy gamma-ray emission.

16:50: **Flare and Shock Components in Large SEP Events**

Hilary Cane, Ian Richardson, Tycho von Rosenvinge

We summarise the properties of large solar energetic particle (SEP) events and the related solar phenomena that led us to propose that flares provide an additional source of energetic particles in addition to those generated by CME-driven shocks. This two component model is illustrated by examining a number of events with different properties. Of interest is the small class of events with no evidence of particle escape from the low corona as evidenced by the lack of type III bursts. Such events also lack prompt particles, are dominated by interplanetary shock acceleration, and have elemental composition similar to the solar wind.

17:15: *Discussion*

18:00 - 19:30 **Debate**

5.6 Working group 6: Flows vs Waves; Does it Matter?

Northern Harrier

16:00: **Jet-excited kink oscillations of coronal loops observed by Hinode/EIS and SDO/AIA**

Tongjiang Wang, Leon Ofman, Joseph M. Davila

Transverse coronal loop oscillations were first observed by TRACE in EUV images, and have been interpreted as fast standing kink modes. These loop oscillations are typically associated with a flare or a CME, and suggested to be excited by a blast wave or a fast-mode wave/shock. In contrast, we report simultaneous imaging and spectroscopic observations of loop kink oscillations triggered by jets at a footpoint. The strongly damped kink oscillations of warm ($\sim$1.5 MK) loops were for the first time detected in Doppler shifts by Hinode/EIS with fast scanning of a 1-min cadence. Three oscillation events were observed on the limb and they show the propagating features along the slit. We examine whether they are caused by the fast-mode waves or due to the standing oscillations of a loop system (composed of multiple loops of different size) in combination with SDO/AIA observations. In addition, we do 3D MHD modeling to understand the excitation of kink oscillations by impulsive flows.

16:25: **SDO/AIA Observations of Quasi-periodic Fast (1000 km/s) Propagating (QFP) Waves in the Low Corona**

Wei Liu , Leon Ofman, Alan M. Title, Junwei Zhao, Markus J. Aschwanden

Recent EUV imaging observations from SDO/AIA led to the discovery of quasi-periodic fast ($\sim$2000 km/s) propagating (QFP) waves in active regions (Liu et al. 2011). They were interpreted as fast-mode magnetosonic waves and reproduced in 3D MHD simulations (Ofman et al. 2011). Since then, we have extended our study to a sample of more than a dozen such waves observed during the SDO mission (2010/04-present). We will present the statistical properties of these waves including: (1) Their projected speeds measured in the plane of the sky are about 400-2200 km/s, which, as the lower limits of their true speeds in 3D space, fall in the expected range of coronal Alfven or fast-mode speeds. (2) They usually originate near flare kernels, often in the wake of a coronal mass ejection, and propagate in narrow funnels of coronal loops that serve as waveguides. (3) These waves are launched repeatedly with quasi-periodicities in the 30-200 seconds range, often lasting for more than one hour; some frequencies coincide with those of the quasi-periodic pulsations (QPPs) in the accompanying flare, suggestive a common excitation mechanism. We obtained the k-omega diagrams and dispersion relations of these waves using Fourier analysis. We estimate their energy fluxes and discuss their contribution to coronal heating as well as their diagnostic potential for coronal seismology. We also compare these new observations to 3D MHD models of QFPs with a range of parameters.

16:50: *Discussion*

18:00 - 19:30 **Debate**

5.7 Working group 7:Free or discussion

American Kestrel (4th floor)

18:00 - 19:30 **Debate**

6 Friday Session 1: 08:30 - 10:00

6.1 Working group 1: Marina Overlook (Business Center)

Energy Transfer: CMEs and Filament Eruptions

08:30: **Correlations Between EUV Coronal Spectral Line Dimming and CME Kinetics**

James Mason, Tom Woods, Amir Caspi

Coronal dimming in several spectral lines of the extreme ultraviolet (EUV) during and after flares may be indicative of the kinetics of coronal mass ejections (CMEs). Data from the EUV Variability Experiment (EVE) onboard the Solar Dynamics Observatory (SDO) are used to characterize the coronal dimming in several of the cooler corona emission lines available (e.g. Fe IX through Fe XII in the 17-20 nm range). Data from the Large Angle and Spectrometric Coronagraph Experiment (LASCO) onboard the Solar and Heliospheric Observatory (SOHO) and the Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) coronagraphs onboard the twin Solar TErrestrial RElations Observatory (STEREO) spacecraft are used for identifying CMEs and deriving their velocities. These coronagraph data and also in-situ data from the Advanced Composition Explorer (ACE) are used for estimating the CME mass. Using these data sets, correlations are drawn between EUV emissions and their time variation during coronal dimming and the mass and velocity of coronal mass ejections.

08:50: **A Comparative study of Current Sheets in Relation to Coronal Mass Ejections**

Rui Liu

It has been a controversial issue as to whether an ideal MHD process or magnetic reconnection plays a dominant role in driving solar eruptions. Although the two types of processes are typically closely coupled, recent numerical studies suggest that an observational discrimination is possible by comparing the speed of the upward reconnection outflow and that of the flux rope above the reconnecting vertical current sheet (CS). In this talk, we investigate the initiation of two CMEs. Both were associated with M-class flares. One is a typical impulsive CME driven primarily by instability; the other is a typical gradual CME, in which magnetic reconnection played a dominant role. A cold CS ($\sim$0.5 - 2 MK) appeared in the wake of the former eruption, while a hot CS ($\sim$10 MK) in the wake of the latter. Simultaneous upward and downward reconnection outflows were detected along the CS in both events, with comparable speeds (200 - 300 km/s). The reconnection outflow is faster than the erupting flux rope in the instability-driven event, while slower than the erupting flux rope in the reconnection-driven event, consistent with the numerical predictions. For the former event, in which there was an approximate equipartition between flow and thermal energy, the current sheet is probably of Sweet-Parker type; for the latter event, the reconnection was fast and most likely in the regime of bursty reconnection, as evidenced by the small blobs observed within the sheet structure.

09:10: **Super-elastic Collision between Two Coronal Mass Ejections in the Heliosphere**

Yuming Wang, Chenglong Shen, Shui Wang, Ying Liu, Rui Liu, Angelos Vourlidas, Bin Miao, Pinzhong Ye, Jiajia Liu, Zhenjun Zhou

Super-elastic collision is an abnormal collisional process, in which some particular mechanisms cause the kinetic energy of the system increasing. Most studies in this aspect focus on solid-like objects, but they rarely consider gases or liquids, as the collision of the latter is primarily a mixing process. With cross-field diffusion being effectively prohibited, magnetized plasmoids are different from ordinary gases. But it remains unclear how they act during a collision. Here we present the global picture of a unique collision between two coronal mass ejections in the heliosphere, which are the largest magnetized plasmoids erupting from the Sun. Our analysis for the first time reveals that these two magnetized plasmoids collided like solid-like objects with a 75%likelihood of being super-elastic. Their total kinetic energy surprisingly increased by about 6.9% through the collision, which significantly influenced the dynamics of the plasmoids.

09:30: *Discussion*

10:00 - 10:30 **Coffee Break**

6.2 Working group 2: CMEs and SEPs

Caspian Tern (4th floor)

08:30: **3D-kinematics of CMEs (distance-time, speed, acceleration) and total mass**

Manuela Temmer

08:50: **New things on CME kinetic and thermal energies**

Angelos Vourlidas

New things on CME kinetic and thermal energies

09:10: **A Comparison of Solar Energetic Particle Events with the Properties of Coronal Mass Ejections**

Steve Kahler, Angelos Vourlidas

We carry out a statistical comparison of properties of 115 SEP events with those of their associated CMEs observed over the past solar cycle. We estimate the total SEP event energies of 93 events for which the 2-MeV proton fluences could also be determined. Improved measurements of white-light CME images enable us to improve calculations of the masses and energies of CMEs using both leading edge (fr) and center-of-mass (cm) kinematics. These values are used in statistical comparisons with the peak 20-MeV intensities, the 2-point energy power-law spectral indices, the 2-MeV/nuc H/He ratios, and calculated total energies of SEP events observed on the Wind spacecraft. The large dynamical ranges of the SEP parameters allow us to look for statistical trends in the data that could give us physical insights into the physics of SEP production as well as possible SEP prediction tools. Those correlations are higher with V(fr) than with V(cm) speed parameters, indicating a less significant role for the body of the CME than for the CME front in SEP production. The high ratios ($\geq$ 10%) of Esep to CME energies found by Mewaldt et al. (2008) are confirmed, and the fits are consistent with a linear relationship between the two energies.

09:30: **Sep Kinetic Energy Estimates Using 2 And 3 Point Measurements**

Richard Mewaldt

10:00 - 10:30 **Coffee Break**

6.3 Working group 3: Constraints on flare physics from observations of the lower atmosphere

Golden Eagle (Business Center)

Discussion: constraints on flare physics from observations of the lower atmosphere

10:00 - 10:30 **Coffee Break**

6.4 Working group 4: WG4/WG5 - Shock and waves

Blue Heron Ballroom

08:30: **Onset of coronal type II radio bursts at dm/m wavelengths and relation with eruptive plasmas**

Nicole VILMER, Ivan ZIMOVETS

The origin of coronal type-II radio bursts in the low corona (blast wave or piston-driven) is still under discussion.

We shall present results on one event of detailed spatially resolved observations of type-II burst sources observed with the Nanay radioheliograph and of their relations to erupting plasmas. Our analysis shows that the shock wave, which could be responsible for the observed type-II radio burst, could be initially driven by the multi-temperature eruptive plasmas, but later transformed to a freely propagating blast shock wave. We shall also discuss the interpretation of the type-II burst splitting for this event.

08:55: **Kinetic Simulations of Nonlinear Wave Interactions leading to Type II Bursts**

Urs Ganse, Felix Spanier, Rami Vainio

Type II radiobursts are commonly accepted to originate from CME- and flare driven shocks, with observational evidence of electron beam populations in the purported emission regions. Using the kinetic particle-in-cell code ACRONYM, we have investigated nonlinear wave interaction processes in CME foreshock regions in presence of electron beams. Focus lay on the quantitative analysis of wave kinematics: excitation of electrostatic waves by the electron beams and and nonlinear coupling to tranverse magnetic modes can be observed in the simulation data. By varying parameters of the background plasma, the emission process at low and high heliocentric distances have been compared, and found to be very similar despite a significant difference in density and magnetization.

09:20: **Theoretical aspects of radio emission from shocks in the corona**

Gottfried Mann, Stephan Braune, and Henry Aurass

Shocks are generated either by flares or by coronal mass ejections (CMEs) in the solar corona. Since electrons are accelerated at these shocks, they appear as type II bursts in the solar radio radiation. The type II burst radio radiation is generated in the following way: Electrons are accelerated at the shocks. These energetic electrons excite Langmuir waves, which convert into escaping radio waves appearing as type II radio bursts. From the radio data, requirements for the electron acceleration at type II burst associated shocks are derived by means of theoretical studies of Langmuir wave excitation by energetic electrons. Adopting shock drift acceleration as the mechanism of the generation of energetic electrons at shocks, requirements for the associated shocks are derived. In result, a consistent picture of type II radio bursts and the associated shocks are obtained by this study.

09:45: *Discussion*

10:00 - 10:30 **Coffee Break**

6.5 Working group 5: WG4/WG5 - Shock and waves

Blue Heron Ballroom

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09:45: *Discussion*

10:00 - 10:30 **Coffee Break**

6.6 Working group 6: Flows vs Waves; Does it Matter?

Pelican (Business Center)

09:00** *(note later start time)* **Three-dimensional MHD models of waves and flows in active region loops: what can we learn?**

Leon Ofman, Tongjiang Wang, Joseph M. Davila

Recent high resolution EUV imaging observations with TRACE, and SDO, and spectroscopic observations by Hinode indicate that quasi-periodic disturbances (QPD) that travel close to the sound speed are present in active region loops, and that the interpretations of these events in terms of waves or flows is not straightforward. Recently, Ofman et al (2012) reported the results of 3D MHD models of active region loops that show the close relation between flows and waves. In order to further investigate the physics of QPD's we expand the 3D MHD models of active region loops and magnetic flux tubes to various magnetic geometries and coronal plasma temperature regimes. We investigate continuous, and quasi-periodic flow injection in the flux tubes, and study the formation of flows and waves. We find that impulsive flow injection at nearly sonic (subsonic) speed at the coronal base of loops leads to the generation of waves (slow magnetosonic and kink mode oscillations) of the loops in all cases studies. However, direct generation of waves in the model does not necessarily produce significant flows. We conclude that rapid quasi-periodic flows likely lead to the generation of waves in coronal loops.

09:20: **Mass flows between the chromosphere and corona in a 3D numerical model approach**

Pia Zacharias, Sven Bingert, Hardi Peter

We have investigated mass and energy flows in the outer solar atmosphere in a 3D MHD model and identified at least two processes that produce the observed Doppler shifts. Reconnection sites in the corona were identified and magnetic field lines were found to be connected to different places on the solar surface, depending on the photospheric plasma motions. While being connected to different upflow and downflow regions, the loops are either filled with plasma or plasma is draining from the loops. We also see that plasma is propelled into the corona through cold fingers that reach high up into the solar atmosphere. The plasma is then heated and eventually falls back to the solar surface. Because of its low temperature and since the plasma is filling only a small fraction of space when feeding the corona, these upflows are not visible in the average spectra, but instead, the Doppler maps are dominated by redshifts. In addition, the ejection of cool plasma into the corona in the 3D MHD model will be discussed and compared to the flows in a 1D coronal loop model. We will present results on a parameter study showing the temporal evolution of these loops following the injection of a heating pulse. In contrast to earlier studies, in which similar heating events are observed to lead to both redshifts in transition region and blueshifts in the corona, our findings indicate exclusive upflows along the loops, but almost no downflows during the heating phase. We will discuss these results in terms of the mass cycle between the chromosphere and corona.

09:40: *Discussion*

10:00 - 10:30 **Coffee Break**

6.7 Working group 7: Observational signatures of microflares

Avocet (Business Center)

09:00** *(note later start time)* **Constraining Differential Emission Measure and Energy Estimates for Microflares by Combining SDO/AIA and RHESSI**

Steven Christe, Andrew Inglis

Direct diagnostics of the fundamental parameters of solar coronal phenomena remains an active and challenging goal. Spatially resolved values of many parameters, such as the magnetic field strength, temperature, density, and energy content, are often difficult to determine. The Atmospheric Imaging Assembly (AIA) on board SDO provides us with a new opportunity to pursue some of these measurements. Here, we present differential emission measure (DEM) analysis of a selection of recent microflares, using AIA combined with high temperature measurements from RHESSI x-ray observations. A tailored forward-fitting temperature mapping, a procedure initially developed by Achwanden et al. (2011) for SDO/AIA is used to recover the DEM from the flux measurements. This procedure models the plasma temperature as a parameterized distribution (e.g. gaussian), and uses the instrument response functions to find the parameters which best reproduce the observed fluxes in each channel. We find that the AIA-only derived Gaussian DEM do not agree well with the RHESSI observations. AIA predicts much more high temperature emission than is observed by RHESSI. We use RHESSI observations to inform the DEM and provide the missing information which AIA cannot. We investigate other functional forms for the DEM as well. This new technique can produce more accurate time and spatially-depend DEM measurements as well as spatial energy density maps and better estimates of the total thermal energy these events.

09:30: **The energetics of microflares with RHESSI, AIA and XRT**

Iain Hannah,

Microflares are small active region flares (GOES A and B-class) that demonstrate similar signatures of electron acceleration and plasma heating as larger flares. RHESSI spectral data allows the non-thermal energy to be estimated and the thermal response to this is seen not only in RHESSI but SDO/AIA and Hinode/XRT as well. Using a regularised inversion method we have implemented to determine the Differential Emission Measure (DEM) we can quantify the thermal properties of the microflares (i.e. density, energy). Our method also allows us to investigate the robustness of the DEMs as well as the consistency between the observations at different wavelengths. With AIA and XRT microflares observations the DEM can be recovered over a broad range of temperatures, something not readily possible with larger flares due to the substantially saturated images. This combination of RHESSI, AIA and XRT data analysis allows us to present the comprehensive non-thermal and thermal energetics in a selection of microflares.

10:00 - 10:30 **Coffee Break**

7 Friday Session 2: 10:30 - 12:00

7.1 Working group 1: Energy Transfer: CMEs and Filament Eruptions continued

Marina Overlook (Business Center)

10:30: **SDO/AIA Observations of a Hyder-flare during 22 October 2011**

R. A. Maruya

10:50: **Phases of HXR emission during the evolutionary stages of a filament eruption and associated X-class solar flare**

Bhuwan Joshi, Upendra Kushwaha, Astrid Veronig

In this paper, we present a multi-wavelength study of the activation and eruption of a filament from active region NOAA 10656 on 18 August 2004 which was accompanied with an X-class flare. EUV and X-ray observations clearly indicate two phases of the filament evolution. The activities of the first phase, or activation phase, are characterized by three impulsive sub-peaks superimposed over smoothly varying GOES SXR flux, about an hour before the main eruption, during which HXR emission was also briefly observed. The comparison between X-ray and EUV imaging observations indicates that HXR emission is associated with three localized events of energy release that took place in the vicinity of a sub-filament region. We find that the morphological evolution and the slow rise of the sub-filament during this activation phase are temporally as well as spatially associated with these pre-eruption events. The observations provide clear evidence for magnetic reconnection, non-thermal emission and particle acceleration during the activation phase in the form of plasmoid ejection, HXR emissions and soft-hard-soft evolution of HXR spectra. The sub-filament region, weakened by the multiple events of localized magnetic reconnection, rapidly evolved into a twisted structure and eventually erupted producing a large CME associated X-class flare. During this second or eruption phase of the filament, multiple HXR bursts are observed during which X-ray spectra follow hard power laws. From these multi-wavelength signatures along with available magnetic field measurements, we conclude that the HXR emission during the first or activation phase of the filament evolution represents localized events of magnetic reconnection that play a crucial role in destabilizing the active region filaments and provide a trigger for the large-scale eruption and associated two-ribbon flare.

11:10: *Discussion*

12:00 – ***Poster session/free time***

7.2 Working group 2: WG2/WG3 Session on Energetics of Lower Atmosphere

Golden Eagle (Business Center)

10:30: **Broad Wavelength Coverage Spectra of White-Light Flares**

Adam F Kowalski, Gianna Cauzzi, Suzanne Hawley, Lyndsay Fletcher

Self-consistent flare heating simulations of the lower solar atmosphere are now possible with the advanced 1D radiative-hydrodynamic code RADYN. These models make detailed predictions for the Balmer jump and continuum emission in the optical, blue, and near-ultraviolet (white-light). Unfortunately, we do not yet have the ability to obtain spectra to compare to these models and to the literature of flare spectra from other stars. We first summarize the results from recent blue/optical spectra during flares on nearby, active M dwarfs and discuss how these data show that stellar flare models are incomplete. Then, we describe a new observing program at the Dunn Solar Telescope where we use a non-standard setup of the Horizontal Spectrograph (HSG) to obtain broad wavelength coverage spectra around the Balmer jump in order to provide the missing constraints for solar flare heating models. We show the first results from observations of a two-ribbon C1 flare observed in August 2011.

10:50: **The total radiated energy vs. X-ray-derived energetics in solar flares**

Alexander Warmuth, Gottfried Mann

Recent observations by SORCE and SOHO/VIRGO have revealed that an unexpectedly large amount of total radiated energy in solar flares. It is not entirely clear how this tremendous amount of radiation (primarily emitted by cool material in UV and WL) is produced. To shed light on this issue, we compare physical parameters of both thermal and nonthermal particle populations obtained from RHESSI spectroscopy and imaging of a larger sample of flares to the total radiated energy in solar flares. In particular, energy input by nonthermal electrons, as well as radiative and conductive losses of the hot plasma are considered as possible contributions to the total radiated energy.

11:10: **Radiative output of the total solar irradiance during solar flares**

Phillip Chamberlin, Chris Moore (U. of Colorado)

A more robust statistical algorithm than that presented by Woods et al. (2006) for determining the radiative output in the total solar irradiance (TSI) measured by the Total Irradiance Monitor (TIM) will soon be submitted to Ap. J. Lett. by Moore et al. The radiative outputs for each of the five flares and each of the impulsive and gradual phases are then compared to the modeled VUV irradiance output from the Flare Irradiance Spectral Model (FISM) in order to derive a relationship between the VUV and the TSI and subsequently estimate the TSI radiative output for other flares. Presented will be updates on new solar flare EUV measurements from SDO/EVE, how they changed the soon-to-be-released Version 2 of the Flare Irradiance Spectral Model (FISM), and the impact these new measurements and models have on the estimated solar flare TSI radiated output.

11:30: *Discussion*

12:00 – ***Poster session/free time***

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11:30: *Discussion*

12:00 – ***Poster session/free time***

7.4 Working group 4: WG4/WG5 - Shock and waves cont'd

Blue Heron Ballroom

10:30: **Where do Shocks form in the Corona?**

Nat Gopalswamy, Hong Xie, Joseph Davila

The height of shock formation in the solar corona is an important in understanding particle acceleration by shocks. The coronal density where the shock forms decides some of the properties such as the charge state composition of solar energetic particle events. Recent estimates have shown that of shock formation typically happens at heliocentric distances ¡ 1.5 solar radii (Rs). This estimate was possible due to the availability of coronagraphic and EUV observations close to the solar surface that became available after the launch of the Solar Terrestrial Relations Observatory (STEREO) mission. The heliocentric distance of the coronal mass ejection (CME) at the starting time of the metric type II burst was taken as the height of shock formation (leading edge method). The height can also be determined by measuring the diameter of the EUV wave and derive the height under early spherical expansion of the CME (diameter method). During the rise phase of solar cycle 24, nearly 80 metric type II radio bursts have been observed until the middle of year 2012, which we analyze to obtain statistically meaningful values of the CME height at the time of metric type II burst. We identify the CMEs associated with the metric type II bursts and measure their heights at the time of metric type II burst using one or more of STEREO/COR1, STEREO/EUVI, and Solar Dynamics Observatory images. Our study conclusively finds that the shock formation can occur at heights substantially below 1.5 solar radii. We discuss the implications of such low heights for the Alfven speed profile commonly used in describing the ambient corona.

10:55: **An investigation of CME-shock standoff distance using 2.5D MHD Simulations to better estimate upstream coronal magnetic fields**

Neel Savani, D. Shiota, K. Kusano, A. Vourlidas, N. Lugaz

In order to better estimate the magnetic field upstream of a CME driven shock from remote sensing as defined by Gopalswamy et al. (2012), we perform four numerical magnetohydrodynamic simulations in 2.5 dimensions (2.5D) of fast Coronal Mass Ejections (CMEs) and their associated shock fronts between 10Rs and 300Rs. We investigate the relative change in the shock standoff distance, Δ, as a fraction of the CME radial half-width, Dob (i.e. Δ/ Dob). Previous hydrodynamic studies have related the shock standoff distance for Earth's magnetosphere to the density compression ratio (DR, ρu/ρd) measured across the bow shock (Spreiter, Summers, & Alksne 1966). The DR coefficient, kdr, which is the proportionality constant between the relative standoff distance (Δ/ Dob) and the compression ratio, was semi-empirically estimated as 1.1. For CMEs, we show that this value varies linearly as a function of heliocentric distance and changes significantly for different radii of curvature of the CME's leading edge. We find that a value of 0.8$\pm$0.1 is more appropriate for small heliocentric distances (¡30Rs) which corresponds to the spherical geometry of a magnetosphere presented by Seiff (1962). As the CME propagates its cross section becomes more oblate and the kdr value increases linearly with heliocentric distance, such that kdr= 1.1 is most appropriate at a heliocentric distance of about 80Rs. For terrestrial distances (215Rs) we estimate kdr= 1.8 $\pm$0.3, which also indicates that the CME cross-sectional structure is generally more oblate than that of Earth's magnetosphere.

11:20: *Discussion*

12:00 – ***Poster session/free time***

7.5 Working group 5: WG4/WG5 - Shock and waves cont'd

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11:20: *Discussion*

12:00 – ***Poster session/free time***

7.6 Working group 6: Flows vs Waves; Does it Matter?

Pelican (Business Center)

10:30: *Closing Discussion, Prepare report for plenary session*

12:00 – ***Poster session/free time***

7.7 Working group 7: Radio microflares

Avocet (Business center)

10:30: **RHESSI microflares with quiet radio emission**

Zongjun Ning,

We statistically study RHESSI microflares from the first month of 2003. In total, 94 events are selected from the RHESSI flare catalog in the 3-6 and 12-25 keV energy ranges. The sample differs from those of previous studies in that the events are characterized by having quiet microwave emission, based on observations from the Nobeyama Radio Polarimeters. Consistent with previous findings, the thermal plasma observed by RHESSI is found to be hot, 10MK¡T¡15 MK, with low emission measure $(10^{46}cm^{-3} < EM < 10^{47}cm^{-3}) anddensity (1.0 \times 10^{9}cm^{-3} < n_e < 12 \times 10^{9}cm^{-3})$. The spectral fitting requires a steep nonthermal power-law component, with median index of 8.1. Similar to findings for large flares, roughly half of these microflares (46 of 94) display the Neupert effect.

11:00: *Final discussion and wrap up*

12:00 – ***Poster session/free time***

8 Saturday Session 1: 08:30 - 10:00

8.1 Working group 1: Thermal pt. 1

Marina Overlook (Business Center)

08:30: **Spectrally-resolved X-Ray and Extreme Ultraviolet Irradiance Variations during Solar Flares**

Tom Woods, SDO EVE Team

In spite of lower activity during solar cycle 24, there have been several episodes of intense and frequent solar storms during the Solar Dynamics Observatory (SDO) mission. Understanding the time variations of the hard X-ray (HXR), soft X-ray (SXR), and extreme ultraviolet (EUV) emissions can reveal the energy transfer throughout a solar flare event. The SXR and EUV irradiance observations by SDO EUV Variability Experiment (EVE), as enabled by 10 sec cadence and 0.1 nm spectral resolution in the 6-105 nm range, are providing new insights into flare energetics and dynamics over a broad range of corona, transition region, and chromosphere temperatures. Most of the EVE flare observations can be decomposed into four distinct characteristics. Firstly, the emissions that dominate during the flares impulsive phase are the transition region emissions, such as the He II 30.4 nm. Secondly, the hot coronal emissions above 5 MK dominate during the gradual phase and are highly correlated with the GOES X-ray. A third flare characteristic is coronal dimming, seen best in the cool coronal EUV emissions such as the Fe IX 17.1 nm. The coronal dimming appears to be related to coronal mass ejections (CMEs), thus representing a new way to possibly estimate CME events from SDO observations. As the post-flare loops reconnect and cool, many EUV coronal emissions peak a few minutes after the GOES X-ray peak. One interesting variation of the post-eruptive loop reconnection is that warm coronal emissions (e.g., Fe XVI 33.5 nm) sometimes exhibit a second large peak separated from the primary flare event by many minutes to hours, with EUV emission originating not from the original flare site and its immediate vicinity, but rather from a volume of higher loops. We refer to this second peak as the EUV late phase. The characterization of many flares during the SDO mission is provided, including quantification of the spectral irradiance from the coronal dimming and EUV late phase that cannot be inferred from GOES X-ray diagnostics.

08:40: **Observations of Enhanced EUV Continua during an X-Class Solar Flare Using SDO/EVE**

Ryan Milligan, Phil Chamberlin, Hugh Hudson, Tom Woods, Mihalis Mathioudakis, Lyndsay Fletcher, Adam Kowalski, Francis Keenan

The EVE instrument onboard SDO was designed to monitor the solar variability at EUV wavelengths with high precision and cadence. However, EVE's spectroscopic capability also offers us a unique opportunity to investigate changes in the EUV spectrum during solar flares: both line and continuum emission can be used to diagnose the dynamics and energetics of the flaring atmosphere in response to a beam of nonthermal electrons. In this talk I will present observations of the free-bound (recombination) and free-free (bremsstrahlung) continua as measured by EVE throughout an X-class flare, including their contribution to the total flare energy and their relationship to the HXR emission observed by RHESSI.

09:00: **Exploring Thermal and Non-Thermal Flare Emission with EVE and RHESSI**

Amir Caspi, James M. McTiernan, Harry P. Warren

Solar flares accelerate electrons up to hundreds of MeV and heat plasma to tens of MK, but the physical processes behind these phenomena remain poorly understood. In intense (GOES M- and X-class) flares, in addition to the common 10-25 MK plasma thought to be the result of chromospheric evaporation, even hotter plasma (up to 50 MK) may be directly heated in the corona.

While observations of hard X-ray bremmstrahlung directly probe the non-thermal electron population, for large flares, the spectra below 20-30 keV are typically dominated by this strong thermal emission. The low-energy extent of the non-thermal spectrum can be only loosely quantified, resulting in significant implications for calculating flare energy budgets and for constraining possible acceleration mechanisms. A precise characterization of the thermal electron population is imperative, and this requires an equally precise characterization of the thermal emission.

Extreme ultraviolet observations from the EUV Variability Experiment (EVE) on-board the Solar Dynamics Observatory (SDO), combined with X-ray data from the Reuven Ramaty High Energy Spectroscopic Imager (RHESSI), currently offer the most comprehensive view of the flare temperature distribution. EVE observes EUV emission lines with peak formation temperatures of 2-20 MK, while RHESSI observes the X-ray bremsstrahlung of hot, 10-50 MK plasma; combined, the two instruments cover the full range of flare plasma temperatures. We have calculated differential emission measures (DEMs) using EVE and RHESSI independently, for a small number of flares. Here, we concentrate on comparing the observed DEM functions from EVE and RHESSI with each other, during different phases of flares, for the purpose of cross-calibration of the two instruments. Once cross-calibration is successful, we will combine the data from the two instruments to create a DEM function for the full temperature range up to 50 MK.

09:20: *Discussion*

10:00 - 10:30 **Coffee Break**

8.2 Working group 2: Free Magnetic Energy

Caspian Tern (4th floor)

08:30: **Magnetic energy partition between a flare and a CME in AR 11283**

Li Feng, Thomas Wiegelmann, Yang Su, Bernd Inhester, Youping Li, Xudong Sun, Weiqun Gan, Julia Thalmann

On 6 September 2011, an X-class flare and a halo CME as observed from the Earth were erupted from the same active region AR 11283. The magnetic energy partition between the flare and the CME has been investigated. SDO/HMI vector magnetograms were used to obtain the coronal magnetic field with the nonlinear force-free field (NLFFF) extrapolation method. The free magnetic energy before and after the flare was calculated to estimate the released energy available to power the flare and the CME. For the flare energetics, thermal and nonthermal energies were derived using the RHESSI and GOES data. To obtain the dominant energy component of the flare, the radiation, SDO/EVE data in the 0.1-37 nm waveband were utilised. We have also developed a new method to derive the mass of a CME, in which the 3D volume of the CME is reconstructed with the new mask fitting method (Feng et al. 2012) from the STEREO-A and B plus SOHO coronagraph images. Then the mass calculations were based on a more precise Thomson scattering geometry including the CME width and the variation of the Thomson scattering angle along a line of sight. The subsequent estimate of the kinetic and potential energies of the CME took advantage of the more accurate mass calculations, and the height and speed of the CME in a three dimensional frame. The released free magnetic energy resulting from the NLFFF model is about 6.4×10^{31} ergs. As it underestimates the free energy (Metcalf et al.2008), the derived energy was corrected to $1.8 times 10^{32}$ ergs. The thermal and nonthermal energies have an order of magnitude of 10^{30} ergs which are almost one order of magnitude lower than the radiative output of $2.2 times 10^{31}$ ergs from SDO/EVE for this event. The total radiation integrated over the whole solar spectrum is probably a few times larger than this value. The sum of the kinetic and potential energy of the CME could go up to $6.8 times 10^{31}$ ergs. In summary, the free magnetic energy is able to power the flare and the CME in AR 11283. Within the uncertainty, the flare and the CME may consume similar amount of magnetic energy.

08:50: **Estimating flare's free energy using Poloidal-Toroidal Decomposition method.**

Maria D. Kazachenko, George H. Fisher, Brian T. Welsch

The existence of systematic measurements of vector magnetic fields and Doppler shifts allows us to estimate electric field in the photosphere, by solving Faraday's law, using a Poloidal-Toroidal Decomposition (PTD) of the magnetic field and its partial time derivative, as well as incorporating information from Doppler shifts (Fisher et al. 2012). The method is based on solving a set of two-dimensional Poisson equations. We have recently modified the method in the following two ways. First, we improved the speed and accuracy of the Poisson equation solver using the FISHPACK elliptic partial differential equation software developed at NCAR, employing Neumann boundary conditions appropriate for zero electric fields on the vector-magnetogram boundary. Second, we developed a more general procedure which allows us to calculate electric fields from magnetic fields observed at non-zero viewing angles. We apply the improved technique to ANMHD-simulation test case with a known electric field and find that it yields more accurate values of Electric field, Poynting and helicity fluxes than before. We then apply our method to three-days-long HMI data-set centered on AR 11158, which produced an X2.2 flare. We find electric field, helicity and free energy evolutions in AR 11158. We further discuss the errors of the method and its future as a potential tool to estimate flare's free energy and helicity.

09:10: **Estimating the Coronal Magnetic Energy from a Photospheric Magnetogram**

Brian Welsch

Vector magnetograms - measurements of the magnetic field vector (B_x, B_y, B_z) at the approximately planar photosphere (z=0) - are the only routine measurements of the solar magnetic field currently available. Since flares and CMEs are driven by the magnetic field in the corona, the ability to infer the magnetic energy (and helicity) present in the field above a given magnetogram would be useful. While J_z is generally nonzero in an observed magnetogram, a hypothetical magnetogram with B_z matching the observations, but J_z set to zero, corresponds to the (unique) coronal field with minimum magnetic energy. By solving the vector induction equation, we can derive a sequence of electric fields to drive a hypothetical evolution from the initially current-free magnetogram to match the observed magnetogram. In principle, these electric fields can be used to estimate the fluxes of magnetic energy (and helicity) into the corona during this evolution. Unlike force-free extrapolation methods, this approach does not require that the photospheric magnetic field be force-free. The resulting estimates of magnetic energy (and helicity) in the coronal field might be useful in space weather forecasting. We demonstrate this approach by applying it to (i) theoretical vector magnetograms derived consistent with known, force-free fields, and (ii) observed vector magnetograms.

09:30: **A nonlinear force-free magnetic field approximation suitable for fast forward-fitting to coronal loops**

Markus Aschwanden,

We derive an analytical approximation of nonlinear force-free magnetic field solutions (NLFFF) that can efficiently be used for fast forward- fitting to solar magnetic data, constrained either by observed line-of-sight magnetograms and stereoscopically triangulated coronal loops, or by 3D vector-magnetograph data. The derived NLFFF solutions provide the magnetic field components Bx(x), By(x), Bz(x), the force-free parameter ?(x), the electric current density j(x), and are accurate to second-order (of the nonlinear force-free ?-parameter). The explicit expressions of a force-free field can easily be applied to modeling or forward-fitting of many coronal phenomena. We anticipate that this code can be used for most active regions observed on the disk to calculate the free magnetic energy that is dissipated during flare events.

09:50: *Discussion*

10:00 - 10:30 **Coffee Break**

8.3 Working group 3: WG3/WG4/WG5 Session on EUV Waves

Blue Heron Ballroom)

08:30: **Automated Detection/Characterization of EUV Waves in SDO/AIA Data**

Andrew Inglis, Albert Y. Shih, Jack Ireland, Steven Christe, Vincent Keith Hughitt, C. Alex Young, Matthew D. Earnshaw, Florian Mayer

Although EUV waves in the solar corona (also called coronal bright fronts or 'EIT waves') were first observed in 1996, many questions still remain about their nature and their association with other phenomena such as flares, CMEs, and Moreton waves. The high-resolution, high-cadence data from the Atmospheric Imaging Assembly (AIA) instrument on the Solar Dynamics Observatory (SDO) allows for unprecedented analysis of the kinematics and morphology of EUV waves. This information can be crucial for constraining and differentiating between theoretical models. While this analysis can be performed 'by hand', the large volume of AIA data is well-suited for an automated algorithms to detect and characterize these waves. We are developing such algorithms, which will generate a comprehensive catalog that can be used for statistical studies, and the biases of the algorithms can be well-studied using simulated data. We take advantage of imaging processing methods developed in Python, a general-purpose scientific computing language widely used used by multiple communities, as well as the SunPy Python library. We compare the results of our automated algorithms with other efforts that use more traditional, human-powered methods to identify and characterize EUV waves.

08:52: **SDO/AIA Observations of Global EUV (EIT) Waves and Their Relationship With CME Initiation**

Wei Liu, Leon Ofman, Nariaki Nitta, Carolus J. Schrijver, Markus J. Aschwanden, Alan M. Title, Theodore D. Tarbell

The nature of global EUV waves (so-called EIT waves) and their relationship with CMEs have long been under debate largely because of instrumental limitations. Recent high cadence, high resolution, full-disk imaging observations from SDO/AIA have opened a new chapter in understanding these waves. Various features of EUV waves have been discovered or observed in unprecedented detail. In this presentation, we will review such new observations, focusing on (1) multiple components (fast and slow) of EUV waves suggestive of their hybrid wave and non-wave nature, (2) quasi-periodic wave trains within broad, diffuse pulses of global EUV waves running ahead of CME fronts, and (3) interactions of global EUV waves with local coronal structures on their paths, such as flux-rope coronal cavities and their embedded filaments (kink oscillations) and coronal holes or active regions (deflections). We will discuss the implications of these observations on the mechanisms of EUV wave generation and its relationship with CME/flare initiation.

09:14: **The relation of global coronal disturbances with the angular spread and onset behavior of electron events**

Nariaki Nitta, Ral Gmez Herrero

We study the relation of global disturbances in the corona as found in EUV images with the angular spread and onset behavior of electron events. SDO AIA has observed a variety of kinematics and spatial characteristics of the coronal disturbances which usually appear as propagating fronts. However, we still do not clearly understand their relations with CMEs and flares. Using AIA and STEREO EUVI data, we characterize these fronts in CMEs and flares associated with electron events with and without large angular spread as observed by at least two of the following instruments: SEPT on STEREO-B and STEREO-A and 3DP on Wind. We study the relation of the global coronal disturbances with CMEs as observed by SOHO LASCO and STEREO COR-1 and COR-2. For a handful of well-observed events, we try to locate the propagating fronts in coronal structures around the onset of the electron event. We will also discuss the relation of these electron events with SEP events. Limitations of this study are also addressed in terms of the lack of our proper understanding of magnetic field connection between the Sun and the observer.

09:46: **CME shocks and their association with EUV waves and Type II radio bursts**

Eoin Carley, David M. Long, Peter T. Gallagher, Pietro Zucca

Eruptive events in the solar atmosphere can accompanied by a variety of activity, including coronal mass ejections (CMEs), EUV waves, and Type II radio bursts. However, the exact relationship between these processes is still and open question. Here we present observations that clarify this relationship. The observations show, in unprecedented detail, the co-propagation of an EUV wave with a 150 MHz radio emission source, imaged using the Atmospheric Imaging Assembly and the Nancay Radioheliograph, respectively. Coronagraph observations confirm that the EUV wave and radio source are located at the CME flank, while the Rosse Solar Terrestrial Observatory provided radio spectral observations that show the existence of a shock. The results confirm the driving of a shock by a CME, with this shock producing both the EUV wave and Type II radio burst.

10:00 - 10:30 **Coffee Break**

8.4 Working group 4: WG3/WG4/WG5 Session on EUV Waves

Blue Heron Ballroom

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10:00 - 10:30 **Coffee Break**

8.5 Working group 5: WG3/WG4/WG5 Session on EUV Waves

Blue Heron Ballroom

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10:00 - 10:30 **Coffee Break**

8.6 Working group 6: Free

10:00 - 10:30 **Coffee Break**

8.7 Working group 7: Free

10:00 - 10:30 **Coffee Break**

9 Saturday Session 2: 10:30 - 12:00

9.1 Working group 1: Thermal pt. 2

Marina Overlook (Business Center)

10:30: **The evolving spatial and spectral properties of solar flare X-ray loops with time**

Natasha Jeffrey, Eduard Kontar

X-rays from solar flares serve as an important and direct observational tool for determining how and why electrons are accelerated. Using observations from the Ramaty High Energy Solar Spectroscopic Imager (RHESSI) of three solar flares with coronal X-ray loops, the imaging technique of visibility forward fitting (VIS FWDFIT) was used to find loop length, width and position variations with time. We observed how these parameters changed during the evolution of each flare; before, during and after the peak X-ray emission at energies between 10-25 keV. Spectroscopy was also used to determine the corresponding variation in emission measure and plasma temperature with time. Loop volume, number density, thermal pressure and energy density were inferred from combining imaging and spectroscopy parameters, thus allowing us to study how the global loop properties evolved during each flare. Each X-ray loop showed similar temporal variations in loop length, width and position, with times of peak X-ray emission denoting changes in the trends of each of these parameters. Before a peak, there is a decrease in loop length and width, and hence loop volume, for all three flares. For one limb event, there is also a definite decrease in loop top altitude. We also see increases in loop number density, thermal pressure and energy density during the rise stage. After the X-ray peak, loop volume increases, mainly due to an increase in loop width, for all three events and again for the limb event, there is a slight increase in loop top altitude. Number density, thermal pressure and energy density all fall after the peak in X-ray emission. To our knowledge, this is the first time that changes in X-ray loop width and length, and hence loop volume, have been observed. The similarity of temporal variations for each loop indicates that analogous processes are occurring in the coronal loop regions for these types of event. The processes occurring in the loop regions can be described using pressure relations if we assume that there is an inflow of particles from above the loop region, but the results may also be explained using a reduction in magnetic pressure via Taylor relaxation or a combination of processes.

10:50: **Kappa Distribution Model for Hard X-Ray Coronal Sources of Solar Flares**

Mitsuo Oka, Shinnosuke Ishikawa, Pascal Saint-Hilaire, Sam Krucker, Robert Lin

Solar flares produce hard X-ray emission of which the photon spectrum is often represented by a combination of thermal and power-law distributions. However, the estimates of the number and total energy of non-thermal electrons are sensitive to the determination of the power-law cutoff energy. Here we revisit an 'above-the-loop' coronal source observed by RHESSI on 2007 December 31 and show that a kappa distribution model can also be used to fit its spectrum. Because the kappa distribution has a Maxwellian-like core in addition to the high-energy power-law tail, the emission measure and temperature of the instantaneous electrons can be derived without assuming the cutoff energy. With the kappa distribution model, we estimated that the total electron density of the 'above-the-loop' region was $\sim 2.4 \times 10^{10}$ cm^{-3}. We also estimated without assuming the source volume that a large fraction $\sim 20\%$ of these electrons had non-thermal energies and carried $\sim 50\%$ of the total electron energy in the region. The temperature was somewhat large, 28 MK, and the power-law index of the electron density distribution was -4.3. These results are compared to the conventional power-law model combined with a super-hot thermal core component.

11:10: **The 3-6 keV source motions in RHESSI flares**

Zongjun Ning

We explore the 3-6 keV X-ray source motions along the loop legs in RHESSI flares, which show a simple light curve and weak X-ray emission at higher energy to avoid the RHESSI attenuator in. First, an artificial flare loop is outlined to cover the X-ray sources at a energy band between 3-20 keV and at various times. Second, RHESSI images are reconstructed at 8 energy bands with a 8 seconds integration widow but a one second cadence. Third, the X-ray source motions are traced from the brightness distribution along the loop. We find that the 3-6 keV sources not always stay around the loop top, but display motions along the loop during the flare development.

11:30: *Discussion*

12:00 - 1:30 **Lunch**

9.2 Working group 2: WG2/WG7 - Joint Analysis of Multiple Flares - Results and Methods

Caspian Tern (4th floor)

10:30: **How well do we know the total radiative energy loss in any given major eruptive flare?**

Dick Canfield,

This is intended to be a discussion, not a formal talk. Everyone is encouraged to contribute. To get the discussion started, I will outline a very simplified approach we've used in a few flares as a test of the Minimum Current Corona model for preflare energy and helicity storage (Kazachenko et al, Solar Phys 277, 165, 2012). To be provocative, I will compare and contrast the approaches that have been taken to estimating the values and uncertainties of these two quantities in solar and interplanetary physics.

10:50: **Energy components from the automated analysis of GOES and other data sets**

Daniel Ryan

Energy components from the automated analysis of GOES and other data sets.

11:10: **The thermal energy of 150 M- and X-class flares observed with AIA/SDO.**

Markus Aschwanden,

We measured statistics of length scales L, flare areas A, flare volumes V, the durations T, the fractal area 2-D dimension D2, diffusion coefficients kappa, diffusion exponents beta, maximum expansion velocities v, for 15 M- and X-class flares observed with AIA/SDO in all 7 coronal wavelengths (94, 131, 171, 193, 211, 304, 335 Å), with 5 different flux thresholds for flare area detections. From these measurements we can deduce also the emission measures EM(t), the DEM peak temperatures T_e, the DEM electron densities n_e, and the thermal energies $E_{th} = 3 n_e k_B T V$. We show the statistical occurrence frequency distributions and correlations of these parameters. The multi-wavelength with 7 AIA/SDO filters yields an unprecedented temperature coverage that allows us to determine the DEM sufficiently accurate to obtain a reliable estimate of the thermal energies of flares.

11:30: *Discussion*

12:00 - 1:30 **Lunch**

9.3 Working group 3: Seismic Waves I

Golden Eagle (Business Center)

10:30: **On the WL and HXR emission of flaring events on the 24 solar cycle and their possible relation to seismic activity.**

Juan Camilo Buitrago-Casas, Juan Carlos Martinez-Oliveros, Charles Lindsey, Lindsay Glesener, Benjamn Calvo-Mozo

Solar flares are explosive phenomena, thought to be driven by magnetic free energy accumulated in the solar corona. Some flares release seismic transients, "sunquakes", into the Sun's interior. Different mechanism are being considered to explain how sunquakes are generated. We are conducting a survey of HXR, white-light and seismic emission from X- and M-class flares in the early ascending phase of solar cycle 24. Seismic diagnostics are based upon standard time-distance techniques, including seismic holography, applied to Dopplergrams obtained by HMI/SDO and GONG. The relation between HXR and white-light emissions may carry important information on impulsive chromospheric heating during flares, a prospective contributor to seismic transient emission, at least in some instances.

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10:50: **On The Energetics Of Seismic Excitation Mechanisms**

Juan C. Martinez Oliveros, Hazel Bain, Säm Krucker, Alina Donea, Hugh Hudson, Charles Lindsey

Some solar flares emit strong acoustic transients into the solar interior during their impulsive phases (Kosovichev and Zharkova, 1998). These transients penetrate thousands of kilometers beneath the active region photosphere and refract back to the surface, where they produce a characteristic helioseismic signature tens of thousands of kilometers from their origin over the succeeding hour. Several mechanisms of seismic excitation have been proposed, ranging from hydrodynamic shocks to Lorentz force perturbations. However, regardless of the mechanism of generation, it is clear that not all flares induce an acoustic response in the interior of the Sun. A concrete hypothesis or theory about the nature of this is still a topic of ongoing investigations. For some particular flares, we present a comparative study between the energy deposited by the proposed mechanisms of seismic excitation and the acoustic energy deduced using holographic techniques.

11:10: **Comparison of Time-Distance and Holography Analyses of Sunquake Observations from HMI**

Alexander Kosovichev, Junwei Zhao

HMI observations of solar flares revealed new sunquake events. We analyze and compare the results obtained using two different approaches: time-distance analysis and holography. The time-distance analysis provides detailed information about physical properties of the flare-excited helioseismic waves, including their interaction with strong magnetic field regions. On the other hand, the holography approach, which measures the integrated signal, allows us to detect weak events and investigate their relative power and its frequency dependence. A remarkable features of the observed events are their strong anisotropy, probably, associated with the rapid motion of the flare impacts in the low atmosphere, which are the source of the energy and momentum of sunquakes. We identify the sunquake source spatial-temporal characteristics and show that source locations determined from the holographic method systematically differ from the HMI observed Doppler impact locations. We discuss the potential mechanisms of sunquakes, and their relationship to the energy release and transport in solar flares.

11:30: *Discussion*

12:00 - 1:30 **Lunch**

9.4 Working group 4: Modelling

Pelican (Business Center)

10:30: **Numerical modeling of the initiation of coronal mass ejections in active region NOAA 9415**

Francesco Zuccarello, Zakaria Meliani , Stefaan Poedts

Coronal mass ejections (CMEs) and solar flares are the main drivers of the space weather. Understanding how these events can occur and what conditions might lead to eruptive events is of crucial relevance for up to date and reliable space weather forecasting. The aim of the present paper is to present a numerical magnetohydrodynamic (MHD) data-driven model suitable for the simulation of the CME initiation and their early evolution. Starting from a potential magnetic field extrapolation of the active region (AR) NOAA 9415, we solve the full set of ideal MHD equations in a non-zero plasma-beta environment. We investigate the response of the solar corona when photospheric motions, resembling the ones observed for AR 9415, are applied at the inner boundary. As a consequence of the applied twisting motions a force-free magnetic field configuration, having the same chirality as the investigated active region, is obtained. As a response to the converging shearing motions a flux rope is formed that quickly propagates outwards, carrying away, against the gravitational attraction by the Sun, the plasma confined inside the flux rope. Moreover, a compressed leading edge propagating at a speed of about 550 km/s and preceding the CME is formed. The presented simulation shows that both the initial magnetic field configuration and the plasma-magnetic field interaction are relevant for a more comprehensive understanding of the CME initiation and early evolution phenomenon.

10:55: **Plasmoids and Supra-Arcade Downflows in CME events**

Lijia Guo, Amitava Bhattacharjee, Yimin Huang

The study of CME eruptions has a long history and yet there are many interesting questions that remain, especially with regards to CME initiation. Many recent observational studies have addressed this issue. Lin et al. have reported blobs (interpreted as plasmoids) moving along a current sheet in a CME event. Liu et al. observed sunward moving plasmoids along a current sheet at the same time Type-III burst and DPS was observed in a CME event. Savage & Mckenzie et al. reported the observation of low emission supra-arcade downflows (SADs) in some flare sites after CME eruption. Asai et al. found there is correlation between SADs and Microwave (17 GHz), HXR (50-100 keV) enhancement. These observations suggest magnetic reconnection might play an important role in CME initiation. We have conducted 2D resistive MHD CME simulations with high Lundquist number (10^5) to study CME initiation. Results of our simulations show that soon after CME eruption a post CME current sheet forms and this current sheet soon brakes into secondary current sheets and plasmoids because it is unstable in the high-Lundquist number limit. We have also conducted a statistical analysis of plasmoids both in our simulation data as well as in LASCO/SOHO C2 observations. We find that plasmoids tend to follow an exponential distribution. The exponential distribution for large scale plasmoids in the process of plasmoid instability has been reported by Huang & Bhattacharjee et al. Our results along with existing observational studies seem to suggest that plasmoid instability is possible mechanism for post-CME current sheet reconnection. We have also studied the SADs problem using 3D resistive MHD simulations. In these simulations, along the direction of the flare ribbon, a ballooning-like instability develops in the region above the flare site and this leads to the formation of a low density drops. Simulated EUV and X-ray emission measure images show that the low density drop structures are also of low emission. This preliminary result provides a possible explanation for SADs.

11:20: **Prediction of arrival times of halo CMEs in the vicinity of the Earth**

Nishant Mittal, V. K. Verma

It is well known that the arrival times of Coronal Mass Ejections (CMEs) in the vicinity of the Earth play an important role for solar terrestrial environment. For the forecasting of Space Weather, It is necessary to predict the CMEs arrival time at 1 AU. Here, using LASCO halo CMEs data of 100 events those associated with ICMEs and observed during time period 1996-2009, we have tried to predict the arrival times as accurately as possible of full halo CMEs only. We have given an empirical model for predicting arrival time of CMEs. We have also studied arrival time of halo CMEs associated with type II radio bursts and X-class soft x-ray bursts, separately. We have also study the statistical properties of CMEs those are associated with type II bursts. The results obtained in the present investigation are discussed in the light recent scenario of CMEs understanding.

11:45 *Discussion*

12:00 - 1:30 **Lunch**

9.5 Working group 5: Onset Analysis and Inversion Tools

Avocet (Business Center)

10:30: **Analysing solar particle event onset: The effect of pre-event background — Analysing solar particle event onset: The effect of p**

Timo Laitinen, Kalle Huttunen-Heikinmaa (Univ. of Turku, Finland), Eino Valtonen (Univ. of Turku, Finland), and Silvia Dalla (UCLan, UK)

The release time of Solar Energetic Particles (SEPs) at the Sun has been traditionally determined by using the velocity dispersion analysis (VDA). In this method the release time of the first particles at the Sun and their apparent path length in the interplanetary space are determined by linearly fitting the observed onset times at 1 AU to the inverse of their velocity, at several SEP energies. The particles, however, scatter in the interplanetary space, resulting in a diffusive-like profile for the observed particles. The first, (*non-scattered*) particles have very low intensity compared to the event maximum, and may remain below the pre-event background intensities, whereas the particles forming the observed SEP onset have have likely suffered significant scattering. This causes a systematic error to the SEP event onset estimation. We discuss the implications of the interplanetary scattering to the VDA analysis, and quantify the errors in different pre-event background, SEP event and interplanetary scattering scenarios, for protons of energies 1-100 MeV. Using simulated events and simple theoretical considerations, we present an estimate for the systematic error, parametrised by the steepness of the intensity rise at the observed event onset at 1 AU. We discuss the challenges that spatially and temporally evolving particle acceleration at the Sun and cross-field interplanetary transport of SEPs pose to the onset analysis, and the determination of the SEP source.

10:55: **Determination of Solar Particle Release Time and Interplanetary Path Length from Observed Particle Onset**

Chee K. Ng, Cara Rakowski, Donald V. Reames, Alexis P. Rouillard, Allan J. Tylka, Tycho T. von Rosenvinge

The timing of solar energetic particle (SEP) release is important for understanding their origin by comparing it with the timing of X-ray and gamma-ray flare, CME launch, Type II radio emission, etc. SEP release time has usually been determined by plotting the observed onset time versus reciprocal particle velocity for a range of particle energies. The release time is given by the vertical intercept and the path length by the slope of the fitted straight line. The procedure assumes (a) 'simultaneous' release of both high and low energy particles - a reasonable approximation since the inferred release of GeV protons is generally delayed relative to the relevant flare/CME by only a few minutes (comparable to measurement errors) and (b) the first arriving particles have suffered little pitch-angle scattering and have been quickly focused to travel nearly parallel to the magnetic field. However, concerns on the accuracy of the above procedure have been raised regarding the validity of the approximation (b) above and the effect of SEP intensity background which delays the experimentally determined onsets (e.g., Lintunen and Vainio 2004; Saiz et al. 2005). We will discuss in this context the timing accuracy of the numerical SEP transport model of Ng, Reames, & Tylka (2003), which takes account of self-amplified waves. We will clarify the roles of the time spread arising from particle release over a broad range of pitch angles, interplanetary scattering, and the intensity background. We will also discuss our determination of the SEP release times and path lengths in the 2011 March 21 event observed by STEREOA/IMPACT detectors (Rouillard et al. 2012).

11:20: **Inversion Tools for the Study of SEP Release Mechanisms in the Low Corona**

Neus Agueda, SEPServer Consortium Team

In-situ observations of solar energetic particles (SEPs) in the heliosphere provide us with diagnostics of the release mechanisms of SEPs in the low corona. The observation of SEPs is made after the accelerated particles have propagated a long distance from the Sun in the interplanetary medium, being subjected to scattering off the fluctuations in the interplanetary magnetic field (IMF). Detailed simulations of the propagation of SEPs along the IMF allow us to use tools to invert the problem and gain information about the processes that contribute to SEP release and transport. To solve the inverse problem is to infer the values of the model parameters (solar injection profile and interplanetary scattering conditions) from the SEP intensities observed in the heliosphere. In contrast to velocity dispersion analyses and forward modeling approaches, the advantage is that it allows us to get information not only about the onset, but also the intensity and duration of the particle release process, without any a priori assumption about its functional form. We will review the results of applying the inversion methodology to the study of a decade of near-relativistic electron events observed by the Advanced Composition Explorer spacecraft. Two types of release episodes were found: short (¡ 15 min) and time-extended (¿ 1 h). Short injection episodes appear to be associated with flare processes and/or reconnection phenomena in the aftermath of the CME, while time-extended episodes suggest injection from CME-driven shocks. Finally, we will present the inversion software package that is being made publicly available to the solar and heliospheric community within the FP7 SEPServer project.

11:45: *Discussion*

12:00 - 1:30 **Lunch**

9.6 Working group 6: Free

12:00 - 1:30 **Lunch**

9.7 Working group 7: WG2/WG7 - Joint Analysis of Multiple Flares - Results and Methods

Caspian Tern (4th floor)

10:30: **How well do we know the total radiative energy loss in any given major eruptive flare?**

Dick Canfield,

This is intended to be a discussion, not a formal talk. Everyone is encouraged to contribute. To get the discussion started, I will outline a very simplified approach we've used in a few flares as a test of the Minimum Current Corona model for preflare energy and helicity storage (Kazachenko et al, Solar Phys 277, 165, 2012). To be provocative, I will compare and contrast the approaches that have been taken to estimating the values and uncertainties of these two quantities in solar and interplanetary physics.

10:50: **Energy components from the automated analysis of GOES and other data sets**

Daniel Ryan

Energy components from the automated analysis of GOES and other data sets.

11:10: **The thermal energy of 150 M- and X-class flares observed with AIA/SDO.**

Markus Aschwanden,

We measured statistics of length scales L, flare areas A, flare volumes V, the durations T, the fractal area 2-D dimension D2, diffusion coefficients kappa, diffusion exponents beta, maximum expansion velocities v, for 15 M- and X-class flares observed with AIA/SDO in all 7 coronal wavelengths (94, 131, 171, 193, 211, 304, 335 Å), with 5 different flux thresholds for flare area detections. From these measurements we can deduce also the emission measures EM(t), the DEM peak temperatures T_e, the DEM electron densities n_e, and the thermal energies $E_{th} = 3 n_e k_B T V$. We show the statistical occurrence frequency distributions and correlations of these parameters. The multi-wavelength with 7 AIA/SDO filters yields an unprecedented temperature coverage that allows us to determine the DEM sufficiently accurate to obtain a reliable estimate of the thermal energies of flares.

11:30: *Discussion*

12:00 - 1:30 **Lunch**

10 Saturday Session : 13:30 - 15:30

10.1 Working group 1: Imaging Techniques

Marina Overlook (Business Center)

13:30: **High Speed Imaging System for Solar Flare Research at Hida Observatory**

Tomoko Kawate, Takako Ishii, Yoshikazu Nakatani, Satoshi Morita, Kiyoshi Ichimoto, Satoshi Masuda

We developed a new flare monitoring system on Solar Magnetic Activity Research Telescope (SMART) at Hida observatory of Kyoto University. SMART consists of four telescopes, and we updated one of the telescopes whose aperture size is 250mm. The system aims to take white light (647.2nm) and H alpha images simultaneously with high spatial and temporal resolutions, i.e., with a frame rate of 25fps, spatial sampling of 0.215 arcsec per pixel (diffraction limit = 0.65 arcsec at 656nm) and a field of view of 344 arcsec x 255 arcsec. Our motivation is to reveal the emission mechanism of white light flares and to investigate the rapid evolution of magnetic connectivity by capturing H alpha flare kernels during impulsive phase of flares. Type I white light flares are known to be highly correlated with light curve and position of HXR, and sources are thought to be results of high energy electrons precipitated to the solar surface. However, how non-thermal electrons produce white light flares is still unclear, i.e., if they directly precipitate and heat up the WLF source, or if they indirectly excite the WLF source through the radiative backwarming by producing a X-ray source above it. One of our aim is to settle this problem by observing a number of white light flares and comparing their property with the energy spectra of non-thermal electron obtained by RHESSI. The system will provide highly complementary data sets with Hinode SOT, SDO AIA and other ground-based instruments with its high temporal resolution. Regular observation was started on Nov. 2011 by focusing an active region which is likely to produce flares. In this talk, we introduce our new system and report early results of observations.

13:50: **Bayesian approach to RHESSI imaging**

Anna Maria Massone, Alberto Sorrentino, Richard A. Schwartz, MIchele Piana

RHESSI data potentially contain very sophisticated information concerning crucial physical parameters like position, intensity and size of the source. However, imaging methods currently implemented in SSW are not fully reliable in the recovery of such quantities and, particularly, in the determination of the source size. We believe that Bayesian approaches have the power to recover such information in an unprecedentedly accurate fashion and further, that they are intrinsically able to provide the uncertainty with which such parameters are determined. Here we describe a first attempt to use a sequential Monte Carlo algorithm for RHESSI image reconstruction and validate it against different sets of synthetic data.

14:10: **A New Method for Producing High Quality RHESSI Images**

Richard Schwartz, Federico Benvenuto, Michele Piana, Annamaria Massone, Gabriele Torre

The scientific utilization of RHESSI data depends on the ability to produce images that fully utilize the spatial, temporal, and energy resolution of the instrument. To support this goal we introduce the Expectation Maximization (EM) method for the deconvolution of RHESSI x-ray images from the observed counts. The method utilizes the same basic Lucy-Richardson algorithm that is used in the removal of dispersive effects that occur in more traditional imaging systems where the measurements are made in pixels in a focal plane. What is different here is that our measurements are of counts measured as a function of the telescope rotation axis. Nevertheless,the technique has produced images of comparable quality to the Pixon method used in the RHESSI software with improvements in speed of factors of 10. We will soon introduce this method into the RHESSI software and expect a further improvement in speed of a factor of 4 so that we expect to produce high quality images within 10-15 seconds.

14:30: **Statistical approach for the reconstruction of regularized electron flux maps**

Federico Benvenuto, Gabriele Torre, Richard Schwartz, Anna Maria Massone, Michele Piana

We present a statistical approach for the construction of regularized electron flux maps at different energies starting from RHESSI measurements.

This approach relies on modeling the physical emission process by means of a bremsstrahlung kernel and the data formation process by coding RHESSI hardware characteristics in a projection matrix. Further, it implements maximum likelihood by means of an expectation-maximization algorithm which reconstruct the electron flux maps by iteratively fitting the count modulation profiles.

Joint energy and space regularization is guaranteed by an early stopping rule for the iterations and provides spatially resolved high energy electron maps that are fundamental for a deeper comprehension of the acceleration mechanisms during the flaring events.

14:50: *Discussion*

15:30 - 16:00 **Coffee Break**

10.2 Working group 2: Free

15:30 - 16:00 **Coffee Break**

10.3 Working group 3: Seismic Waves I

Blue Heron Ballroom

13:30: **Constraints on transport mechanisms derived from Physical conditions in recent flares with sunquakes**

S. Zharkov, V. Zharkova

13:50: **Sunspot Penumbrae as hosts of seismic sources generated by flares**

Alina Donea,

Seismic sources generated by solar flares seem all to be located in the penumbrae of sunspots in flaring active regions. Why? I will use the existing database of seismically active flares of solar cycles 23 and 24 to analys physical properties of seismic sources and their host penumbrae, which may help answering this question.

14:10: *Discussion*

15:30 - 16:00 **Coffee Break**

10.4 Working group 4: Free

15:30 - 16:00 **Coffee Break**

10.5 Working group 5: Connectivity, Longitudinal Spread and Transport

Avocet (Business Center)

13:30: **CME Deflection and Changes in Connectivity as Revealed by MHD Simulations**

N Lugaz, I. I. Roussev, N. Schwadron, C. Downs, K. Shibata, M. Gorby, I. V. Sokolov

We will discuss magneto-hydrodynamic (MHD) simulations of CMEs and associated phenomena. In particular, our focus will be on the changes in magnetic connectivity and the opening of previously closed field lines during and after an eruption and discuss the consequences for the acceleration and transport of energetic particles. We will also present recent efforts in coupling MHD codes with a particle acceleration code to study the acceleration of SEPs and their transport in the corona.

13:55: **Diagnostics of sector boundaries from energetic particle dynamics in the HCS during a magnetic reconnection**

Zharkova V.V., O.Khabarova and R. Dobranskis

In this talk we discuss various aspects of solar wind particle energisation during their passage through the reconnecting heliospheric current sheet in the attempt to reconcile some contradictory features in defining the sector boundaries for HCS. We will show that the 2.5D PIC model can account for the most observable features in the energetic particles of the solar wind at their crossing of the sector boundary. Some implications for modelling the similar processes in the solar corona will be also discussed.

14:20: **The longitudinal spread and onsets of solar energetic particle events**

Alexis Rouillard,

The physical mechanisms that accelerate particles to high energies are still debated with two serious candidates being flares and CME-driven shocks. It is generally agreed that SEPs accelerated in solar flares can have 1000-fold enhancements in 3He/4He and enhanced heavy ions thought to be the result of resonant wave-particle interactions in the flare site (with ions being highly stripped of orbital electrons by the hot environment). Recent measurements made by STEREO suggest that a single flare-associated 3He/4He event can be observed over a very wide longitude band (Wiedenbeck et al. 2010). This is puzzling since measurements near 1AU show that particles cannot easily move across field lines in the time available during their transport from the Sun (e.g. Mazur et al. 2000; Chollet and Giacalone 2011). Similarly gradual SEP events can be observed at all longitudes in the ecliptic plane within a few hours of the launch of a single fast CME event (e.g. Rouillard et al. 2013). We will review the physical mechanisms that can inject/channel particles over a wide longitude range, they include magnetic field line meandering, coronal magnetic field line slipping, coronal diffusion, significant lateral expansions of shocks). In some particle events, the onset of particle flux increase measured in situ can be delayed by several tens of minutes to several hours relative to the flare impulsive phase, we will review the interpretations that have been put forward to explain these delays, they include: delayed shock formation in the corona, lateral expansion of the shock, delayed magnetic connectivity with the flare site (including 'footpoint exchange') or with the current sheets formed at the back of the CME. We will review observations that, combined with our current knowledge of coronal and heliospheric physics, either favor a shock or flare origin of SEPs.

14:45: *Discussion*

15:30 - 16:00 **Coffee Break**

10.6 Working group 6: Free

15:30 - 16:00 **Coffee Break**

10.7 Working group 7: Free

15:30 - 16:00 **Coffee Break**

11 Saturday Session 4: 16:00 - 17:30

11.1 Working group 1: Wrap up

Marina Overlook (Business Center)

16:00: *Discussion and wrap up on all of WG1*

11.2 Working group 2: Wrap up

Caspian Tern (4th floor)

16:00: *Discussion and wrap up on all of WG2*

11.3 Working group 3: Wrap up

Golden Eagle (Business Center)

16:00: *Discussion and wrap up on all of WG3*

11.4 Working group 4: Wrap up

Pelican (Business Center)

16:00: *Discussion and wrap up on all of WG4*

11.5 Working group 5: Wrap up

Avocet

16:00: *Discussion and wrap up on all of WG5*

11.6 Working group 6: Free

11.7 Working group 7: Free

12 Posters

Poster session: Friday 12:00 - 18:00

Blue Heron Ballroom

A Comprehensive Overview of the 2011 June 7 Solar Storm

D. Shaun Bloomfield, E Carley, P T Gallagher, P A Higgins, D M Long, S A Maloney, S A Murray, A O 'Flannagain, D Perez-Suarez, D Ryan, P Zucca

A comprehensive overview is presented of a particularly well observed event that commenced on 2011 June 7. Multi-wavelength observations from a multitude of space-based (SDO, GOES, RHESSI, STEREO, ACE) and ground-based observatories (Kanzelhohe, Ondrejov, Bleien, RSTO) are used to characterize the evolution of this eruptive event. A variety of techniques are employed to study the wide range of phenomena. Active region evolution is investigated prior to the event using an automated detection algorithm (SMART) and localized regions of interest. Emitting plasma properties are derived during the flare onset, impulsive, and peak phases using an optimized soft X-ray (SXR) background subtraction method (TEBBS), while flare-related energy deposition is studied via motions of the UV and hard X-ray (HXR) flare arcade foot points. Distance-time plots are utilized to determine the kinematics of the propagating coronal bright front (CBF), the erupting filament, and the coronal mass ejection (CME). Finally, ballistic propagation is used to investigate the solar wind conditions of the inner heliosphere into which the CME propagates and to estimate energetic particle and CME arrival times at L1 near Earth. The event begins with the destabilization of a filament in the core of NOAA active region 11226 following a B-class SXR flare at one foot point. The filament lift-off is accompanied by an M-class SXR flare at 06:16 UT, with the filament material accelerated to form the core of a CME. This acceleration phase is co-temporal with HXR and Type III radio bursts, as well as rapid UV and HXR arcade foot-point motions. Co-temporal with the flux-rope acceleration, a large-scale CBF is launched across the solar disk at a speed <500 km s^{-1}. The primary flare energy release also accelerates electrons and protons that escape along open field lines to arrive at L1. The CME arrives at L1 later than expected by simple zero-drag propagation, indicating that the initially fast CME front ($\sim$1200 km s^{-1}) tends towards the ambient up-stream solar wind velocity ($\sim$300-500 km s^{-1}) during propagation.

Dual Trigger Of Transverse Oscillations In A Prominence By EUV Fast And Slow Coronal Waves: SDO/AIA And STEREO/EUVI Observations

Sanjay Gusain, Claire Foullon

We analyze flare-associated transverse oscillations in a quiescent solar prominence on 8-9 September, 2010. Both the flaring active region and the prominence were located near the West limb, with a favorable configuration and viewing angle. The fulldisk extreme ultraviolet (EUV) images of the Sun obtained with high spatial and temporal resolution by the Atmospheric Imaging Assembly (AIA) aboard the Solar Dynamics Observatory, show flare-associated lateral oscillations of the prominence sheet. The STEREO-A spacecraft, 81.5° ahead of the Sun-Earth line, provides on-disk view of the flare-associated coronal disturbances. We derive the temporal profile of the lateral displacement of the prominence sheet by using the image cross-correlation technique. The displacement curve was de-trended and the residual oscillatory pattern was derived. We fit these oscillations with a damped cosine function with a variable period and find that the period is increasing. The initial oscillation period (P0) is $\sim$28.2 minutes and the damping time $\sim$44 minutes. We confirm the presence of fast and slow EUV wave components. Using STEREO-A observations we derive a propagation speed of $\sim$250 kms^{-1}for the slow EUV wave by applying time-slice technique to the running difference images. We propose that the prominence oscillations are excited by the fast EUV wave while the increase in oscillation period of the prominence is an apparent effect, related to a phase change due to the slow EUV wave acting as a secondary trigger. We discuss implications of the dual trigger effect for coronal prominence seismology and scaling law studies of damping mechanisms.

Bayesian model comparison of solar flare spectra

Jack Ireland, Gordon D. Holman

The detailed understanding of solar flares requires an understanding of the physics of accelerated electrons, since electrons carry a large fraction of the total energy released in a flare. Hard X-ray energy flux spectral observations of solar flares can be fit with different parameterized models of the interaction of the flare accelerated electrons with the solar plasma. Each model describes different possible physical effects that may occur in solar flares. Bayesian model comparison provides a technique for assessing which model best describes the data. The advantage of this technique over others is that it can fully account for the different number and type of parameters in each model. We demonstrate this using Ramaty High Energy Solar Spectroscopic Imager (RHESSI) spectral data from the GOES (Geostationary Operational Environmental Satellite) X4.8 flare of 23 July 2002. We suggest that the observed spectrum can be reproduced using two different parameterized models of the flare electron content. The first model assumes that the flare-accelerated electron spectrum consisting of a single power law with a fixed low energy cutoff assumed to be below the range of fitted X-ray energies, interacting with a non-uniformly ionized target.

The second model assumes that the flare-accelerated electron spectrum has a broken power law and a low energy cut-off, which interacts with a fully ionized target plasma. The low energy cut-off in this model is a parameter used in fitting the data. We will introduce and use Bayesian model comparison techniques to decide which model best explains the observed data. This work is funded by the NASA Solar and Heliospheric Physics program.

A Survey of Pre-Impulsive Hard X-Ray Emission from RHESSI Flares

Andrew Marsh, David M. Smith, Säm Krucker

We present a survey of pre-impulsive flare emission in a set of non-occulted flares observed with the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI). This emission can take the form of a gradual rise, and sometimes a distinct, brief plateau (e.g. the November 4, 2003 X28 flare). Pre-impulsive emission gives an opportunity to look for coronal acceleration sites without contamination from footpoint or thermal loop emission, even without occultation. There is also the opportunity to directly compare the pre-impulsive emission to where the footpoint and loop emission later appears, something that is not possible for occulted flares. We are preparing a systematic sample of images and spectra of all non-occulted RHESSI flares above GOES-class M1 that have good coverage of the pre-impulsive and impulsive data. While the hard x-ray images later in the flare will serve as a starting point to discuss magnetic loop and reconnection geometries, we will ultimately include EUV, magnetogram, and other data to clarify the geometry of the initial reconnection. As with all spectra from hard x-ray coronal sources, the energy spectra from these pre-impulsive measurements may allow a relatively direct measurement of the electron spectrum produced by the reconnection process.

Observations of the Flux Density of Some Interplanetary Type II and Type III Radio Bursts and Initial Comparison with Theory

Amaal Mohamed, Iver Cairns, Dean Hillan, and Peter Robinson

The measured intensity of a radio signal depends on the effective antenna length, which may vary with (at least) the plasma properties and radiation frequency. Here the effective antenna lengths are estimated as a function of frequency for the RAD1 and RAD2 instruments on the Wind spacecraft when in SUM mode. This is done by calibrating against the known galactic background radiation spectrum after removal of receiver noise and thermal plasma noise where possible. Flux density spectra and lower limits to the maximum brightness temperature are determined for three type II and three type III radio bursts based on two calibration methods, one of which uses the effective antenna lengths as a function of frequency. The second calibration method uses Wind data for the relative flux in dB to equate the minimum flux observed with the galactic background and receiver noise. The results emphasize that the second method is more successful in obtaining calibrated type II and III fluxes. Calibrated flux densities obtained show that The type IIs have similar maximum flux densities to the type III events in this sample, but the type IIs are much more variable in frequency and time. Theoretical predictions are obtained for shocks moving with a suitable range of initial speeds and accelerations. Dynamic spectra are then predicted for the three selected type II events using the theory of Knock et al. [2001] and a simple, unstructured, solar wind model. Because of the continuous emission of 24-26 August 1998 that is present in a wide range from 100 MHz to 21 kHz, albeit with strongly varying intensity, a comparison between its observed and predicted dynamic spectra is presented. The agreement between theory and data is discussed and the implications described for future modeling.

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Source Region of the Decameter-Hectometric Type II Radio Burst: Shock-Streamer Interaction Region

Chenglong Shen, Chijian Liao, Yuming Wang, Pinzhong. Ye, Shui Wang

A method was developed to check the source region of the Decameter-Hectometric (D-H) type II radio busrt. In this method, the SOHO/LASCO observations are used to find the position of the shock. As the D-H type II radio burst is caused by the shock driven by coronal mass ejection (CME), the position of the shock front is defined as the possible source region of the type II radio burst (Sshock). In addition, the WIND/WAVES and the SOHO/LASCO polarized brightness observations are used to find the possible source region of the radio burst (S) where the electron density is suitable to generate the type II radio burst at the frequency range of the observed radio burst. Thus, the overlap of the shock and S is the source region of the type II radio burst. By appling this method to two typical events, we found that the sources of these two events are located in the interaction regions between shocks and streamers. In addition, by checking the intensity of the radio burst and the interaction between the shock and streamer, we suggest that the interaction between the shock and the streamer will enhance the shock strength significantly.

Comparison of Electron density distributions derived using the spherically symmetric inversion and 3D tomography

Tongjiang Wang, Maxim Kramar, Joseph M. Davila

The distribution of the electron density is one of the most fundamental roperties of the coronal plasma. Its measurement is very important for our understanding of physical processes in the solar corona, and for the interpretation of solar radio emission produced by coronal eruptions such as CMEs. The derivation of the electron density in the K-corona from its white-light polarized radiance (pB) is a classical problem of coronal physics. A simple and commonly-used method based on the Thompson scattering theory and the assumption of spherical symmetry has been applied to obtain the electron density models for the coronal hole and background corona. In order to check the limits and validity of the spherical symmetrical model, we applied it to synthetical pB-images simultaneously seen from A and B spacecrafts. These synthetical pB-images were produced by line-of-sight integrating the 3D coronal electron density reconstructed by the regularized tomography method based on STEREO/COR1 observations. We find that when STEREO-A and -B are separated by an angle less than 40 degree s (or more than 140 degree) their radial pB light curves at some streamer belts are consistent, suggesting a good condition there for the spherically symmetry assumption. We find at these locations the spherically symmetric inversion can derive the radial electron density distrubition close to that in the cross-section of the 3D density tomographic reconstruction (used as testing model) at the plane of sky. We also discuss the restrictions on the application of the spherically symmetric inversion.

Origins of the Highest Energy Solar Energetic Particles

G.A. de Nolfo, M. Boezio, U. Bravar, E. Christian, M. Martucci, E. Mocchiotti, R. Munini, M. Ricci, J. Ryan, S. Stochaj, J. Stockton, N. Thakur

Gamma-ray observations of solar flares extend well above 40 MeV and are observed both in the impulsive phase but more often in a second phase or extended phase of emission. The nature of this emission has been a challenge to explain both due to the extreme energies and the long temporal durations observed. The highest energy emission has generally been attributed to pi-meson production from the interaction of high-energy protons with the ambient matter. The nature of this extended emission is quite different from the impulsive phase and has led scientists to conclude that the two processes are distinct, one mainly generated by stochastic acceleration along closed magnetic field lines and the other attributed to delayed shock acceleration on open coronal field lines that should allow particles to escape more readily. Being able to test whether particles escape from the extended emission process has been hampered by the lack of instrumentation to measure both the high-energy component of the flare emission as well as the corresponding population of solar energetic particles above the pion production threshold of 200 MeV. The 2012 March 7 (X5.4, N18E31) solar flare produced extended emission in high-energy gamma rays that were registered by Fermi/LAT. The event also produced solar energetic particles exceeding 500 MeV that were registered by the Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics (PAMELA). We present, for the first time, a direct comparison between the accelerated ion population at the flare derived from the observations of Fermi/LAT with measurements from PAMELA of solar energetic particles in the energy range that corresponds to the pion-related emission observed with Fermi. We address the question of the origin of the highest energy SEPs and their relation to flare extended emission. On Behalf of PAMELA Collaboration

Toward Prediction of Gradual SEP Events in the Heliosphere

Dusan Odstrcil, Janet Luhmann, Hyesook Lee, Aleksandre Taktakishvili

A super-fast coronal mass ejection (CME), with estimated speed of 3435 km/s, was observed in coronagraphs on 2012-07-23. It arrived to Stereo-A spacecraft in about 17 hours and caused very strong solar energetic particles (SEP) events over a wide longitudinal extent. We use the WSA-ENLIL-Cone-SEPMOD modeling tool to investigate effects of this event in the heliosphere. We found that it is necessary to extend the computational domain up to the Jupiter orbit to simulate the connectivity of interplanetary magnetic field (IMF) lines from planets and space-probes to an interplanetary shock. This is caused by the spiraling nature of the IMF lines and by an interplanetary shock that is strong even at large helioscentric distances. We will present simulation results of this CME together with nearby CMEs, compare with in-situ observations, and present predicted shock parameters and proton energy spectra.

Energetic Particle Observations During the Early Stages of ~ 25 MeV Proton events in Solar Cycles 23 and 24

Ian Richardson, Hilary Cane, Tycho von Rosenvinge

We summarize the properties of energetic particles during the early stages (~first 12 hours) of the more than 400 solar energetic particle events that included ~ 25 MeV protons during solar cycles 23 and 24, the latter including observations from the STEREO spacecraft separated in heliolongitude from the Earth. We examine the related solar events, including CMEs, flares and radio emissions, and discuss the implications for particle acceleration and transport.

PAMELA Measurement of the 2012 May 17 GLE

James M. Ryan, M. Boezio, U. Bravar, E.R. Christian, G.A. de Nolfo, M. Martucci, E. Mocchiutti, R. Munini, M. Ricci, S. Stochaj , J. Stockton,

The highest-energy solar energetic particle events, those that produce a ground level enhancement (GLE) on Earth, remain a challenge to explain. These events are typically associated with large flares and fast CMEs, making it difficult to separate key signatures of particle acceleration. Generally speaking, it is thought that the bulk of the acceleration of GLEs is from coronal and/or interplanetary shocks, perhaps driven by large CMEs. Shock acceleration to GeV energies depends on the strength of the shock, its speed, the diffusion coefficient upstream and downstream of the shock, and the altitude for which the particles are finally released to the interplanetary medium. Furthermore, there is evidence that GLE production requires special conditions such as precursor events that generate a seed population for further acceleration (Gopalswamy, Mewaldt). However, observations of high charge states and enhancements in Fe/O ratios from ACE has shifted the attention back to acceleration within the flare itself or perhaps some admixture of flare and shock acceleration. The Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics (PAMELA) presents a unique opportunity to study the highest energy SEP events. It spans the energy or rigidity range between the highest data channel of ACE or GOES and neutron monitors. Furthermore, it measures electrons, positrons, 3He, and ions, up to and including carbon. PAMELA registered the 2012 May 17 GLE covering an energy range from several hundred MeV up to almost a GeV. We present the spectral evolution, net composition, and timing of the 2012 May 17 GLE and discuss the implications for the nature of the acceleration and the conditions of the inner heliosphere.

SEPServer - A new tool for the analysis of SEP events

Rami Vainio, SEPServer consortium

SEPServer (www.sepserver.eu) is a three-year collaborative project between eleven European partners that will provide the solar energetic particle (SEP) research community with a new tool for the analysis of solar energetic particle events: a server providing access to a number of energetic particle datasets and related electromagnetic emission observations, as well as to simulation-based analysis tools designed for obtaining information on the properties of the energetic particle sources near the Sun. We will also scan the observations for SEP events and provide preliminary analysis results on them. This poster will present the server prototype and a summary of the first results from the project: a catalog of 114 SEP events from 1997-2010 and statistical analysis results of the event onset times in relation to the solar electromagnetic emissions related to the events. We will also present some case studies of well-observed events performed during the first two years of the project, with the aim of providing insights into the accuracy of different data-analysis methods commonly used for obtaining estimates of the timing the energetic particle release.

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Do Type III-associated escaping electron beams cool the corona?

Pascal Saint-Hilaire, Linghua Wang, Nicole Vilmer, Alain Kerdraon

A recent study of decimetric Type III radio burst emission from data from the Nancay Radio Heliograph will be presented. It examined sizes, locations, and fluxes of close to 10,000 decimetric Type III bursts.The flux study suggests that electron beams related to Type III emission could be responsible for carrying energy away from the corona in a proportion similar to coronal heating by EUV nanoflares. This tentative conclusion was reached from comparing Type III dN/dS distributions to the dN/dS of EUV/SXR nano-/micro-flares. The biggest uncertainty is the radiative efficiency, i.e. the ratio of radiated energy in decimetric Type III bursts and the energy of the electrons in the beams associated with them. We will constrain this value through other, new observations: we have already computed the amount of Type III radiated energy from NRH observations, and we will now compare them with the amount of energy in the corresponding beam electron detected in-situ by the Wind spacecraft. Given our sample of close to 10000 decimetric Type IIIs, we expect a decent amount of in-situ beam energy estimates from magnetically connected events. Moreover, we will compare with X-ray-derived energies from corresponding RHESSI (micro)flares, when such an association exists.

Resistive flux emergence and the response of the solar atmosphere

Santiago Vargas Dominguez, Lidia van Driel-Gesztelyi

We analyse data from Hinode spacecraft during the emergence of AR 11024 focused on small-scale portions and discover the appearance of very distinctive small-scale and short-lived dark features in Ca I I H chromospheric filtergrams and Stokes I images. Energy release in the low chromospheric line is detected while the dark features are fading. In time series of magnetograms a diverging bipolar configuration is observed accompanying the appearance of the dark features and the brightenings. The observed phenomena are explained as evidencing elementary flux emergence in the solar atmosphere, i.e. small-scale arch filament systems rising up from the photosphere to the lower chromosphere with a length scale of a few solar granules.

Study of the time delay and correlation between microwave and hard X-ray emissions from flares observed by KSRBL and RHESSI

Jungeun Hwangbo, Su-Chan Bong, Sung-Hong Park, D.-Y. Lee, Y. D. Park

We studied the time delays between the radio burst and the hard X-ray emission observed by the microwave radio telescope, the Korean Solar Radio Burst Locator (KSRBL), and the Reuven Ramaty High-Energy Solar Spectroscopic Imager (RHESSI). KSRBL was installed at Korea Astronomy and Space Science Institute in August 2009. It records the spectra of solar microwave (0.5 18GHz) bursts with 2s time and 1MHz frequency resolution, and locates their positions on the solar disk. The time profiles of microwave radio bursts observed by KSRBL were compared with hard X-ray time profiles, and the time delay and correlation between them were analyzed in different radio frequencies and hard X-ray energy channels.

Spatially resolved polarization of hard X-rays from solar flares

Natasha Jeffrey, Eduard Kontar

In the Sun's atmosphere, flare events produce high energy electrons that mostly propagate into the chromosphere, producing hard X-ray (HXR) bremsstrahlung emission. HXR photons emitted away from the Sun will propagate freely into interplanetary space while HXRs emitted towards the photosphere are either absorbed or Compton scattered. Compton scattering leads to a reflected albedo component that is always observed in conjunction with the primarily produced bremsstrahlung component, and hence leads to an alteration in the observed HXR emission, greatest at peak scattering energies of 20-50 keV. Amongst the many other important consequences of such a reflection, the albedo component also alters the polarization of the primary HXR source, a property that is highly dependent on the directivity of the HXR distribution and hence provides us with a method of determining the anisotropy of the radiating electron distribution. We created Monte Carlo simulations of photon transport in the photosphere in order to simulate the radiation transfer of polarized X-ray photons and to obtain the Stokes parameters for each source. We present the first results of spatially resolved polarization for a single HXR source due to the presence of a photospheric albedo component. Our results show for an HXR source at a single disk location, spatially resolved polarization substantially changes with photon and hence electron directivity, with changes for both the degree and angle of polarization. Hence our results highlight how spatially resolved polarization measurements could help constrain electron directivity for an individual flare and optimise future X-ray imaging polarimetry missions.

On the physical meaning of the n-distributions in solar flares and soft X-ray line spectra

Marian Karlicky, Elena Dzifcakova, Jaroslav Dudik

During the flares, the electron distribution function can be affected by a presence of accelerated electrons, return current, and double layers. The shape of the electron distribution results in changes of ionization equilibrium and relative intensities of the allowed and satellite lines in X-ray spectra. The electron distributions corresponding to moving Maxwellian, n-distribution, distribution in double layers and combination of double layer distribution with Mawellian one have been used to calculate synthetic soft X-ray spectra of Si XII - Si XIV allowed and satellite lines and explain their observed features. The low energy part of the distribution function controls relative abundances of ions and therefore, the relative intensities of lines belonging to different ionization degree of Si. The gradient of high energy part of distribution affects the relative intensities of allowed lines to satellite ones. The spectrum for the combination of the distribution formed in double layer with Mawellian one shows the best agreement with observations.

Connecting Imaging and In Situ Observations of CMEs: Analysis of STEREO CME Trajectories and their Solar Origins

Paulett Liewer, K. Amla, J. R. Hall, Christian Moestl, Olga Panescenco

Understanding the connection between Coronal Mass Ejections and ICMEs observed at 1 AU is important for Space Weather; it is one of the primary goals of the STEREO mission. Here, we identify and analyze 19 STEREO CMEs that have been detected in situ by STEREO, ACE or WIND. We compare the observed speeds and arrivals time with trajectories predicted by three different techniques using data from STEREO's coronagraphs and heliospheric imagers. In this way, we study the feasibility of using heliospheric imaging to forecast CME arrival times. For nine of these CMEs, the source locations can be determined accurately and we determine the deviation of the CMEs trajectory from purely radial propagation near the Sun. The deviations from radial are analyzed in terms of the large-scale structure of the coronal magnetic fields.

Hα filter commissioning and observation of the Sun from the UND Observatory

Rakesh Nath, Paul S. Hardersen

The sun is the most obvious astronomical object that has not had effective continuous monitoring. In the quest to bring better solar physics and solar monitoring programs to UND, we are actively working on setting up an H-alpha solar filter which can be used for continuous monitoring of the sun. The H-alpha wavelength is set up at 656.3nm, and pertains to the region of the sun known as the chromosphere.The H-alpha filter is Fabry-Perot Etalon that observes the sun in a 0.4 A narrow band frequency. Continuous monitoring in this frequency is essential to observe life cycles of specific features such as prominences, filaments etc which have not been mapped for their entire life time before. The goal of this exercise would be to evaluate which such features are observable and what kind of image processing algorithms we could apply to extract effective scientific benefit from the images. The program would be capable of continuously monitoring the sun and uploading images to the observatory website for download using ftp methods. The observatory is actively engaged in modifying two of its telescopes for this goal.

Impact of Solar wind parameters on Geomagnetic Parameter during cycle-23

Balveer Singh Rathore, Subhash Kaushik, Dinesh C. Gupta

Magnitude of geomagnetic effects largely depends upon the configuration and strength of potentially geo-effective solar/interplanetary features. In the present study the identification of 200 geomagnetic storms associated with disturbance storm time (Dst) decrease of less than -50 nT have been made, which are observed during 1996-2009. The study is made statistically between the Dst strength (used as an indicator of the geomagnetic activity) and the value obtained by solar wind plasma parameters and IMF B as well as its components By and Bz. We have used the hourly values of Dst index and the wind measurements taken by various satellites. We observed that IMF B is highly geo-effective during the main phase of magnetic storms, as well as at the time IP Shock. The correlation between Dst and wind velocity is higher, as compared with IMF southwards components Bz and ion density. It has been verified that geomagnetic storm intensity is correlated well with the total magnetic field strength of IMF better than with its southward component at time of IP shock and instant of Dst minimum.

RHESSI hard X-rays and NoRH microwave emission from a sigmoid flaring structure observed with SDO/AIA

Paulo Simoes, Lyndsay Fletcher, Hugh Hudson

Solar flares emission at Hα and EUV wavelengths are often observed in the form of two ribbons, and this has been regarded as evidence of magnetic reconnection. Hard X-ray (HXR) emission from accelerated electrons are also frequently spatially well correlated with the positions of such ribbons, suggesting regions of precipitation of those electrons into the dense chromosphere. We report observations of the M6.3 solar flare that occurred in 2012 March 09 with a GOES peak at 03:22UT. The event is associated with the active region NOAA 11429, near the disk center (N17W12), and triggered a halo CME. Ultraviolet images taken with Atmospheric Imager Assembly (AIA) on board of the Solar Dynamics Observatory (SDO) reveal a highly complex flaring loop system in a sigmoid shape. Longer wavelengths reveal two highly sheared ribbons, far from the typical quasi-parallel configuration, but still separated by the magnetic neutral line. The ribbons seem to be connected by coronal field lines, as suggested by shorter EUV wavelengths images. Signatures of accelerated electrons were detected in HXR by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) and in microwaves by Nobeyama Radio Polarimeter (NoRP) and Heliograph (NoRH). The position of the two HXR footpoints at 30-50 keV correlate spatially well with each one of the ribbons, and 17 GHz and 34 GHz emission morphologies are clearly associated with the EUV flaring structure. Moreover, EUV images also show a system of larger scale loops, rooted on the flare region, rapidly collapsing during the course of the flare. We discuss the observed spatial morphologies and propose a scenario for the magnetic topology and evolution of the accelerated particles, suggesting an association between magnetic reconnection, particle acceleration and the collapsing field loops.

How Well Do We Know the Sunspot Number?

Leif Svalgaard

A hundred years after Rudolf Wolfs death, Hoyt et al. (1994) asked "Do we have the correct reconstruction of solar activity?" After a heroic effort to find and tabulate many more early sunspot reports than were available to Wolf, Hoyt et al. thought to answer that question in the negative and to provide a revised measure of solar activity, the Group Sunspot Number (GSN) based solely on the number of sunspot groups, normalized by a factor of 12 to match the Wolf numbers 18741991. Implicit in that normalization is the assumption or stipulation that the Wolf number is correct over that period. In this talk we shall show that that assumption is likely false and that the Wolf number (WSN) must be corrected. With this correction, the difference between the GSN and WSN becomes even more disturbing: The GSN shows either a plateau until the 1940s followed by a Modern Grand Maximum [MGM], or alternatively a steady rise over the past three hundred years, while the (corrected) WSN shows no significant secular trend and no MGM. As the sunspot number is often used as the basic input to models of the future evolution of the Earth's environment and of the climate, having the correct reconstruction becomes of utmost importance, and the difference between GSN and WSN becomes unacceptable. By re-visiting the construction of the GSN we show how the GSN can be reconciled with the WSN, resolving the issue. We finally report on recent discrepancies between various indices of solar activity which raise the issue of the very meaning of the sunspot number and of the future evolution [and predictability] of solar activity. The talk is based on work in support of the Sunspot Number Workshops: http://ssnworkshop.wikia.com/wiki/Home