Abstracts

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Plenaries and Invited Talks:

Cauzzi, Gianna (for the DKIST team)

DKIST and prospects for ground-based observations of solar activity

The Daniel K Inouye Solar Telescope (DKIST) is a 4-m, off-axis facility being built at the summit of Haleakala (Maui, Hawai'i) by the the National Solar Observatory (NSO), in conjunction with the broader solar community. First light is currently expected for early 2020.

In this presentation we will review the DKIST capabilities and its current status, including the state of first light instrumentation. In particular, we will focus on the prospects for observations of solar activity and flares, by addressing a subset of science cases that can benefit from the DKIST enhanced spatial and temporal resolution, as well as novel diagnostics.

Finally, we will present the ongoing effort by NSO in preparing for the early science of DKIST in the context of the Critical Science Plan (CSP), including opportunities for community involvement.

Gary, Dale (presented by Bin Chen)

EOVSA Results & Status: Microwave Spectral Imaging with The Expanded Owens Valley Solar Array (EOVSA)

The Expanded Owens Valley Solar Array (EOVSA) is now fully operational, and undergoing commissioning activities to improve its calibration and automate its imaging capabilities. EOVSA is a newly expanded and upgraded, solar dedicated radio array that has 13 antennas equipped with wide-band receivers designed to cover the 1–18 GHz frequency range. Its capabilities have steadily improved from the first total power spectral data taken on 4 antennas in fall of 2014, to the first rough images in late-2016, to its current, fully operating state. The talk describes its operation, demonstrates its performance for both burst and full-disk imaging, and shows some highlights from the Apr. 2017 series of solar bursts. Its 1-s time resolution and imaging at hundreds of frequencies provides a new perspective on the structure of the solar corona and acceleration of high-energy electrons. The talk emphasizes the remarkable temporal and spectral resolution of the instrument, together with joint RHESSI hard X-ray and SDO EUV observations.

Glesener, Lindsay

FOXSI Results & Space Prospects: What have we learned from FOXSI-1 and FOXSI-2?

The FOXSI sounding rocket has demonstrated the usefulness of focusing optics for hard X-ray observation of the Sun in two successful flights. Scientific objectives centered on measuring impulsively heated plasma in active regions and searching for hints of flares in the quiet Sun. Serendipitously, FOXSI has also observed three microflares, including one of sub-A class. This presentation will survey the observations and results from the first two flights, will describe the development in progress for FOXSI-3, and will provide an update on proposal efforts for a spacecraft version of FOXSI.

Jeffrey, Natasha

How to determine solar flare non-thermal electron energetics: the “warm-target” model

X-ray observations are a direct diagnostic of fast electrons produced in solar flares, energised during the energy release process and directed towards the Sun. A cold thick target model is ubiquitously used for inferring fast electron properties, since it provides a simple analytic relationship between the accelerated and the emitting electron spectra, with the latter quantity readily obtained from hard X-ray spectral observations. However, such a model, used for the last 50 years, is unable to determine the total electron acceleration rate or energy due to the low-energy cut-off problem. The use of a more realistic model, properly accounting for the properties of the flaring plasma, and the collisional diffusion of electrons eliminates the low-energy cut-off problem of the cold thick target model. The correct use of the “warm-target” fitting function (f_thick_warm.pro, now available in OSPEX) will be discussed and its outputs compared to the widely-used cold thick target model, showing how its use helps to constrain the electron acceleration in solar flares.

Woods, Tom

MinXSS Results & Status: New Solar Soft X-Ray (SXR) Spectral Studies with Data from the MinXSS CubeSat

CubeSats, at about the size of a shoe box, have been an educational tool for students to develop small satellites since 1999. The NSF CubeSat program that started in 2008 merged the educational aspect of CubeSats with science, and finally NASA embraced CubeSats in 2014 for science missions. The University of Colorado’s Miniature X-ray Solar Spectrometer (MinXSS) is the first NASA science division mission launched as a CubeSat in 2016, and dozen more NASA science CubeSats will be launched in the next few years. The MinXSS CubeSat is a 3-Unit (3U) CubeSat to study the energy distribution of solar flare soft X-ray (SXR) emissions of the quiet Sun, active regions, and during flares and to model the solar SXR impact in Earth’s ionosphere, thermosphere, and mesosphere (ITM) using these MinXSS solar measurements. The energy variability in the SXR range can vary by more than a factor of 100, yet we have limited spectral measurements in the SXR to accurately quantify the spectral dependence of this variability. Energy from SXR radiation is deposited mostly in the ionospheric E-region, from ~80 to ~150 km, but the precise altitude is strongly dependent on the SXR spectrum because of the steep slope and structure of the photoionization cross sections of atmospheric gases in this wavelength range. The new MinXSS solar SXR spectra measurements and associated modeling of the solar spectra and Earth’s ITM response will address these outstanding issues. The MinXSS primary instrument is the Amptek X123 X-ray spectrometer that measures over the range of 0.5 to 30 keV [2.5–0.04 nm] with a nominal 0.15 keV energy resolution [spectral resolution of 0.7 nm at 2.5 nm and 0.0002 nm at 0.04 nm]. This presentation will include a brief overview of the MinXSS CubeSat design and MinXSS science results about the solar SXR spectra measurements and variability in 2016.

Instrumentation Plenary:

Casadei, Diego (presented by Erica Lastufka)

Design of MiSolFA Hard X-Ray Imager

Advances in the study of coronal electron-accelerating regions have so far been limited by the dynamic range of X-ray instruments. A quick and economical alternative to desirable focusing optics technology is stereo observation. The micro-satellite MiSolFA (Micro Solar-Flare Apparatus) is designed both as a stand-alone X-ray imaging spectrometer and as a complement to the Spectrometer/Telescope for Imaging X-rays (STIX) mission. These instruments will be the first pair of cross-calibrated X-ray imaging spectrometers to look at solar flares from very different points of view. MiSolFA will achieve indirect imaging between 10 and 60 keV and provide spectroscopy up to 100 keV, equipped with grids producing moiré patterns in a similar way to STIX. New manufacturing techniques produce gold gratings on a graphite or silicon substrate, with periods ranging from 15 to 225 µm, separated by a distance of 154.7 mm, to achieve angular resolutions from 10” to 60”. We present the progress of the imager design, the performance of the first prototypes, and reach out to the community for further scientific objectives to consider in optimizing the final design.

Gan, Weiqun

ASO-S: Progress and Prospect

ASO-S (Advanced Space-base Solar Observatory) is a mission proposed in 2011 for the 25th solar maximum by the Chinese solar community. In past two years, ASO-S underwent its so-called background studies and fulfilled some key technique issues. By the end of 2016, ASO-S is officially accepted to initiate formal steps as an approval project. This paper describes in brief the progress in recent two years and the prospect in near future.

Machol, Janet

First Measurements from the EUV and X-Ray Irradiance Sensors (EXIS) on GOES-16

The NOAA Geostationary Operational Environmental Satellites (GOES) have measured terrestrial and space weather phenomena since the 1970s. GOES-16, the first of 4 satellites in the new GOES-R series, launched in November 2016. It carries the EUV and X-Ray Irradiance Sensors (EXIS) suite which consists of an X-ray Sensor (XRS) and an Extreme Ultraviolet Sensor (EUVS). An XRS has been aboard all GOES satellites to monitor solar flares, and the new XRS design continues that long history, measuring the solar irradiance in the 0.05-0.4 nm and 0.1-0.8 nm bands, but with a larger dynamic range. EUVS, measuring broad bands, have been on GOES since 2006, aboard the GOES 13-15 satellites. The EUVS on the new satellite series are of a very different design; they measure spectra with high resolution at a 7 EUV wavelengths as well as near 280 nm. The EUVS products include specific EUV line irradiances, the Mg II index, and modeled real-time solar irradiance spectra from 5-127 nm. This talk will discuss EXIS capabilities, calibration challenges, and preliminary data.

Narukage, Noriyuki

X-ray imaging-spectrometers for the next solar satellite mission

We plan to realize the satellite mission for the detailed investigation of magnetic reconnection and particle acceleration. The observation target is the sun (with 5 degree offset to observed other heavenly bodies, namely, Crab Nebula, Sco X1, etc.). The observed wavelength is soft X-rays (0.5 - 10 keV), hard X-rays (5 - 30 keV) and soft gamma rays (up to 600 keV). For the X-ray observations, we use new observation technology as follows: In the soft X-ray observation, the imaging spectroscopic observation will be realized for the first time in the solar coronal observation using precise X-ray mirrors and high-speed CMOS cameras. In the hard X-ray observation, we plan to use focusing mirrors (like FOXSI sounding rocket) for the higher dynamic range than the modulation collimator type hard X-ray telescope. For the hard X-ray cameras, we will use CdTe sensors for high QE. These instruments are designed to investigate the region around the X-point (above flaring loop), where key phenomena related to reconnection, i.e., shocks, particle acceleration, etc., are predicted. Now we are developing the key elements of these X-ray imaging-spectrometers, namely, precise X-ray mirrors, high-speed CMOS cameras, CdTe sensors, etc.

Seaton, Dan

The Solar Ultraviolet Imager on NOAA’s GOES-16 Spacecraft

The Solar Ultraviolet Imager, launched November 19, 2016, on NOAA’s GOES-16 spacecraft, is the first in a line of four identical instruments that will image the Sun’ 's atmosphere in the extreme ultraviolet for the next 20 years. SUVI's six passbands — 94, 131, 171, 195, 284, and 304 Å — provide images of the solar chromosphere and corona over a temperature range from about 50,000 K to 10 million K, tracking phenomena such as solar prominences, coronal holes, active regions, and dynamic events such as solar eruptions and flares. SUVI is distinguished among other EUV solar imagers by its relatively large 53×53 arcmin field of view, an asset that may be of particular value for the study of the process of magnetic reconnection that powers solar flares. SUVI is presently undergoing its initial calibration, and we expect data to be regularly available to the scientific community by September 2017. Here we present an overview of the instrument and some preliminary results, and discuss some of the anticipated SUVI data products and pathways for data access.

Stęślicki, Marek

X-ray Flux Sensor for the Focusing Optics X-ray Solar Imager - FOXSI

XFS will monitor solar X-ray flux in two energy passbands 3–15 keV and 6–15 keV with accuracy better than 10% for B1 class, 1% for M1 class and above. These measurements will be used to control FOXSI attenuators state. This is the main task for XFS. In addition XFS also provides fast solar X-ray spectroscopy in the entire flux intensity range, variable seven order in intensity form quiet solar conditions to strongest flares. The data collected by XFS will complement the main FOXSI instrument measurements and allow temperature and emission measure analysis of small flares as well as a quiet Sun.

Working Group 1 (Electron acceleration and transport):

Alaoui, Meriem

Is a 1D return-current collisional thick target model adequate to explain RHESSI spectral breaks? – current instability

RHESSI x-ray spectra in the deka-keV to 300 keV range that show “strong” spectral breaks have been fitted with a 1D return-current collisional thick target model. Strong breaks are defined as those that cannot be explained by non-uniform ionization or Compton back-scattering alone. The 1D return current collisional thick target model (RCCTTM) assumes the electrons lose some of their energy in the corona due to the return-current potential drop before they are stopped by Coulomb collisions in the thick-target. The model also assumes a warm target approximation, where electrons become thermalized and therefore lost from the beam at energy δkT, where δ is the electron spectral index and T the temperature of the loop. I will show that the resistivity in the corona needs be “enhanced” by a few orders of magnitude as compared to Spitzer resistivity, even though the beam/return current system is apparently stable.

Battaglia, Marina

Electron energization in magnetic reconnection outflow regions observed with RHESSI and SDO/AIA

We present observations of electron acceleration and plasma energization in the magnetic reconnection outflow region during the pre-impulsive stage of a solar flare. Simultaneous forward fits of RHESSI spectra and SDO/AIA data with a kappa-distribution provide the total electron distribution as a function of time in the acceleration region. We derive the energy release rate necessary to form the observed spectrum in both, the traditional cold target model as well as the warm target approximation and compare it with the total instantaneous source energy and the dominant energy loss mechanisms. We find that the cold target approximation overestimates the power in energized electrons by at least one order of magnitude.

Drake, James

Electron Acceleration during Magnetic Reconnection in 2D and 3D Systems

Magnetic reconnection is a significant driver of energetic particles in flares both on the sun and beyond. Single x-line models fail to explain the large number of energetic electrons seen in flares. Reconnection in systems with weak collisions multi-island reconnection spontaneously develops and dominates energy release. There are three basic mechanisms for particle energy gain in multi-island reconnecting systems: motion along parallel electric fields; and the magnetic curvature and gradient B drifts along perpendicular fields. The latter two produce the classical Fermi and betatron acceleration, respectively. Simulations reveal that electron acceleration is dominated by parallel electric fields and Fermi reflection with Fermi dominating in reconnection with modest guide fields and parallel electric fields dominating with strong guide fields. A major surprise is that in the strong guide field limit where parallel electric fields dominate electron energy gain the production of the most energetic electrons drops precipitously. Parallel electric fields are therefore inefficient drivers of very energetic electrons. For electron-ion plasmas the rate of production of energetic eleqramatically increases compared with 2-D reconnection. A major challenge is to extend small-scale kinetic simulations to the energy release in the large-scale magnetic fields relevant to flares and other macroscopic systems. A new hybrid kinetic-fluid system for exploring particle acceleration in very large systems will be discussed.

Emslie, Gordon

The Role of Turbulent Kinetic Energy in Energy Transfer in Solar Flares

Using an unprecedented set of coordinated observations, from a suite of instruments, we here report on a hitherto largely overlooked energy component — the kinetic energy associated with small-scale turbulent mass motions. We show that the spatial location of, and timing of the peak in, turbulent kinetic energy together provide persuasive evidence that turbulent energy may play a key role in the transfer of energy in solar flares, in particular from energy in stressed magnetic fields into accelerated nonthermal particles. Although the kinetic energy of turbulent motions accounts, at any given time, for only ~(0.5–1)% of the energy released, its relatively rapid (~1–10 s) energization and dissipation causes the associated throughput of energy (i.e., power) to rival that of major components of the released energy in solar flares.

Kuhar, Matej

NuSTAR X-Ray Brightenings from Outside of Active regions: Closing in on Nanoflares?

We report observations of a tiny X-ray brightening outside of active regions during the 7th NuSTAR solar campaign, carried out on July 26 2016. The brightening was also detected with SDO/AIA and the GOES Soft X-ray Imager (SXI), but it was well below the background level of the full-sun GOES lightcurves with an estimated GOES class of A0.01 (i.e., about 7 orders of magnitudes smaller than the largest flares seen in active regions). The NuSTAR flux above 2.5 keV shows an intriguing time evolution with two ~1 minute peaks, which are also seen in the AIA UV channel at 1600A, while the EUV channels of AIA show only a single peak. We will discuss the results of a combined spectral analysis between NuSTAR, AIA and GOES SXI instruments to investigate the potential for a non-thermal origin of the X-ray emission detected by NuSTAR. Finally, a comparison to several brightenings observed in the latest NuSTAR campaign on March 21 2017 will be given, as well as the discussion on their energetics and importance for coronal heating.

Mann, Gottfried

[WITHDRAWN] Electron Acceleration in the Magnetic Reconnection Region

RHESSI observations revealed that 10^{36} electrons are accelerated up to energies >30 keV within one second during large flares. A flare is a manifestation of magnetic reconnection in the solar corona. According to the standard (or CSHKP-) model, a filament becomes unstable due to its photospheric footpoint motions and rises upwards. Hence, the underlying magnetic field lines are stretched leading to the formation of a current sheet, where the magnetic reconnection can take place. The plasma is shooting away from the magnetic reconnection site. Slow-mode shocks separate the inflow region from the outflow one. Since the plasma-beta is small in the corona, the plasma is strongly heated at these slow-mode shocks. If the jet of the out flowing plasma is super-Alfvénic, then a fast-mode shock (also called termination shock) is established in the outflow region. According to this model, energetic electrons are generated within few steps. At first, they are strongly heated at the slow-mode shocks and, subsequently, they are heated once more and, additionally, accelerated at the fast-mode shock. This scenario is quantitatively considered by means of the Rankine-Hugoniot relationships and shock drift acceleration at the termination shock. That allows to explain the generation of 10^{36} electrons per second with energies >30 keV as observed by RHESSI.

McTiernan, James

[POSTER] Non-Thermal Cutoff Energy Obtained Using EVE-RHESSI DEM calculations

Solar flare spectra are typically dominated by thermal bremsstrahlung emission in the soft X-ray (<10 keV) energy range; at higher hard X-ray energies (>30 keV) the emission is non-thermal from beams of electrons. The low energy extent of non-thermal emission has only been loosely quantified. In particular, it is difficult to obtain a lower limit for any possible non-thermal cutoff energy due to the larger amount of thermal emission. In this work we use solar flare data from the EUV Variability Experiment (EVE) on-board the Solar Dynamics Observatory (SDO) and X-ray data from the Reuven Ramaty High Energy Spectroscopic Imager (RHESSI) to calculate the Differential Emission Measure (DEM). This improvement over the isothermal approximation is intended to help to resolve ambiguities in the range where thermal and non-thermal emission overlap. In this model, thermal emission is due to a DEM that is parametrized as multiple gaussians in log(T). Non-thermal emission is modeled as a photon spectrum obtained using a thick-target emission model. Spectra for both instruments are fit simultaneously in a self-consistent manner. Our results have been obtained using a sample of 52 large (GOES X and M class) solar flares observed between February 2011 and February 2013. It turns out that it is often possible to determine low energy cutoffs and breaks early (in the first two minutes) during large flares. Cutoff energies are typically low, less than 10 keV, with most values of the lower limits in the 5 to 7 keV range, at the low limit of RHESSI's energy range.

Motorina, Galina

Quantification of the thermal response in a 'cold' flare

Solar flares are sudden explosive processes in the solar atmosphere covering the wide electromagnetic range, which demonstrate remarkable variety of the partitions between various energy components. Understanding the flare acceleration site requires knowledge of exactly how flare energization works and what is the partition between nonthermal, thermal and kinetic energies. In this perspective the so-called 'cold flares' (Bastian et al. 2007; Fleishman et al. 2011; Masuda et al. 2013) can be perfect candidates. These 'cold flare' events are characterized by domination of nonthermal component, but very weak thermal emission and almost no soft X-ray enhancement; thus GOES often does not recognize such events as flares. The purpose of the work is to quantify the thermal and nonthermal energies and their evolving relationship in a

2013-Nov-05 cold flare. For nonthermal diagnostics we use the RHESSI data, while the SDO/AIA data are employed for the thermal diagnostics. We computed evolving maps of emission measure and temperature from the EUV DEM analysis, which allowed us to accurately determine the flaring area and infer the evolving thermal energy. This thermal energy was compared with the rate of the nonthermal energy release. This comparison suggests that the observed plasma heating is entirely supplied by the loss of the nonthermal energy released in the impulsive phase of the flare. With this data set, we developed a 3D model of the flare. We then fine-tuned it via comparison of the synthesized and observed emissions in X-ray and EUV domains. In addition, microwave data from Nobeyama and BBMS/SSRT instruments were used to validate the model. After the model has been validated, we more accurately quantified the nonthermal and thermal energies directly from the model 3D volume. We discuss physical implications of the obtained results.

Musset, Sophie

X-ray emitting electrons in connection with coronal EUV jets

Coronal EUV jets associated with flares offer the opportunity to study electron acceleration and transport to the high corona and interplanetary space in a relatively simple magnetic configuration. Indeed, jets are generally thought to be produced due to interchange reconnection between a closed magnetic loop in the low corona and nearby open magnetic field along which coronal or chromospheric plasma escape towards the interplanetary space. Other models include the possibility that jets arise as small-scale filament eruptions. Past studies have shown that energetic electrons and ions are also produced in relation with jets. These observations raise the question of the link between the flare and jet occurrence, as well as the role of energetic electron acceleration in such events. In particular, are the electrons accelerated in a flaring closed loop or in the jet itself, and are the accelerated electrons a precursor or a consequence of the jet? This talk will focus on these questions by examining the timing between the flare and the jet and the location of the energetic electrons, for several jet events associated with solar flares.

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Working Group 2 (Ions):

Chen, Wei

[WITHDRAWN] The evolution of de-excitation line shapes in solar flare

Solar gamma-ray lines are expected to display significant Doppler broadening because the recoiling nuclei de-excite in flight. The energies and widths of these lines provide a wealth of information on the accelerated ions' directionality and spectra in solar flare. With the calculation of 1.634 MeV 20Ne line as example, we calculated several de-excitation line shapes for various ions spectrum in solar flare. Based on the analysis of RHESSI observation data, we found that the widths of spectral lines showed a narrow-wide-narrow variation with the evolution of flares. It seems to imply that the spectrum of accelerated ions in the evolution of the flare have a soft-hard-soft pattern, in which the gamma-rays become harder during the rise to peak intensity, then soften during the decline phase of the flare.

Cranmer, Steven

[POSTER] What Can Coronal Holes Tell Us About Ion Energization?

When one wants to understand high-energy particle acceleration on the Sun, it is rare to see much reference to quiet and unipolar magnetic regions such as coronal holes. However, these low-density sources of high-speed solar wind contain plasma that becomes collisionless very close to the Sun. This has allowed us to measure a wide range of departures from thermal equilibrium there. Coronal holes are optimal testbeds for studies of kinetic wave-particle interactions, and they have been observed to contain preferential bulk acceleration of heavy ions (with respect to proton bulk flow), ion temperatures exceeding 100 million K, and extreme departures from Maxwellian velocity distributions. In this poster I will summarize the observational data (both remote-sensing and in-situ) and discuss the laundry list of proposed collisionless mechanisms that have been proposed to explain them. How relevant is all of this to the high-energy events probed by RHESSI and MinXSS? Let's find out.

Omodei, Nicola

Fermi LAT Observation of High Energy Solar Flares

The Fermi Large Area Telescope (LAT) observations of the active Sun provide the largest sample of detected solar flares with emission greater than 30 MeV to date. These include detections of impulsive and hours-long sustained emission coincident with GOES X-ray flares of X, M and C classes as well as very fast Coronal Mass Ejections (CME). Of particular interest are the recent detections of three solar flares whose position behind the limb was confirmed by the STEREO-B spacecraft. Fermi LAT detections of solar flares at high energy present an unique opportunity to diagnose the mechanisms of high-energy emission and particle acceleration and transport in solar flares. We will present the results from the First Fermi-LAT solar flare catalog covering the majority of Solar Cycle 24 including correlation studies with the associated Solar Energetic Particles (SEP) and CMEs.

Working Group 3 ([Solar] Atmospheric response):

Caspi, Amir

Progress on MinXSS/RHESSI Joint DEMs

We present progress on using MinXSS and RHESSI data simultaneously for joint DEM calculations during flares and quiescence. MinXSS measured SXR spectra from ~1 to ~10 keV, with ~0.15 keV FWHM resolution and ~10 s cadence, from June 2016 to May 2017. MinXSS provides access to plasma temperatures from ~2 to ≳20 MK, as well as abundances of both low-FIP (Mg, Si, Ca, Fe, S) and high-FIP (Ar) spectral lines, during both flaring and quiescent times. The MinXSS SXR spectra are directly comparable and compatible with RHESSI HXR spectra, and can be combined to provide plasma diagnostics over the full coronal temperature range and multiple ion species. We show comparisons of simultaneous MinXSS and RHESSI observations of various solar flares, and discuss future plans for joint-instrument DEM analysis.

Cauzzi, Gianna

[POSTER] Spectral signatures for multi layered heating and condensation in a solar flare: HXR and UV observations and modelling

We extend our recent analysis of the X-Class flare SOL2014-09-10T17:45 (Graham & Cauzzi 2015), and concentrate on the chromospheric dynamics of multiple, elementary flaring kernels by using multiple spectral lines of Mg II, Fe II, Si I, and C I observed at high cadence with IRIS, combined with HXR observations obtained by Fermi. We show that many flaring kernels display high velocity downflows in the spectra of all of these chromospheric lines, manifested as a primary quasi-stationary component, plus a distinct, transient and strongly redshifted spectral component. From modelling using RADYN with a thick-target interpretation, the presence of two spectral components appears to be consistent with a high flux beam of accelerated electrons. In particular, the highest energy electrons can heat the denser, lower layers of the atmosphere, while the bulk of the beam energy, deposited higher in the atmosphere, is sufficient to produce chromospheric evaporation with a corresponding condensation.

Dennis, Brian

Dimensions of Coronal X-ray Sources

The location and dimensions of coronal X-rays sources and their variation with energy and time provide important information about flare plasma energization and energy loss processes. The accurate determination of these parameters from RHESSI images will be explored for sources at different locations on the solar disk and above the limb. Results will be presented for several flares including those for which strong hard X-ray footpoints are observed and those with strong coronal hard X-ray sources but minimal or weak footpoint emission. Implications for the models of these coronal hard X-ray sources will be discussed.

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Effenberger, Frederic

Investigating the connection between RHESSI X-ray and AIA DEM heating signatures in solar limb flares

By studying partially occulted flares, we can investigate the thermal and non-thermal heating processes in coronal flare emissions without contamination of the strong non-thermal footpoint emission. We use a combination of multi-instrument, multi-wavelength observations from RHESSI, and SDO/AIA together with differential emission measure (DEM) inversion algorithms to address the questions of coronal heating and non-thermal energy deposition. We correlate the non-thermal hard X-ray signatures with time, space and temperature dependent heating processes and study different regions along the flaring loops. We show different energy ranges of hard X-ray signatures obtained from RHESSI imaging, which indicate the spatial and temporal relation of energy deposition and transport processes from non-thermal particles and super-hot plasma. In this way, we investigate the thermal response of the upper atmosphere to non-thermal processes for different types and phases of a solar flare.

Hernandez-Perez, Aaron

Generation mechanisms of quasi-parallel and quasi-circular flare ribbons in a confined flare

We analyze a confined multiple-ribbon M2.1 flare (SOL2015-01-29T11:42) that originated from a fan-spine coronal magnetic field configuration within active region NOAA 12268. The ribbons form in two steps. First, two primary ribbons form at the main flare site, followed by the formation of secondary ribbons at remote locations. We observe a number of plasma flows at extreme-ultraviolet temperatures during the early phase of the flare (as early as 15 min before the onset) propagating towards the formation site of the secondary ribbons. The secondary ribbon formation is co-temporal with the arrival of the pre-flare generated plasma flows. The primary ribbons are co-spatial with RHESSI hard X-ray sources, whereas no enhanced X-ray emission is detected at the secondary ribbons sites. The (E)UV emission associated to the secondary ribbons peaks approximately 1 min after the last RHESSI hard X-ray enhancement. A nonlinear force-free model of the coronal magnetic field reveals that the secondary flare ribbons are not directly connected to the primary ribbons, but to regions nearby. Detailed analysis suggests that the secondary brightenings are most likely produced due to dissipation of kinetic energy of the plasma flows (heating due to compression), and not due to non-thermal particles accelerated by magnetic reconnection, as is the case for the primary ribbons.

Kleint, Lucia

Magnetic field changes and their relation to X-ray emission

We analyze polarimetric data of the X1 flare on 2014-03-29 to investigate the magnetism of the flare. The photospheric magnetic field shows stepwise changes in several locations near the polarity inversion lines, similar to previous observations of other large flares. Stepwise chromospheric changes of the line-of-sight magnetic field (B_LOS) were observed for the first time. They are stronger and appear in larger areas than their photospheric counterparts. Chromospheric changes are located near footpoints of loops, but they are not exactly co-spatial to hard X-rays, continuum emission, nor a small sunquake, leading to questions about their origin. We investigate potential explanations for the differences in location and timing of the accelerated particles and the observed magnetic restructuring.

Kowalski, Adam

Very Broad Hydrogen Lines in Response to High-Flux Electron Beam Heating in Solar Flares

Radiative-hydrodynamic flare modeling of IRIS data of the brightest flare kernels has shown that the asymmetric chromospheric line profiles of Iron II and the bright near-UV continuum intensity are formed over low optical depth in two chromospheric flare layers. The velocity evolution of the condensation flare layer is well-constrained by the high spectral resolution of IRIS observations, but the very high electron density (>1E14 cm^-3) produced in the model condensation layer remains untested. We implement a new prescription for modeling the electric pressure broadening of the hydrogen lines and the recombination edge regions, which provide accurate constraints on the electron density in the chromospheric flare layers heated by high flux electron beams. The models that successfully reproduce the IRIS spectral data are compared to recent data from the DST/IBIS. Future observations from the Daniel K. Inouye Solar Telescope are critical to determine if such large ambient electron densities from high electron beam heating rates occur in the brightest kernels of solar flares.

Lastufka, Erica

Occulted Flare Observations by RHESSI and MESSENGER

Occulted flares provide a unique opportunity to escape the dynamic range limitations of current X-ray instruments. However, it is rare to find a well-observed coronal source above the limb, and rarer still for the entire flare to be simultaneously observed by another instrument. In preparation for simultaneous observations from well cross-calibrated X-ray instruments, such as the upcoming STIX-MiSolFA combination, we attempt to curate a collection of events observed both by RHESSI and Mercury-orbiting MESSENGER's XRS soft X-ray spectrometer. In addition to searching for joint observations in the two flare lists, we examine the GOES measurements to find flares whose flux given by MESSENGER far exceeds what is seen from Earth, enabling us to find a handful of events that do not register on the RHESSI flare list. In the process, we quantify the relation between MESSENGER's simulated 1–8 Å and 0.5–4 Å flux and observed GOES flux. Agreement with the long wavelength channel is within 5% for 60% of on disk flares, while the same two-thermal spectral fit results in MESSENGER overestimating the short wavelength channel flux by a median of four times the actual amount. Because MESSENGER's spectral range is 1.5–8.5 keV, the inaccuracy of the high energy fit is not unexpected. We find a sample of 23 flares whose coronal source is observed by RHESSI and complete active region is observed by MESSENGER. We discuss the necessary precautions involved when using data of such different origins, and the resulting constraints on interpretations of the results.

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Milligan, Ryan

3-Minute Oscillations in Hydrogen Emission During Solar Flares

There have been increasing reports of quasi-periodic pulsations (QPPs) during solar flares in the literature recently. These recurrent variations in intensity have been detected over a wide range of wavelengths, most prevalently in X-rays and radio waves. The nature of these pulsations is still in dispute but they are widely agreed to be evidence for either a form of periodic driver of nonthermal electrons (such as magnetic reconnection) or magnetohydrodynamic oscillations. Flare observations of QPPs at EUV wavelengths have been scarce in recent years, and those in the literature are often derived from broadband measurements leaving some ambiguity as to whether the periodic behavior was occurring in the line(s) or the continuum. Here we present evidence for synchronous QPPs in the Lyman continuum (from SDO/EVE) and the Lyman-α line (from GOES/EUVS) during the well-studied 15 February 2011 X-class flare. The data were detrended to reveal a periodicity of ~3 minutes during the impulsive phase. Similar values were found in the SDO/AIA 1600 Å and 1700 Å channels despite being saturated, although no such evidence was found in the higher order Lyman lines (Lyman-β, Lyman-γ, Lyman-δ, etc). It is possible that the observed periodicity is an indication that the chromosphere is reverberating at its acoustic cutoff frequency in response to an injection of energy.

Moore, Christopher

Exploring solar coronal properties through soft X-ray observations of the MinXSS (Miniature X-ray Solar Spectrometer) CubeSat

Soft X-rays provide unambiguous probes of hot plasma properties in the solar corona. Additionally, spectrally resolves soft X-ray data allow unique inferences of chemical abundances. The majority of solar soft X-ray observations have included spectrally integrated filter images, high spectral resolution ($E/\Delta E \approx 1{,}000$) narrowband spectra, low resolution ($E/\Delta E \approx 10$) spectral images, but limited spectrally resolved broadband observations. The Miniature X-ray Solar Spectrometer (MinXSS) 3U CubeSats developed by graduate students, professionals and professors at the University of Colorado-Boulder are designed to fill this gap with moderate resolving power ($E/\Delta E \approx 40$, at 5.9 keV) over a fairly broad spectral bandpass (1–10 keV). The twin MinXSS CubeSats, mostly funded by NASA, can provide possibly 5 years of minimally interrupted observations of the solar soft X-ray flux to better constrain the characteristics and dynamics (especially solar flares) of coronal plasma. The MinXSS mission commenced on May 16, 2016 with the deployment of MinXSS-1 from the International Space Station and has been operating nominally. This talk will discuss the MinXSS instrument capabilities, initial science results and the benefit of combining MinXSS observations with other solar observatories.

Panchapakesan, Subramania Athiray

Solar coronal abundances: FIP bias changes with X-ray flux

Solar coronal abundances are known to be different from that of the photosphere for several decades. However the amount of fractionation and its value for different elements is often debated. Using X ray data in the ~ 1.8 to 10 keV from XSM on the ESA's SMART-1 mission, we derive elemental abundances of Si, S, Ca, Ar and Fe of the corona across a range of activity periods. We find that FIP bias values are dependent on the X ray flux level in addition to the first ionisation potential. We will present preliminary results from this ongoing work.

Sadykov, Viacheslav

Multi-Instrument Database of Solar Flares and its Application for Statistical Studies of Chromospheric Evaporation

For a complete understanding of solar flares, it is necessary to perform a combined multi-wavelength analysis using observations from many satellites and ground-based observatories. For efficient data search, integration of different flare lists and representation of observational data, we have developed the Interactive Multi-Instrument Database of Solar Flares (IMIDSF, https://solarflare.njit.edu/). The web database if fully functional and allows the user to search for uniquely-identified flare events based on their physical descriptors and availability of observations of a particular set of instruments. Currently the data from three primary flare lists (GOES, RHESSI and HEK) and a variety of other event catalogs (Hinode, Fermi GBM, Konus-Wind, OVSA flare catalogs, CACTus CME catalog, Filament eruption catalog) and observing logs (IRIS and Nobeyama coverage), are integrated, and an additional set of physical descriptors (temperature and emission measure) is provided along with a summary of available observations, data links and multi-wavelength light curves for each flare event since January, 2002. To demonstrate the IMIDSF performance, we selected the flare events jointly observed by IRIS, SDO and RHESSI. The selection of IRIS observations was restricted to the fast-scanning regimes (coarse-raster or sparse-raster modes with ≥4 slit positions, ≥ 6″ spatial coverage, and ≤60 sec loop time). We have chosen 13 events, and estimated the spatially-resolved intensities and Doppler shifts of the chromospheric (Mg II), transition region (C II) and hot coronal (Fe XXI) lines reflecting the dynamics of the chromospheric evaporation. The results reveal that the structure and dynamics of chromospheric evaporation determined from line profile properties correlate with quasi-separatrix layers of magnetic field of the flaring active regions and hard X-ray characteristics observed by RHESSI.

Su, Yang

Investigating the origin of X-ray sources in solar flares

Understanding the origin and evolution of flare X-ray sources is a key step in studies on the detailed process in magnetic reconnection and the initiation phase of flares. With SDO/AIA EUV data and our improved DEM calculation, we obtained so far the best DEM results for flare plasma, from which thermal X-ray spectra, light curves, and maps are derived to compare with RHESSI observations. The results show distinct heating and cooling processes at different locations in flares. Temperature, density, and energy can now be estimated with better accuracy for individual sources. We also investigate the nature of X-ray sources and plasma heating before flare start.

Vievering, Juliana

Investigation of Energy Release from X-ray Flares on Young Stellar Objects with NuSTAR

Young stellar objects (YSOs), which tend to flare more frequently and at higher temperatures than what is typically observed on Sun-like stars, are excellent targets for studying the nature of energy release and transport in large flaring events. Multiple star-forming regions have been observed in the past by soft x-ray missions such as Chandra and XMM-Newton, but the energy ranges of these missions fall off prior to the hard x-ray regime, where it would be possible to search for a crossover from thermal to nonthermal emission. To investigate this hard X-ray emission, three 50 ks observations of the star-forming region rho Ophiuchi have been taken with the Nuclear Spectroscopic Telescope Array (NuSTAR), which is optimized over the energy range of 3–79 keV. Multiple stellar flares have been identified in the observations; here we present the current spectral and timing analyses of the brightest of the these events, exploring the way energy is released as well as the effects of these large flares on the surrounding environment. We compare these results to what is typically observed for solar flares.

Warmuth, Alexander

Current questions relating to solar flare energetics

Various recent studies have aimed for a detailed characterization of the energy partition in solar flares. The knowledge of the energetics of thermal and nonthermal particle populations is essential for our understanding of energy release and transport processes as well as particle acceleration mechanisms. We will address three specific questions that have arisen from these recent studies. 1. X-ray and EUV observations have shown that the thermal plasma in solar flares is not isothermal. There are indications for two components: a hot component resulting from chromospheric evaporation, and a super-hot component generated by direct heating of coronal material. We investigate this scenario further by using time-resolved RHESSI imaging and spectroscopy. 2. Thermal energies in flares have been constrained with two main methods: X-ray observations (using RHESSI images and RHESSI and/or GOES spectral data, isothermal or bithermal spectral models) and EUV observations (AIA images and multithermal models). We investigate how the thermal energies derived by the different methods relate to each other. 3. Two methods have been used to derive the energy in the injected nonthermal electrons: the classical cold thick-target model and the more recent warm-target model. The latter model allows a calculation of the low-energy cutoff. This is not possible with the cold thick-target model, which is commonly used to give a lower estimate of the number of injected electrons. Therefore, the warm-target model tends to yield much higher electron fluxes. We investigate whether these large values are consistent with other observations, in particular the bolometric radiated energies.

White, Stephen

Daily coronal DEMs with EVE

As part of a study to better understand the relationship between the radio F10.7 index and the ionizing flux from the Sun, we have derived daily coronal DEMs for the 4 years of EVE MEGS-A data from 2010 to 2014, starting in near-solar-minimum conditions and passing through solar maximum. We discuss the method used to derive the DEMs and the limitations involved. A striking result is that there is surprisingly little variation in the amount of cool ($\log(T)<6.1$) material over the cycle, and there seems to be a discontinuity in behavior at the onset of significant solar activity. These DEMs are used to estimate the total coronal energy and the timescales at which it needs to be replenished.

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Working Group 4 (Radio/HXR):

Chen, Bin

VLA observation of decimetric type III radio bursts in a microflare

Energetic electron beams propagating along magnetic field lines can emit radio waves, commonly known as type III radio bursts. Such bursts at decimetric wavelengths are generated in the low corona, serving as an excellent tracer of newly energized electron beams emerging from the acceleration site. Here we report observations of decimetric type III bursts in a jet-associated microflare event recorded by the Karl G. Jansky Very Large Array (VLA) in 1-2 GHz. VLA, RHESSI, and SDO imaging results show that these bursts origin in a region just below the eruption and above the lower-lying hot flare loops, presumably the magnetic reconnection site. Thanks to VLA's great sensitivity and high-cadence spectroscopic imaging capability, we are able to map many tens of electron beam trajectories during the ~20-s duration of this event. These trajectories appear as groups, each of which lasts only for ~1-2 seconds. More interestingly, each group of electron beam trajectories seems to converge to a common region, which is probably where the beams are accelerated.

Hayes, Laura

QPP in the soft X-ray and the Earths Ionosphere

The Earth's ionosphere is affected by solar phenomena such as solar flares. In particular, photons with wavelengths <10 Å (X-rays) can penetrate down to the D region resulting in a dramatic increase of ionization in this lowest lying region of the Earth's ionosphere. It has now become clear that X-ray emission generated in solar and stellar flares show pronounced pulsations and oscillatory behavior, with periods ranging from seconds to several minutes. These 'quasi-periodic pulsations' (QPP) are thought to occur in flaring loops created following magnetic reconnection but their physical origin remains unclear. To date, it has not been known if the Earth's ionosphere is sensitive to these dynamic solar pulsations. Here, we report ionospheric pulsations with periods of ~20 minutes that are synchronised with a set of pulsating flare loops using VLF observations of the ionospheric D-layer together with X-ray and EUV observations of a solar flare from the NOAA/GOES and NASA/SDO satellites. Our results show that the Earth's ionosphere is more sensitive to small-scale changes in solar activity than previously thought.

Holman, Gordon (on behalf of Nicolina Chrysaphi and Eduard Kontar)

Imaging Spectroscopy of a Type II solar radio burst observed by LOFAR

The location and time evolution of the radio emission from a Type II radio burst has been imaged with LOFAR. One harmonic is observed, which shows band splitting. For the first time, the spatial location of the emission from each band is determined to arise from different locations. The trajectory of the two sources relative to a coincident coronal mass ejections is shown and discussed.

Inglis, Andrew

A large-scale search for evidence of quasi-periodic pulsations in solar flares using GOES and Fermi/GBM

We present a large-scale search for evidence of signals consistent with quasi-periodic pulsations (QPP) in solar flares, focusing on the 1-300 s timescale. We analyze 675 M- and X-class flares observed by GOES in 1-8 Å soft X-rays between 2011 February 1 and 2015 December 31. Additionally, over the same era we analyze Fermi/GBM 15-25 keV X-ray data for each of these flares associated with a GBM solar flare trigger, a total of 261 events. Using a model comparison method and the Bayesian Information Criterion statistic, we determine whether there is evidence for a substantial enhancement in the Fourier power spectrum that may be consistent with a QPP signature. From this, we determine that ~30% of GOES flares and ~8% of the same flares observed by GBM show strong signatures consistent with classical interpretations of QPP, which include MHD wave processes and oscillatory reconnection events. Hence, quasi-steady periodic signatures appear more prevalently in thermal soft X-ray data than in the counterpart hard X-ray emission. For both datasets, preferred characteristic timescales of ~5-30 s were found in the QPP-like events, with no clear dependence on flare magnitude. Individual events in the sample also show similar characteristic timescales in both GBM and GOES data sets, indicating that the same phenomenon is sometimes observed simultaneously in soft and hard X-rays. These survey results have substantial implications for the fundamental processes taking place during solar flare impulsive emission.

Kashapova, Larisa

The possible method of the faint solar flare study with the Siberian Multiwave Radioheliograph

During the powerful solar flares the processes of energy release and transport overlap each other doing analysis of an event scenario complicated and ambiguous. From this point of view the faint solar flares are curious and perspective objects providing more pure data for testing our models and hypothesis. However, often the flux of hard X-ray (HXR) emission during the faint flares is too weak for spatial analysis. Sometimes we have only time profiles and spectral data. Microwave (MW) emission is more sensitive to the small amount of accelerated electrons but its spatial observation are usually limited by one or two frequencies. The Siberian Multiwave Radioheliograph nowadays allows to carry out observations at five frequencies and this possibility can be used for widening the applications of MW data in the diagnostics of the flare process. We present results of analysis of the two solar flares with combination of HXR and microwave data. The first event is M7.6 GOES flare on the 23 July 2016 that was observed both by RHESSI and Konus-WInd. The second event is C4.4 GOES flare on the 18 July 2016. The HXR emission for this event was detected by the GRB/Lomonosov (time profiles and spectral data only). Both flares show significant microwave emission with polarization sign changing with frequency. The 23 July flare gives us the possibility to analyze position of MW sources relative to HXR sources and the possible reasons for polarization sign inversions. We used only the data of the initial phase of this flare in order to avoid additional effects and to compare results with analysis carried out for the 18 July flare. The main question that we are trying to answer is: has such comparison helped us to solve the puzzle or not.

Liou, Yu-Lun

Analysis of Hard X-ray and Microwave Observations with Fokker-Planck Model in Solar Flares

The electrons accelerated to several MeV during flare impulsive phase are believed to be responsible for the non-thermal emissions in hard X-ray (HXR) and microwave observations. In order to understand the behaviors of these non-thermal electrons, we analyze a M2.3 flare on 2014 September 23 by combining the RHESSI and Nobeyama measurements. The HXR sources are appeared as double chromospheric footpoints in RHESSI CLEAN maps with the soft-hard-soft (SHS) spectral profile, while the microwave emission is shown as loop-top source in Nobeyama 17 GHz images with soft-hard-harder (SHH) spectral feature. Furthermore, by solving the spatially homogeneous Fokker-Planck equation with different energy, we are able to calculate spectral indices and compare them with observations.

Ning, Zongjun

[WITHDRAWN] Oscillation seen in Soft X-rays

We statistically study quasi-periodic pulsations (QPPs) in the solar flares detected by the Geostationary Operational Environmental Satellites (GOES). Wavelet is used to analyze the data. We find that some events show the QPPs with a period around 100 s.

Reid, Hamish

Type U and J Radio Bursts observed with LOFAR Imaging Spectroscopy

Radio U-bursts and J-bursts are signatures of electron beams propagating along magnetic loops that are confined to the corona. With the prevalence of solar magnetic flux to be closed in the corona, it is unclear why type III bursts are more frequently observed than U-bursts or J-bursts. We use LOFAR imaging spectroscopy between 30–80 MHz of U-bursts and J-bursts to understand why electron beams travelling along closed coronal loops produce radio emission less often. The different radio source positions were used to model the spatial structure of the guiding magnetic flux tube and then deduce the energy range of the exciting electron beams without the assumption of a standard density model. The radio sources infer a magnetic loop 1 solar radius in altitude, with the highest frequency sources starting around 0.6 solar radii. Electron velocities were found between 0.13 c and 0.24 c, with the front of the electron beam travelling faster than the back of the electron beam. The density along the loop is higher than typical coronal density models and the density gradient is smaller. The large instability distances required before Langmuir waves are produced by some electron beams, and the small magnitude of the background density gradients make closed loops less facilitating for radio emission than loops which extend into interplanetary space. This can result in type III bursts being more frequently observed than U-bursts or J-bursts.

Yu, Sijie

Imaging spectroscopic observation of a new type of decimetric burst in a solar flare by VLA

Broadband radio dynamic imaging spectroscopic observations at decimetric wavelengths provide powerful diagnostics for magnetic energy release and particle acceleration processes in solar flares. On November 1st, 2014, we used the Karl G. Jansky Very Large Array (VLA) to observe a C7.2 flare in 1–2 GHz with 512 spectral channels and a 50 millisecond cadence. A new type of decimetric radio burst was recorded during the flare. The burst starts with a positive frequency drift (toward higher frequencies) followed by a negative frequency drift, which resembles the inversion of the type U bursts but with slower frequency drift rate. Using simultaneous imaging and dynamic spectroscopy, we obtain the location and morphology of the radio source as well as its evolution in time and frequency. Our preliminary results suggest that the burst is probably not related to fast electron beams that are responsible for type III or U bursts, but are likely due to propagating waves in the flare loop associated with the flare energy release.

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Working Group 5 (RHESSI imaging: next steps):

Hudson, Hugh

[POSTER] The X-ray Limb of the Sun

An X-ray source behind the Sun defines the location of the solar limb in a particularly precise manner, especially at higher photon energies where Compton scattering dominates the opacity. We describe a first application of this technique to measure the height of the X-ray limb with observations from an occulted X-ray flare observed by RHESSI. This method has model dependences different from those present in traditional observations at optical wavelengths (a radial brightness decrease, rather than an increase.) The interpretation of the optical limb depends upon detailed modeling involving radiative transfer in a medium with complicated geometry and flows. RHESSI's direct measurement makes use of the flare X-ray source's Fourier components (the visibilities), which reflect the presence of the sharp edge at the lower boundary of the occulted source. We have found a suitable flare event for analysis, SOL2011-10-20T03:25 (M1.7), and report a first result from this novel technique here. We find $R_X = 964.00 \pm 0.29''$, with allowance for systematic error, using a 4-minute integration over the 3–25 keV energy range. The standard VAL-C model predicts a value of 963.48″, about 1.8σ below our value.

Hurford, Gordon

RHESSI vs STIX: Implications of design and operational differences for solar imaging science

Following RHESSI, the next solar hard x-ray imager to fly will be STIX on Solar Orbiter. Although both instruments are Fourier-based imaging/spectrometers with considerable overlap in energy (STIX: 4-150 keV) and angular resolution (STIX: 7-180 arcsec), the two instruments differ significantly in design and operational constraints. This talk will discuss how these differences may affect their relative imaging properties and scientific strengths and weaknesses.

Maloney, Shane

[POSTER] A comparison of imaging with STIX and RHESSI

Synthetic data is used to compare and contrast imaging with STIX and RHESSI. Synthesis imaging is dependent upon deconvolution algorithms to counteract the sparse sampling of the Fourier plane. Numerous algorithms with different methodologies have been developed for this task. In this work, we compare a number of well-known methods with IDL implementations such as CLEAN, multiscale-CLEAN, MEMNJIT and PIXON comparing how both STIX and RHESSI would image the same underlying source. We also explore how the differing temporal resolutions, energy resolutions and energy ranges of the two instruments could be best utilised in the future.

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Massone, Anna Maria

A Bayesian approach for parameter estimation in RHESSI images

This talk will describe how Sequential Monte Carlo is able to estimate physical and morphological parameters of hard X-ray sources from the knowledge of RHESSI visibilities.

Piana, Michele

Wavelet-based deconvolution for RHESSI image reconstruction from visibilities

This talk will describe an image reconstruction method using RHESSI visibilities and based on wavelet deconvolution.

Plowman, Joseph

Unified Source Reconstruction from Heterogeneous Observations (e.g., AIA & RHESSI)

I describe how observations from highly disparate instruments can be combined in a simultaneous reconstruction of their multidimensional solar source functions (e.g., an emission measure as a function of space and temperature). The technique combines regularization with large-dimensional sparse matrix inversion and is very general -- it can be applied to any problem where the measurements are linearizable functions of the source distribution. An application to simultaneous AIA & RHESSI observations is shown.

Schwartz, Richard

Progress in RHESSI Imaging

New methods are presented and discussed for imaging with RHESSI.

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Working Group 6 (Theory):

Guo, Fan

The roles of magnetic reconnection and flare termination shock in accelerating particles in solar flares

We present a series of numerical studies (MHD and kinetic) that may lead to further understanding of particle energization and emissions in solar flares. In the reconnection region, magnetic energy gets rapidly converted into plasma kinetic energy, which leads to acceleration of particles and development of turbulence. Global MHD simulation for solar flares shows that flare termination shock forms when the high-speed outflow jet collides the magnetic loop. Because of the upstream turbulence from the reconnection region, the shock front is likely to be turbulent and rippled at a range of spatial scales, which has a strong implication for electron acceleration. Future studies need to include the sequence of processes into a more integrated model.

Hannah, Iain

Simulating tiny HXR flares

Recent observations with NuSTAR and FOXSI have started to show a variety of small flares below the GOES A1 level. In this talk I will briefly show some of the recent NuSTAR observations of these small flares as well as quiescent times which may be due to an unresolved ensemble of even smaller events. These will be shown in the context of a discussion about how we can model this emission, both in terms of the challenges with current approaches as well as future developments.

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Krucker, Säm

Temperatures of flare ribbons derived from de-saturated SDO/AIA images: implications for the standard flare model

We apply the newly available AIA desaturation algorithm (Schwartz et al. 2015) to the two-ribbon flare of September 6, 2011 (GOES X2) to investigate the flare ribbon temperature distribution. The reconstructed images of the EUV flare ribbons are found to agree well with the location and extent of the RHESSI non-thermal hard X-ray images consistent with the standard flare picture where flare-accelerated electrons heat the chromosphere. The Differential Emission Measure (DEM) distribution derived from the de-saturated fluxes of the flare ribbon peaks around 9 MK, with a steep decrease towards higher temperatures, similar to what has been reported in the past (e.g., McTiernan et al. 1993, Hudson et al. 1994, Mrozek & Tomczak 2004, Fletcher et al. 2013, Graham et al. 2013, Kennedy et al. 2013). The EUV-derived ribbon temperatures (T=9 MK, EM=0.5×10^{49} cm^{-3}, density of ~9×10^{11} cm-3) are well below the temperature of the main flare loop derived from hard X-ray observations (T=27 MK, EM=1.7×10^{49} cm^{-3}, density of ~2×10^{11} cm^{-3}) making it questionable how 'evaporation' of the 'warm' ribbons could produce the 'hot' flare loop. This suggests that the hottest loops seen in hard X-rays are not produced by 'evaporation,' but more likely by direct heating in the corona.

Li, Xiaocan

The role of fluid compression in particle energization at the reconnection site during solar flares

Theories of particle transport and acceleration have shown that fluid compression is the leading mechanism for particle energization. However, the role of compression in particle energization during magnetic reconnection is unclear. We address this issue using two approaches. First, using fully kinetic simulations, we quantitatively calculate the effect of compression in particle energization during reconnection in low-beta plasmas. We show that compression has an important contribution to the high energy particle energization. Based on this result, we then study the large-scale reconnection acceleration by solving the particle transport equation in a background reconnecting flow provided by either 2D or 3D MHD simulations in in low-beta plasmas. Due to the compressional effect, particles are accelerated to high energies and develop power-law energy distributions. This study clarifies the nature of particle acceleration in reconnection layer and is important to understand particle energization during solar flares.

Loumou, Konstantina

[POSTER] The association of RHESSI flares and the Hale Sector Boundary

In this work, we show the association between RHESSI flares to structures in the solar magnetic field called Hale Sector Boundaries (HSBs). These are the parts of the boundary between the large-scale domains of different polarity of the interplanetary magnetic field, that have the same polarity change as the sunspots back at the Sun. As the polarity of sunspots follows Hale's law, the HSB of a particular polarity change will only occur in one hemisphere per cycle, and then alternate in the next cycle. It has previously been shown that HSBs coincide with stronger magnetic fields and more frequent flare occurrence (Dittmer 1975, Svalgaard & Wilcox 1976, Svalgaard et al. 2011). We extend this work through solar cycles 23 and 24 using RHESSI flare locations from 2002 to 2016. We compare these flares to the HSBs determined using two different methods. One uses the polarity change at the Earth to estimate when the HSB was at solar central meridian and the other uses Potential Field Source Surface (PFSS) extrapolations to identify the HSB for all times. We find that for both Cycle 23 and 24 more than 40% of non-limb flares were located near an HSB, a correlation that varies with cycle phase and hemisphere. We describe how this evolves with time and the potential of these approaches for assisting flare forecasting.

Petrosian, Vahé

Combined Treatment of Particle Acceleration in Solar Flares and Associated CME Shocks

Investigations of particle acceleration in solar eruptive events are carried out by the solar community, with focus is on the acceleration of radiation particles in flares, and by the heliospheric community, with focus on SEPs and the acceleration of particles in CME-driven shocks. However, there is increasing evidence that this disconnect is artificial and a unified approach is necessary. I will review several observations, including observations of high energy long duration gamma-rays by Fermi of several behind-the-limb flares, that require this. I will demonstrate that the similarities and differences between the characteristics of accelerated particles seen near the Earth (as SEPs) and those producing flare radiation in the low corona and chromosphere can shed light on the mechanisms and sites of the acceleration and the transport processes.

Reep, Jeffrey

Exploiting the correlation between transition region line emission and non-thermal hard X-ray emission in flares

Since the Solar Maximum Mission, it has been well known that there exists both a spatial and temporal correlation between transition region line emission and non-thermal hard X-ray emission (HXR) in solar flares. Instrumentally, it is difficult to achieve extremely high spatial resolution in HXR bands, whereas resolutions on the order of 100 km are currently being achieved by instruments like IRIS or Hi-C. In this talk, I discuss the case of a microflare well observed with RHESSI, Hinode, and IRIS, and show how the high spatial resolution of IRIS, with the aid of hydrodynamic modeling, can be used to constrain the flare heating due to an electron beam at spatial resolutions far smaller than HXR instruments allow. The Doppler shifts in Si IV, for example, provide a lower limit on the number of loops being heated, while the intensities provide an estimate of energy distribution. I comment on these results in the context of magnetic reconnection.
