Abstracts
2017 HINODE/IRIS Meeting

Invited Talks

Thomas Ayres, University of Colorado (CASA)

Title: Some Thoughts from the Darkside

Abstract: The powerful X-ray imaging of the Sun delivered by Hinode, and the high-resolution UV stigmatic spectroscopy from IRIS, both have close analogs in the fleet of high-energy orbiting observatories on the "Darkside" (namely looking away from the Sun). For example, NASA's Chandra X-ray Observatory, and its European counterpart XMM-Newton, are capable of recording coronal X-rays from sunlike stars well beyond the outer edge of the solar neighborhood at 100 pc. Further, Hubble's Space Telescope Imaging Spectrograph routinely captures far-UV (C II 133nm, Si IV 139nm) and near-UV (Mg II 2793nm) echelle spectra with resolution very similar to the IRIS channels. Many dozens of sunlike stars have been observed by STIS, and of course many others that are more extreme (in activity or evolutionary state). I will discuss a case in point: the X-ray and UV activity cycles of the central binary (G2V+K1V) of the nearby Alpha Centauri triple system. I also will briefly touch on the "buried coronae" of red giants, which possibly is analogous to an odd phenomenon seen in some solar flares (transient cold molecular absorptions on top of the hot Si IV lines).

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Bin Chen, New Jersey Institute of Technology

Title: Recent Results from Coordinated VLA and Hinode/IRIS Observations

Abstract: After the completion of a decade-long upgrade in early 2012, the Karl G. Jansky Very Large Array (VLA) is now capable of imaging the Sun in 1-8 GHz (soon 1-18 GHz) with unprecedented high cadence (50 ms), spectral resolution (up to 1 MHz), and spatial resolution (~21″/f in GHz). Its powerful dynamic spectroscopic imaging capability and high sensitivity allow unique means of tracing flare-accelerated electrons in the low corona, where the flare energy release presumably takes place. Meanwhile, (E)UV and X-ray observations available from Hinode, IRIS, AIA, and RHESSI provide crucial information on the flare-heated hot plasma and complementary diagnostics on the nonthermal electrons. Since 2011, we have recorded a few dozens of flares (GOES class C or above) with the VLA, some of which had simultaneous coverage from Hinode and/or IRIS. In this talk, I will present recent results from such coordinated observations.

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Sanja Danilovic, Stockholm University, Department of Astronomy

Title: Small-scale Internetwork Magnetic Field Revealed by 2D Inversions

Abstract: Determining the magnetic properties of the solar internetwork is challenging for two reasons. Firstly, the field is structured to very small scales that are at or below the diffraction limit of the current instrumentation. Secondly, these magnetic features harbor rather weak spectropolimetric signals that tend to introduce systematic errors when classical inversion techniques are applied. Two-dimensional inversion code, however, minimizes the influence of noise by fitting the observed spectra simultaneously and selfconsistently. Extensive tests on 3D magneto-hydrodynamic simulations show that the code is able to recover well the overall distribution of the magnetic field strength, but also reveal limitations that current instrumentation imposes.

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Jaime de la Cruz Rodriguez, Institute for Solar Physics, Stockholm University

Title: Chromospheric Inversion and Diagnostics

Abstract: The chromosphere is transparent to most of the radiation that is emitted in the photosphere and only a few spectral lines have sufficient opacity to sample the chromosphere. It is very challenging to infer the physical state of chromospheric plasmas because nonlocal/non-equilibrium physics are usually required to model the observations: Ca II H&K, Ca II 8542, Mg II h&k, Hα, He I 10830. Non-LTE inversion codes allow to construct 3D empirical models from spectropolarimetric observations. In this talk I will review the current status of chromospheric observations and inversion methods in the chromosphere, focusing on IRIS, CHROMIS and HINODE diagnostics.

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Jaroslav Dudík, Astronomical Institute of the Czech Academy of Sciences

Title: Hinode and IRIS Observations of the Active Sun

Abstract: We review the recent Hinode and IRIS observations of the "active Sun", with emphasis on spectroscopy of active regions and flares. These spacecrafts have provided significant advancements in our understanding of the structure of the solar corona and the underlying moss, together with their dynamics including heating, cooling, departures from the ionization equilibrium, as well as possible presence of energetic particles. In flares, we focus on (i) dynamics of upflows (evaporation) as well as downflows observed in different spectral lines within flare kernels, (ii) their connection to variations in magnetic reconnection, as well as on (iii) dynamics of hot or cool magnetic flux ropes, including precursors and initiation of a full eruption. Modelling results are discussed where appropriate.

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Lindsay Glesener, University of Minnesota

Title: A Newly Accessible Regime of Small, High-energy Flares on the Sun

[Lindsay Glesener, Säm Krucker, Iain Hannah, David Smith, Brian Grefenstette, Paul Wright, Matej Kuhar, Hugh Hudson, Stephen White, Andrew Marsh, Juliana Vievering, Subramania Athiray, Steven Christe, Daniel Ryan, Shin-nosuke Ishikawa]

Abstract: The advent of focusing hard X-ray technology for solar purposes offers a high-sensitivity method for studying flare-heated plasma and flare-accelerated electrons. Several focused observations have been performed by the FOXSI sounding rocket and the NuSTAR spacecraft, uncovering abundant flaring activity at scales not accessible to previous HXR instruments. While the flare classes themselves are not new, the ability to observe them at hard X-ray energies offers an unprecedented opportunity to study acceleration and heating and to compare the dynamics of these flares to larger ones. These hard X-ray studies are most effective when combined with thermal images of the corona and chromosphere from Hinode and IRIS. This talk will give an overview of the first set of small-scale flares viewed from this coordinated set of observatories.

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Lijia Guo, Bay Area Environmental Research Institute

Title: IRIS A Spectroscopic Data as a Diagnostic for Reconnection on the Sun

Abstract: Magnetic reconnection is a fundamental process in magnetized plasmas, especially for solar physics. Efforts have been made to understand how reconnection works, i.e. how does energy that accumulated in the magnetic field over a long period of time get released within such short periods of time and cause eruptive phenomena. Nevertheless, clear indication of reconnection mechanisms that is fast enough to account for solar observations has hardly been reported in full details, although both remote imaging or in-situ measurement of reconnection dynamics have been presented. In this presentation, we illustrate how high-resolution spectroscopic observations from the IRIS instrument can be used as a diagnostic of reconnection when combined with numerical experiments.

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Louise Harra, UCL-MSSL

Title: Solar Orbiter, Hinode and IRIS

Abstract: In this review I will summarise the opportunities for observing with the Solar Orbiter mission. I will briefly describe the capabilities of Solar Orbiter, and its observing constraints. I will then describe some key science questions, and show how Hinode and IRIS observations can enhance and complement the results from Solar Orbiter. Different science will be obtained from combining different locations of the spacceraft. Of particular interest is

the science that will be obtained when the spacecraft are at quadrature - which will open up a new science using stereoscopy of magnetic fields, EUV images and (E)UV spectroscopy.

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Haruhisa Iijima, Nagoya University

Title: Numerical Simulations on the Regional Dependence of Chromospheric Jets

Abstract: Three-dimensional radiation MHD simulations are performed to investigate the influence of the magnetic field and coronal conditions on the dynamics of chromospheric jets. It is well known that the spicules exhibit different lengths and lifetimes in coronal holes and quiet regions. The dynamic fibrils near the active region is reported to have the lengths significantly shorter than the spicules. For the better understanding of these regional dependence of chromospheric jets, we perform radiation MHD simulations with the numerical domain extending from the upper convection zone to the lower corona using the numerical code RAMENS. The average magnetic field strength and the coronal temperature are chosen as the control parameters of the simulation. We find that the simulated jets under the high coronal temperature and the strong magnetic field strength (e.g., active regions) become shorter than the case under moderate coronal temperature and field strength (e.g., quiet regions). We will report the physical mechanism of this parameter dependence and discuss the possible scenario of regional dependence of chromospheric jets.

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Graham Kerr, GSFC/NASA

Title: Exploring Alternative Energy Transport Mechanisms in Solar Flares

Abstract: The chromosphere is the origin of the bulk of the enhanced radiative output during solar flares, and so the mechanism(s) by which energy is transported from the release site to the chromosphere is a crucial ingredient in our understanding of flare physics. In the standard model of solar flares, non-thermal electron beams transport energy from the corona to the chromosphere. While this model has been supported by flare observations, and while flare simulations employing this model have been successful in reproducing the observational characteristics of flares, there have been suggestions that electron beams are not the sole energy transport mechanism at play. Originally proposed by Emslie and Sturrock (1982), and revisited by Fletcher and Hudson (2008), the dissipation of downward propagating Alfvenic waves have been put forward as an additional, or alternative, energy transport mechanism. Following the work of Reep and Russell (2016) we have incorporated an approximated form of Alfven wave heating in the radiation hydrodynamics code RADYN. In this talk I will present a comparison of flares simulated with RADYN using electron beams and using this alternative mechanism, discussing both the hydrodynamic and radiative response of the atmosphere in each case. The radiative response will focus on the Mg II k line, but I will touch on the response of the continuum also. I will conclude with a discussion of how research into flare heating via Alfvenic waves might progress.

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Ying Li, Nanjing University

Title: Spectroscopic Diagnostics of Chromospheric Evaporation Using IRIS and Hinode/EIS

Abstract: Chromospheric evaporation refers to drastic mass motions in flaring loops as a result of rapid energy deposition in the chromosphere. It can be diagnosed by Doppler shift measurements in spectral lines: the evaporated (upward) mass motions generate blueshifts usually in warm and hot lines, and downward mass motions (or chromospheric condensation due to momentum balance) produce redshifts in relatively cool lines. Blueshifts/redshifts caused by evaporation/condensation have been observed in the UV and EUV lines from IRIS and EIS. In particular, the high-resolution IRIS observations reveal dominant blueshifts in the hot Fe XXI line, which bridges the gap between the EIS observations (a dominant stationary component plus a blueshifted component in hot lines) and theoretical models (predicting predominant blueshifts in hot lines). Moreover, some important chromospheric lines (Mg II and C II) from IRIS provide us an opportunity to investigate the lower atmospheric condition during evaporation/condensation. On the other hand, the multi-temperature lines from EIS allow us to study the flow reversal temperature from blueshifts to redshifts. Both of the IRIS UV and EIS EUV observations can help diagnose the chromospheric evaporation process. I will present the main results of chromospheric evaporation from these two instruments and also discuss some implications on energy deposition in solar flares.

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Valentin Martinez Pillet, NSO

Title: Complementarities and Synergies between DKIST and Space Missions

[& the DKIST Team]

Abstract: In conjunction with the broader solar community, the National Solar Observatory (NSO) is building the Daniel K Inouye Solar Telescope (DKIST) at the summit of Haleakala (Maui, Hawai'i). This presentation provides a science-driven update on the status of the telescope and its post focus instrumentation. NSO is articulating the early science of the facility in the context of the Critical Science Plan (CSP) activity and its science use cases. The first two years of the operations of the facility (2020/21) will execute the CSP. The 4m aperture of DKIST and the suit of spectropolarimeters available at first light are ideally adapted to target chromospheric vector magnetic fields, becoming a perfect complement for the IRIS and Hinode missions. Starting from the particular science use cases described in the CSP, we provide an update on the DKIST capabilities and its current status, from the telescope structure under assembly at the summit to the state of the first light instrumentation. We also discuss other fundamental aspects driven by the science goals of the facility such as the polarimetric calibration of the telescope and its coronagraphic capabilities relevant to future space missions.

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Masumi Shimojo, National Astronomical Observatory of Japan

Title: New Window of Solar Physics: Solar Observations with ALMA

Abstract: Solar observations with mm/sub-mm waves have been carried out since 1960s, because there is a great potential to provide information on lower chromosphere and accelerated electrons. Nevertheless, mm/sub-mm waves have mostly been an unknown landscape for solar research yet, because it is very hard to obtain images with high spatial resolution. So, it is hoped that solar mm/sub-mm data obtained with ALMA give us new window of solar physics. The Joint ALMA Office (JAO) offered solar observations with Band 3 (100 GHz) and Band 6 (239 GHz) since Cycle 4, and will release first solar scientific verification data on 18 January 2017. Although solar SV data were obtained with only 30 antennas that are included with 9 7m-antennas, the solar images synthesized from them demonstrate the power of ALMA solar observations. In this talk, we will report the current status of solar observations with ALMA, and show the marvelous solar images and the predicted scientific achievements.

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Luc Rouppe Van Der Voort, University of Oslo

Title: Dynamics in Quiet Sun and Plage Regions Observed with IRIS and Hinode

Abstract: The chromosphere in quiet sun and plage regions is dominated by spicules, fibrils and waves. Fundamental processes take place at small spatial and temporal scales. Over the past years, Hinode, IRIS, and ground based telescopes, with their high resolution capabilities, have considerably advanced our understanding of this part of the solar atmosphere. In this review, I will highlight some of the new insights and touch upon some of the challenges we are currently facing.

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Angelos Vourlidas, JHU / APL

Title: Solar Probe Plus Science and Synergies with the Hinode and IRIS Missions

Abstract: Deciphering the origin and early evolution of the solar wind structure has been hampered by the 'disconnected' nature of the observations; remote sensing of the near-Sun corona, in-situ sampling at 1 AU. Two upcoming missions, Solar Orbiter and Solar Probe Plus (SPP), are designed to address this problem head-on with comprehensive suites of remote sensing and in-situ instruments. SPP, in particular, will be the first spacecraft to enter the atmosphere of a star, crossing, reaching within 6 million km from the solar surface. The mission comprises a suite of in-situ detectors to measure the physical properties of the solar wind and a single imager to provide large scale context and 3D reconstructions of the coronal

structure to tie together in-situ sampling and high contrast imaging from 'within' the solar corona from SPP with remote observations of the sources of the solar wind form Hinode and IRIS. In this talk, I introduce the capabilities and science objectives of the SPP mission and discuss possible synergies with the hind and IRIS missions

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Contributed Talks

Yumi Bamba, ISAS/JAXA

Title: Study on Precursor Activity of the X1.6 Flare in AR 12192 with Hinode, IRIS, and SDO

Abstract: The physical properties and its contribution to the onset of solar flare are still unclear although chromospheric brightening is considered a precursor phenomenon of flare. Many studies suggested that photospheric magnetic field changes cause destabilization of large-scale coronal structure. We aim to understand how a small photospheric change contributes to a flare and to reveal how the intermediary chromosphere behaves in the precursor phase. We analyzed the precursor brightening of the X1.6 flare on 2014 October 22 in the AR 12192 using the Interface Region Imaging Spectrograph (IRIS) and Hinode/EUV Imaging Spectrometer (EIS) data. We investigated a localized jet with the strong precursor brightening, and compared the intensity, Doppler velocity, and line width in C II, Mg II k, Si IV lines by IRIS and He II, Fe XII, Fe XV lines by Hinode/EIS. We also analyzed photospheric magnetic field and chromospheric/coronal structures using Solar Dynamics Observatory (SDO)/Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA). We found a significant blueshift (~100 km/s) in the chromospheric and coronal lines, that is related to the strong precursor brightening over a characteristic magnetic field structure. This blueshift seems to be temperature independent flow, which might indicate that the flow is accelerated by Lorentz force. Moreover, the large-scale coronal loop that connects the foot-points of the flare ribbons was destabilized just after the precursor brightening with the blueshift. It suggests that magnetic reconnection locally occurred in the lower chromosphere and it triggered magnetic reconnection of the X1.6 flare in the corona.

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Sean Brannon, Montana State University

Title: A Solar Space Elevator: Imaging and Spectroscopic Analysis of a Series of Jet Eruptions Observed by IRIS and SDO/AIA

Abstract: Coronal jets are ubiquitous transient events in the solar atmosphere. Typically appearing as thin, collimated structures in EUV and X-ray wavelengths, with heights of tens to hundreds of Mm and apparent velocities of several hundred km/s, coronal jets are thought to be the result of reconnection in the lower corona or upper chromosphere. On 2017 October 14, the Interface Region Imaging Spectrograph (IRIS) observed a series of large, jet-like eruptions originating from NOAA AR 12599. The jets were also observed by the Solar

Dynamics Observatory Atmospheric Imaging Assembly (SDO/AIA) in wavelengths ranging from 304 A to 131 A, demonstrating the multi-temperature nature of the jet plasma. The structure of this event has a length-to-width ratio exceeding 50 during some of the jet eruptions, and remains remarkably straight throughout its evolution. During the three main eruptions, bright blobs of plasma can be observed to ascend and subsequently descend along the structure, giving the appearance of elevator cars. We present results from our imaging and spectroscopic analysis of this event, including feature-tracking and Doppler shift of the "cars", to estimate the plasma flow velocity and acceleration and structure inclination. We also present a one-dimensional hydrodynamic simulation of the plasma flows in the jet.

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Pål Brekke, Norwegian Space Centre

Title: Kristian Birkeland - The Almost Forgotten Scientist and Father of the Sun-Earth Connection

Abstract: In 2017, physicist Kristian Birkeland's legacy still stands strong - 150 years after his birth and 100 years after his death. He is regarded as the leading scientist and inventor in Norwegian history. Kristian Birkeland was the first scientist to explain that the sun was the source of the northern lights and founded much of today's modern space research. He was also the man behind the fantastic invention that enabled the making of artificial fertiliser by harvesting nitrogen from the air. The discovery was the basis for the foundation of Hydro and turned out to be extremely important for the food production around the world at that time. Hydro (today called Yara) is still the world's largest fertiliser company operating production in more than 50 countries. Birkeland's theories about the northern lights and electrical currents in the atmosphere met great opposition among internationally renowned scholars such as Lord Kelvin and Sydney Chapman. It took over 60 years before one could confirm Birkeland's theories when satellites became available and observed solar wind particles and detected electrical currents which we today call Birkeland currents. However, in 1994, Birkeland was deservedly honoured. His portrait was chosen for the front side of the Norwegian 200-kroner banknote and he now also features on the tail of a Norwegian Airlines plane. This lecture is a tribute to one of the greatest scientists in space research.

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Jeffrey Brosius, Catholic University at NASA/GSFC

Title: Results from Flare Stare Spectroscopic Observations with EIS and IRIS

Abstract: Spectroscopic observations with time resolutions comparable to the timescales on which flares evolve are necessary to understand the physical processes that occur during solar flares. At present, the best way to do this is with IRIS and EIS, at cadences around 10 s. We present results from two sets of coordinated IRIS and EIS stare spectra, obtained through IHOP 241, along with coordinated hard X-ray observations from RHESSI. A GOES M7.3 flare in AR 12036 on 2014 April 18 underwent explosive chromospheric evaporation during its impulsive rise. Quasi-periodic intensity fluctuations were observed by both EIS (P ~ 75.6 +/- 9.2 s) and IRIS (P ~ 173.2 +/- 23.5 s, changing to 94.4 +/- 4.9 s) in the same ribbon. The IRIS slit was pointed 40 arcsec west of the EIS slit. RHESSI detected 25-100 keV hard X-ray sources in the ribbon near the EIS slit's pointing position during the peaks in the EIS intensity fluctuations, but no hard X-ray emission at the location of the IRIS slit, likely because the beam energy flux was weaker at that location. We conclude that the series of quasi-periodic intensity peaks in the light curves was produced by a series of nonthermal electron injections into the chromosphere. The injections may be attributed to MHD oscillations in a magnetic trap, MHD oscillations in a nearby, non-flaring magnetic loop, or magnetic reconnection in a large-scale current sheet dominated by repeated formation of magnetic islands. We estimate radiative cooling times of 32 s at 2.0 MK, 46 s at 0.63 MK, and 1000 s at 14 MK, leading us to speculate that fluctuations are observed in the lower temperature (but not Fe XXIII) lines because at those temperatures the plasma had sufficient time to radiatively cool between successive energy injections. For a GOES C3.1 flare in AR 12002 on 2014 March 15, the IRIS slit was located near the center of the flare while the EIS slit was pointed about 30 arcsec to the west, apparently outside the flare. About 2.5 m earlier than the GOES flare start, the C II and Si IV line intensities became (and remained) significantly greater than their pre-flare average values; this indicates that the flare had already begun and that it involved the chromosphere and transition region, even though Fe XXI emission was not significant at this time. Eventually the C II and Si IV lines showed large brightenings accompanied by redshifts around 20 km/s, and blueshifted Fe XXI emission appeared at the same location in which the C II and Si IV emission was redshifted, indicating explosive chromospheric evaporation. EIS spectra reveal significant Fe XXIII emission that is too weak to measure velocities, and enhancements by factors up to 1.7 in the Fe XIV and Fe XVI emission. Both of these coronal lines show a hint of a redshift no more than 10 km/s, possibly indicating warm rain.

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Paul Bryans, NCAR/HAO

Title: When is a Coronal Hole Not a Coronal Hole?

Abstract: Coronal holes (CHs) are most commonly defined as long-lived regions of reduced intensity in EUV images. But such an identification can lead to the conclusion that all CHs are created equal. Recent analysis of the spectral characteristics of CHs, using data from IRIS and EIS, belies their apparent uniformity in imaging data. Despite the typical assertion that CHs are the source of the fast solar wind, EIS measurements show regions within a CH of slow-wind composition in the corona. The spectral signatures of these regions extend to the chromosphere, as evidenced in the Mg II lines measured by IRIS, suggesting the differences are a result of effects in the lower solar atmosphere. In this presentation, we explore the magnetic field configurations that could give rise to the observational results, and speculate that the "openness" of the field leads to distinct classes of CHs.

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Mark Cheung, Lockheed Martin Solar & Astrophysics Laboratory

Title: On the Thermal Structure and Evolution of Solar Flares

Abstract: We use SDO/AIA data to study the thermal structure and evolution of solar flares. We apply the AIA team's validated differential emission measure (DEM) inversion procedure to map reconnection outflows and flare loops. We demonstrate that X-ray images and coronal emission line images synthesized from AIA DEMs have good correspondence with observations taken by Hinode/XRT and Hinode/EIS, respectively. We show how IRIS and SDO/AIA data can be used in tandem to effectively track plasma from chromospheric evaporation to coronal condensation.

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Bart De Pontieu, Lockheed Martin Solar & Astrophysics Laboratory

Title: Observations and Numerical Modeling of the Impact of Spicules on the Heating of the Transition Region and Corona

Abstract: While chromospheric spicules have been proposed as significant contributors to the energy and mass balance of the transition region and corona, many unresolved issues continue to hamper progress. For example, transition region counterparts of spicules have been observed with IRIS, but their exact nature remains unclear, with their high apparent motions of several 100 km/s apparently in conflict with directly measured mass flows from Doppler shifts. Similarly, while previous observations have provided a glimpse of short-lived transient brightenings in the corona that are associated with spicules, these observations have been contested and are the subject of a vigorous debate both on the modeling and the observational side so that it remains unclear whether plasma associated with spicules is heated to coronal temperatures. We use high-resolution observations of the chromosphere and transition region with the Interface Region Imaging Spectrograph (IRIS) and of the corona with the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) to show evidence of the formation of coronal structures as a result of spicular mass ejections and subsequent heating of plasma first to transition region and later to coronal temperatures. Our observations suggest that much of the highly dynamic loop fan environment associated with plage regions may be the result of the formation of such new coronal strands, a process that previously had been interpreted as the propagation of transient propagating coronal disturbances (PCD)s. We compare our observations with recent numerical models in which spicules are driven by the violent release of magnetic tension that has diffused into the upper chromosphere through the effects of ambipolar diffusion on the interaction between weak and strong magnetic flux concentrations. The model predicts that spicules are associated with vigorous heating to transition region and coronal temperatures, and matches the IRIS and AIA observations well. It can explain the high apparent speeds observed in transition region lines and the appearance of new loop strands and PCDs in coronal lines. Our results indicate that spicules are a signature of heating to transition region and coronal temperatures, and suggest that heating and strong flows play an important role in

generating maintaining the substructure of loop fans, in addition to the waves that permeate this low coronal environment.

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Clara Froment, University of Oslo – ITA

Title: Long-period Intensity Pulsations as the Manifestation of Heating Properties of Coronal Loops

Abstract: The discovery of long-period intensity pulsations in coronal loops bring a major constraint for loop heating theories. These EUV pulsations, with periods between 2 and 16 hours, can be found at least in half of the active regions, in particular in loops (Auchère et al. 2014). They are understood to be due to evaporation and condensations cycles, resulting of a quasi-constant and highly-stratified heating (Froment et al. 2015, 2017; Auchère et al. 2016). These loops enter in a regime of thermal non-equilibrium (TNE). The thermal runaway triggered during the cooling phase of TNE cycles is believed to play a major role in the formation of coronal rain (Müller et al. 2003, 2004; Antolin et al. 2010,) and prominences (e.g., Antiochos & Klimchuk 1991; Karpen et al. 2006). In order to understand the physical conditions that favor such cycles, we conduct 1D hydrodynamic simulations to scan different loop geometries and heating configurations. This study reveals that TNE cycles are confined to specific ranges in the parameter space. This naturally explain why these pulsations, remaining during several days, are encountered in some loops but not in all. In an active region both loop geometry and heating properties are varying from a loop to another, only the loops with a good match between both can enter in a TNE evolution. Moreover, this parameter space study reveals multiple scenarios, in particular concerning the nature and the localisations of the condensations. Some heating configurations lead to "incomplete" condensations (the temperature and density remaining coronal, i.e. Mikić et al. 2013) while others show "complete" condensations (high density blobs, chromospheric temperature) that develop locally in the corona. These different behavior, predicted by simulations, are then further investigated combining data sets from AIA/SDO and IRIS. In particular because the spatial resolution and the temperature coverage of AIA does not allow to observe the bulk of the condensation distribution. The characterization of TNE cycles, combining observation and modeling, is a key step to constraint the frequency and the location of the heating in solar coronal loops.

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Milan Gosic, Lockheed Martin Solar & Astrophysics Laboratory

Title: Heating of the Chromosphere and Transition Region by Cancellations of Internetwork Fields

Abstract: The heating of the solar chromosphere and corona remains to be one of the most intriguing unanswered problems in solar physics. It is believed that this phenomenon may significantly be supported by small-scale internetwork (IN) magnetic fields. Indeed, cancellations of IN magnetic flux patches might be an efficient way to transport flux and energy from the photosphere to the chromosphere and corona. Therefore, it is crucial to determine where they occur, the rates at which they proceed, and understand their influence on the upper solar atmosphere. Here we study IN cancellations using high resolution, multiwavelength, coordinated observations obtained with the Interface Region Imaging Spectrograph (IRIS) and the Swedish 1-m Solar Telescope (SST). Employing multi-line inversions of the Mg II h&k lines we show that cancelling events, while occurring ubiquitously over IN regions, produce clear signatures of heating in the upper atmospheric layers. We also determine the total amount of energy released due to cancellations of IN elements and discuss about their impact on the dynamics and energetics of the chromosphere and transition region.

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Viggo Hansteen, Institute of Theoretical Astrophysics, University of Oslo

Title: Bombs and Flares at the Surface and Lower Atmosphere of the Sun

Abstract: A spectacular manifestation of solar activity is the appearance of transient brightenings in the far wings of the H(alpha) line, known as Ellerman bombs (EBs). Recent observations obtained by the Interface Region Imaging Spectrograph (IRIS) have revealed another type of plasma ``bombs'' (UV bursts) with high temperatures of perhaps up to 80 kK within the cooler lower solar atmosphere. Realistic numerical modeling showing such events is needed to explain their nature. Here, we report on 3D radiative magneto-hydrodynamic simulations of magnetic flux emergence in the solar atmosphere. We find that ubiquitous reconnection between emerging bipolar magnetic fields can trigger EBs in the photosphere, UV bursts in the mid/low chromosphere and small (nano-/micro-) flares (1 MK) in the upper chromosphere. These results provide new insights on the emergence and build up of the coronal magnetic field and the dynamics and heating of the solar surface and lower atmosphere.

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Nengyi Huang, New Jersey Institute of Technology

Title: Spectral Analysis Flare Ribbons by IRIS and NST

Abstract: Being one of the most powerful phenomena of solar activities, flares have long been observed and studied extensively. Taking advantages of observing capabilities of modern solar telescopes and focal-plane instruments such as the Interface Region Imaging Spectrograph (IRIS) and the 1.6 m New Solar Telescope (NST) at Big Bear Solar observatory (BBSO), we are now able to obtain high resolution imaging spectroscopic data in UV, visible and near-infrared (NIR) wavelengths. Here we present the spectral analysis of an M6.5 flare (SOL2015-06-22T18:23) which was well covered by the joint observation of IRIS and NST. In the visible wavelengths H-alpha and TiO, we can separate the flare ribbon into a very narrow leading front and faint trailing component, of which the former is characterized by the intense

emission and significant Doppler signals. In the IRIS UV spectra, the ribbon front shows distinct properties, such as the line broadening and Doppler shifts, which are consistent with the visible observations. These characteristics suggest that the ribbon front to be the precipitation sites of the energetic electron beams.

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Natasha Jeffrey, University of Glasgow

Title: Non-Gaussian Velocity Distributions in Solar Flares from Extreme Ultraviolet Lines: A Possible Diagnostic of Ion Acceleration

Abstract: In a solar flare, a large fraction of the magnetic energy released is converted rapidly to the kinetic energy of non-thermal particles and bulk plasma motion. This will likely result in non-equilibrium particle distributions and turbulent plasma conditions. We investigate this by analysing the profiles of high-temperature extreme ultraviolet emission lines from a major flare (SOL2014-03-29T17:44) observed by the EUV Imaging Spectrometer (EIS) on Hinode. We find that in many locations the line profiles are non-Gaussian, consistent with a kappa-distribution of emitting ions with properties that vary in space and time. At the flare footpoints, close to sites of hard X-ray emission from non-thermal electrons, the kappa-index for the Fe XVI 262.976 angstrom line at 3 MK takes values of 3-5. In the corona, close to a low-energy HXR source, the Fe XXIII 263.760 angstrom line at 15 MK shows kappa values of typically 4-7. The observed trends in the kappa parameter show that we are most likely detecting the properties of the ion population rather than any instrumental effects. We calculate that a non-thermal ion population could exist if locally accelerated on timescales <0.1 s. However, observations of net redshifts in the lines also imply the presence of plasma down flows which could lead to bulk turbulence, with increased non-Gaussianity in cooler regions. Both interpretations have important implications for theories of solar flare particle acceleration.

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Adam Kobelski, The University of Alabama in Huntsville

Title: Supra Arcade Downflows in the Earth’s Magnetotail

[Sabrina L. Savage, David M. Malaspina]

Abstract: Pinpointing the location of a single reconnection event in the corona is difficult due to observational constraints, although features directly resulting from this rapid reconfiguration of the field lines can be observed beyond the reconnection site. One set of such features are outflows in the form of post-reconnection loops, which have been linked to observations of supra-arcade downflows (SADs). SADs appear as sunward-traveling, density-depleted regions above flare arcades that develop during long duration eruptions. The limitations of remote sensing methods inherently results in ambiguities regarding the interpretation of SAD formation. Of particular interest is how these features are related to

post-reconnection retracting magnetic field lines. In planetary magnetospheres, similar events to solar flares occur in the form of substorms, where reconnection in the anti-sunward tail of the magnetosphere causes field lines to retract toward the planet. Using data from the Time History of Events and Macroscopic Interactions during Substorms (THEMIS), we compare one particular aspect of substorms, dipolarization fronts, to SADs. Dipolarization fronts are observed as rapid but temporary changes in the magnetic field of the magnetotail plasma sheet into a more potential-like dipolar shape. These dipolarization fronts are believed to be retracting post-reconnection field lines. We combine data sets to show that the while the densities and magnetic fields involved vary greatly between the regimes, the plasma βs and Alfvén speeds are similar. These similarities allow direct comparison between the retracting field lines and their accompanying wakes of rarified plasma observed with THEMIS around the Earth to the observed morphological density depletions visible with XRT and AIA on the Sun. These results are an important source of feedback for models of coronal current sheets.

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Kanya Kusano, ISEE, Nagoya University

Title: Study of Flare Prediction Based on the Magnetohydrodynamic Simulation and the Nonlinear Force-free Field Modeling of Solar Activity

Abstract: Solar eruptions, e.g. flares and CMEs, are believed to be the explosive liberation of magnetic energy contained in the solar corona. However, the onset mechanism of solar eruptions is not yet clearly explained. We have proposed that the feedback interaction between an ideal magnetohydrodynamic (MHD) instability driven by the electric current flowing in the solar corona and magnetic reconnection plays a crucial role to drive solar eruptions. However, the mode of instability related to the onset of eruption and its critical condition are not yet well understood. Recently, Ishiguro and Kusano (submitted to ApJ) clarifies that the double-arc electric current loop, which can be formed by the tether-cutting reconnection, can produce a new type of instability called double-arc instability (DAI). The objective of this study is to clarify the critical condition of the DAI using the three-dimensional MHD simulation and also to apply the result to the prediction of solar eruptions. For these purposes, we have analyzed the correlation of a new parameter kappa, which is derived as the critical parameter of the DAI, with the solar flare activity through the nonlinear force-free field (NLFFF) model of various active regions using Hinode/SOT and SDO/HMI data. Finally, we discuss the prospects of physics-based flare prediction based on the numerical simulation and the NLFFF model.

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David McKenzie, NASA MSFC

Title: High-cadence Hinode/XRT Observations for Studying Coronal Events with Very Short Timescales

[David E. McKenzie, Adam R. Kobelski, Sabrina L. Savage]

Abstract: The Hinode X-Ray Telescope's capability for high time cadence observations makes it an excellent tool for probing highly variable conditions in the corona, including wave-like activity, dynamic plasma motions, and short-duration transient events. XRT is capable of producing images at cadences faster than one image per 10 seconds, which is comparable to the energy release timescales, and/or ionization evolution timescales, predicted by a range of models of coronal activity. In the present work, we demonstrate XRT's high-cadence capability through observations of active region AR 10923 (2006 November), with cadences of 3–6 seconds. The image sequences, made sequentially with multiple analysis filters, reveal many transient brightenings (i.e., microflares), for which we derive heating and cooling timescales. We also forward model the observed light curves to estimate the temperature, density, filling factors, and lengths of the observed loops. These estimates allow us to prioritize different heating mechanisms, and to better understand the unresolved structures within the observations. This study provides a test of capabilities, which have still not yet been fully utilized by the ten-year-old Hinode X-Ray Telescope, and thus provides a starting point for future investigations of short-timescale/high-frequency variations in coronal X-ray intensity.

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Nancy Narang, Indian Institute of Astrophysics

Title: IRIS View on Multi-Component Structure of Solar Transition Region

Abstract: High-resolution observations from IRIS have provided detailed information about the fine structure of the less studied solar transition region, a layer between chromosphere and corona. In recent past, it has been claimed by many authors that the transition region emission lines often shows a "Two Gaussian Component Profile". Using IRIS observations, we aim towards the investigation of the sources of the two components by examining the corresponding features in SJIs. These two components might be resulting from the network background with network jets and small cool loops. Using joint spectral and imaging observations of IRIS in a coronal hole, the spectral properties of different spatial structures are studied. From our analysis which is based on reduced chi-square test, we can conjecture that the double Gaussian profile model is better than single Gaussian model near the locations of network boundaries. We observe no one to one correlation among the fitted spectral parameters of the second component except for some locations where high Doppler speeds (20-40 km/s) are mostly accompanied by presence small Doppler widths (<30 km/s). On comparison with slit-jaw images, these locations can be clearly regarded as the locations of presence high speed collimated and short-lived transient flows or network jets. We can mainly conclude that the 2nd component of double Gaussian fitting indeed reveals the presence the transients in chromosphere and TR. Hence, double Gaussian model fitting to the spectral profiles is necessary to study small-scale short-lived transients in details.

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Daniel Nóbrega-Siverio, Instituto de Astrofísica de Canarias

Title: Surges and Si IV Bursts: Unraveling IRIS/SST Observations through Forward-modeling of a Flux Emergence Radiation-mhd Experiment

Abstract: Surges are a good example of the complexity of chromospheric ejections. They often appear alongside other phenomena as a result of the emergence of magnetized plasma from the solar interior. In particular, recent observations have tentatively identified the coexistence of surges with bursts and brightenings in Si IV using the Interface Region Imaging Spectrograph (IRIS). However, whether there is an intrinsic relation between those two types of phenomena is unclear; a theoretical explanation is still missing. In this talk we analyze an episode of Halpha surges and Si IV bursts occurred on 2016 September 03 on active region AR12585. To that end, we use coordinated observations from IRIS and the Swedish 1 m Solar Telescope (SST). We have found that according to their spectral profiles and time of occurrence, there are four well differentiated regions in the combined episode of surge and bursts. We are able to explain the complexity of the four found regions through spectral synthesis of a 2.5D flux emergence radiation-mhd experiment, which has been carried out using the Bifrost code including also the calculation of the Si IV ionization state in non-equilibrium. Furthermore, by means of detailed Lagrange tracing, we are able to determine the source of the Si IV emission, indicating the importance of including the entropy sources associated with thermal conduction and optically thin radiation losses when trying to reproduce the observations of chromospheric and transition regions phenomena.

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Aimee Norton, Stanford University

Title: Magnetic Flux Emergence and Decay Rates of Active Regions Observed with HMI

[Aimee Norton, Eric Jones, Mark Linton, James Leake]

Abstract: Magnetic flux emergence into the solar atmosphere triggers transient events such as flares, coronal mass ejections and jets. The aims of this study are to quantify flux emergence and decay rates of active regions using vector magnetic field data as observed with HMI/SDO in order to constrain the simulation conditions and understand the subsurface emergence process that we cannot observe directly. Signed flux emergence rates for sunspots average 5 x 10^{19} Mx per hour, while decay rates are considerably slower at about half that rate. We put the observed rates into context with results previously reported from observations using various instruments (including Hinode SOT) and simulations. Using a synthesis of the HMI results and previously reported rates, a clear trend is seen that larger flux regions emerge faster than smaller flux regions. We find the observed emergence rate scales with peak flux of the region as a power law with an exponent of 0.32. The rates reported here may assist in constraining the choice of boundary and initial conditions in numerical simulations which have already demonstrated that rates increase when a flux tube has higher buoyancy and twist, or is in the presence of a strong convective upflow.

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Takayoshi Oba, SOKENDAI

Title: The Photospheric Granulation Retrieved by a Deconvolution Technique Applied to Hinode/SP Data

Abstract: Solar granules are bright patterns surrounded by dark channels called intergranular lanes in the solar photosphere and are a manifestation of gas convection. Many observational works have found stronger upflows in granules and weaker downflows in intergranular lanes. This trend is, however, inconsistent with the results of numerical simulations, in which the downflows are stronger than the upflows through the joint action of gravitational acceleration/deceleration and pressure gradient. One cause of this discrepancy is image degradation, caused by optical distortion and light scattering that takes place in the imaging instrument. Accordingly, we use a deconvolution technique that corrects this imaging non-perfection (i.e. recovers the original image), using the Hinode/SP data that is well-suited for such an approach since its PSF is nearly time-independent. Our results show a significant enhancement in the convective velocity fields of both upflows and downflows, especially for downflows, finding values of -3.0 (upward) and +3.0 km/s (downward) at an averaged geometrical height of 49 km, which are derived from the deconvolved spectrum with bisector analysis, whereas the amplitudes in the spectral data before the deconvolution are -2.0 to +1.5 km/s. We found that these changes in the velocity fields match well those derived from the numerical simulations in the same way, applying bisector analysis to the spectral profiles synthesized with the SPINOR code in the atmosphere computed by the MURaM code. The obtained magnitude relations of the vertical flows approach those found in the numerical simulations due to the preferential enhancement in downflows. We will report that the amplitudes and morphology of the photospheric convection, provided by the deconvolved Hinode/SP data.

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Joten Okamoto, NAOJ

Title: The Strongest Magnetic Field in Sunspots

Abstract: Sunspots are concentrations of magnetic fields on the solar surface. Generally, the strongest magnetic field in each sunspot is located in the dark umbra in most cases. A typical field strength in sunspots is around 3,000 G. On the other hand, some exceptions also have been found in complex sunspots with bright regions such as light bridges that separate opposite polarity umbrae, for instance with a strength of 4,300 G. However, the formation mechanism of such strong fields outside umbrae is still puzzling. Here we report an extremely strong magnetic field in a sunspot, which was located in a bright region sandwiched by two opposite-polarity umbrae. The strength is 6,250 G, which is the largest ever observed since the discovery of magnetic field on the Sun in 1908 by Hale. We obtained 31 scanned maps of the active region observed by Hinode/SOT/SP with a cadence of 3 hours over 5 days (February 1-6, 2014). Considering the spatial and temporal evolution of the vector magnetic

field and the Doppler velocity in the bright region, we suggested that this strong field region was generated as a result of compression of one umbra pushed by the outward flow from the other umbra (Evershed flow), like the subduction of the Earth's crust in plate tectonics.

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Hardi Peter, Max Planck Institute for Solar System Research

Title: Width and Helical Structure of Cool Transition Region Loops

Abstract: In our study we measure the widths of cool transition region loops seen in IRIS slitjaw images covering quiescent and flaring active regions, and connect this to the helical structures we see in cool loops as revealed by IRIS Doppler maps. The widths of coronal loops are found to be about 500 km or more from both imaging with Hi-C and spectroscopic investigations with Hinode/EIS. This substantiates the presence of a resolvable, fundamental width for (strands of) loops. Using IRIS data we show that also cool loops at transition region temperatures have a smallest width of about 500 km, while being several 10 Mm long. This raises the question on the nature of this fundamental width, i.e. which processes can determine the cross-field size of a transition region or coronal loop that is of the order of 500 km? In this context we will discuss IRIS observations that show helical structures being present all along the loops. In Doppler maps these loops show a redshift of about 10 km/s on one side of the loop and a blueshift of comparable magnitude on the other, indicating a helical structure of the magnetic field defining the loop. We will discuss what role such a helical structure would play in defining the loop width and relate this to fundamental considerations involving the footpoint structure of the loops or the ongoing MHD turbulence induced by the braiding of the field lines defining the loop.

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Vanessa Polito, Harvard-Smithsonian Center for Astrophysics

Title: Investigating the Response of Coronal Loop Plasma to Nanoflares Heating Using RADYN Simulations

Abstract: Investigating the response of coronal loop plasma to nanoflares heating using RADYN simulations V.Polito, P. Testa, J. Allred, M. Carlsson, B. De Pontieu, T.M.D. Pereira We present the results of 1D hydrodynamic simulations of coronal nanoflare loops heated by beams of non-thermal electrons as well as thermal conduction using the RADYN code. The aim is to investigate the importance of the input parameters and the details of the heating mechanism on the model predictions. In particular, we examine the impact of different electron energy distributions and initial physical conditions of the loops on the atmospheric response. We derive the intensity and Doppler shifts of chromospheric, transition region and coronal lines, which can then be directly compared with spectroscopic and imaging observations from IRIS and SDO/AIA.

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Jeffrey Reep, National Research Council Post-doc at the US Naval Research Laboratory

Title: Chromospheric Evaporation as a Diagnostic of Heating Duration in Flaring Loops

Abstract: Heating occurs across numerous loops in a solar flare, with properties that are unlikely to be resolved. Through a combination of observational constraints and detailed modeling, we previously estimated the energy distribution of heating bursts across the threads, finding them to be well-described by a power law with slope -1.7. However, we do not know how long each individual loop is heated, whether each is heated for the same duration, or whether some distribution of durations describes a flare. Fe XXI up-flows seen with IRIS have a characteristic pattern: they form blue-shifted at around 2-300 km/s, gradually decaying to the rest wavelength over a period of 5-10 minutes. Since the duration of evaporation is connected to the duration of heating in hydrodynamic models, it is plausible that this up-flow pattern in Fe XXI is connected with the heating duration. Using a large sample of simulations, we model the chromospheric evaporation in order to synthesize Fe XXI emission in order to study heating durations. We show that the up-flow duration and decay are linked to the heating duration on individual loops, and can constrain the heating durations. We compare these predictions against the observations of a large flare that was well observed with IRIS, and find that the trends can be reproduced while being simultaneously constrained by other observables.

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Matthias Rempel, HAO/NCAR

Title: Simulations of the Coupled Photosphere/Corona System: MHD Simulation of a Solar Flare

Abstract: Coupling the photosphere and corona requires to cope with a large separation of time scales. While typical photospheric time scales of interest range from minutes (granulation) to days (active region flux emergence), numerical time steps in the corona can be very small due to Alfven velocities exceeding 100,000 km/s and very efficient heat conduction. To cope with these challenges we present a recently developed version of the MURaM radiative MHD code that includes coronal physics in terms of optically thin radiative loss and field aligned heat conduction. The code employs the "Boris correction" (semi-relativistic MHD with a reduced speed of light) and a hyperbolic treatment of heat conduction, which allow for efficient simulations of the photosphere/corona system by avoiding the severe time-step constraints arising from Alfven wave propagation and heat conduction. We demonstrate that this approach can be used even in dynamic phases such as a flare by dynamically adjusting the "reduced speed of light" accordingly. We consider a setup in which a flare is triggered by flux emergence into a preexisting bipolar active region. After an energy release of about 5x10^30 erg in the corona, efficient transport of energy along field lines leads to the formation of flare ribbons within seconds. In the flare ribbons we find downflows (chromospheric condensation) for temperatures lower than 3MK and upflows (chromospheric evaporation) at higher temperatures. The resulting soft X-ray emission shows a fast rise and slow decay, reaching a peak corresponding to a mid C-class flare. The post reconnection energy release in the corona leads to average particle energies reaching 50keV (500 MK under the assumption of a thermal plasma). We show that hard X-ray emission from the corona computed under the assumption of thermal bremsstrahlung can produce a non-thermal spectrum due to the multi-thermal nature of the plasma. The electron energy flux into the flare ribbons (classic heat conduction with free streaming limit) is highly inhomogeneous and reaches peak values of about 3x10^11 erg/cm^2/s in a small fraction of the ribbons, indicating regions that could potentially produce hard X-ray footpoint sources. We demonstrate that these findings are robust by comparing simulations computed with different values of the saturation heat flux as well as the "reduced speed of light".

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Viacheslav Sadykov, New Jersey Institute of Technology (NJIT)

Title: Analysis of Chromospheric Evaporation in Solar Flares

Abstract: Chromospheric evaporation is one of the key processes of solar flares. Properties of chromospheric evaporation are thought to be closely connected to the energy release rates and energy transport mechanisms. Previous investigations revealed that in addition to electron-beam heating the chromospheric evaporation can be driven by heat fluxes and, probably, by other mechanisms. In this work, we present a study of the flare events simultaneously observed by IRIS, Hinode, SDO and RHESSI, focusing on spatio-temporal characteristics of the flare dynamics and its relation to the magnetic field topology. Event selection is performed using the Interactive Multi-Instrument Database of Solar Flares (IMIDSF) recently developed by the Center for Computational Heliophysics (CCH) at NJIT. 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 correlations among the derived line profile properties, flare morphology, magnetic topology and hard X-ray characteristics will be presented, and compared with the RADYN flare models and other scenarios of chromospheric evaporations.

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Alberto Sainz Dalda, Bay Area Environmental Research Institute / LMSAL

Title: How k-mean Clustering Technique Helps Us to Understand the Physics Encoded in Spectral Profiles

Abstract: We have applied an easy-to-implement, fast clustering technique to Hinode-SOT/SP and IRIS data. Analyzing the representative profiles (RPs) of the data set, we may rapidly understand the physics of our observations in a big-picture sense. The individual profiles associated with a particular RP are located in well-defined patches, which evolve coherently

both temporally and spatially. That means, these individual profiles and their associated RP are produced as a result of similar physical conditions. Understanding the physics behind a RP thus allows to understand the physics of all its associated individual profiles. This method simplifies the interpretation of large data sets, and allows us to easily identify regions that host interesting physical events. We show the steps and the pros and cons of this technique. We evaluate the goodness of this method through the comparison between the atmosphere recovered by the inversion of the individual profiles and the one obtained by the inversion of their associated RP.

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Donald Schmit, Bay Area Environmental Research Institute (@GSFC)

Title: Science from the Joint CLASP-IRIS Observations

Abstract: The CLASP rocket flight returned spectrograph measurements of Lyman-alpha profiles and related bandpass images using a slit jaw camera. Lyman-alpha is a unique and important diagnostic tool for the probing the solar transition region. The IRIS instrument observes both the chromosphere and transition region using the Mg II h&k and Si IV 1393A lines, respectively. In this study, we analyze the coordinated IRIS-CLASP dataset. A comparison of the Mg II and Ly-a profiles is discussed with the aid of radiative MHD simulations. In a separate analysis, we discuss the recent results published by Kubo et al (ApJ, vol. 832, 2016) regarding fast propagating intensity disturbances observed in the CLASP slitjaw. We analyze IRIS 1400A slitjaw data at a cadence of 1.7s to quantify the dynamics of the transition region over very short time scales. The IRIS SJI oscillations appear to associated with both spicules and less collimated features over network magnetic concentrations.

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Alphonse Sterling, NASA/MSFC

Title: Active Region Jets II: Triggering and Evolution of Violent Jets

Abstract: We study a series of X-ray-bright, rapidly evolving active-region coronal jets outside the leading sunspot of AR 12259, using Hinode/XRT, SDO/AIA and HMI, and IRIS/SJ data. The detailed evolution of such rapidly evolving “violent” jets remained a mystery after our previous investigation of active region jets (Sterling et al. 2016, ApJ, 821, 100). The jets we investigate here erupt from three localized subregions, each containing a rapidly evolving (positive) minority-polarity magnetic-flux patch bathed in a (majority) negative-polarity magnetic-flux background. At least several of the jets begin with eruptions of what appear to be thin (thickness ~<2′′) miniature-filament (minifilament) “strands” from a magnetic neutral line where magnetic flux cancelation is ongoing, consistent with the magnetic configuration presented for coronal-hole jets in Sterling et al. (2015, Nature, 523, 437). For some jets strands are difficult/ impossible to detect, perhaps due to their thinness, obscuration by surrounding bright or dark features, or the absence of erupting cool-material minifilaments in

those jets. Tracing in detail the flux evolution in one of the subregions, we find bursts of strong jetting occurring only during times of strong flux cancelation. Averaged over seven jetting episodes, the cancelation rate was ~1.5×10^19 Mx/hr. An average flux of ~5×10^18 Mx canceled prior to each episode, arguably building up ~10^28—10^29 ergs of free magnetic energy per jet. From these and previous observations, we infer that flux cancelation is the fundamental process responsible for the pre-eruption buildup and triggering of at least many jets in active regions, quiet regions, and coronal holes.

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Yoshinori Suematsu, National Astronomical Observatory of Japan

Title: Observational Constraints on the Formation Models of Chromospheric Spicules

Abstract: Recent observations with Hinode, IRIS and ground-based observatories of high temporal and spatial resolution have revealed that jet-like structures are ubiquitous in the solar chromosphere not only in the quiet Sun but also in active regions, even in sunspot penumbra and light-bridges. They are likely to play an important role in maintaining the energy balance of the local chromosphere and the mass balance in the corona. On the other hand, the formation mechanism of small-scale jets in the chromosphere such as spicules remains unresolved, although it is no doubt that they are rooted at photospheric magnetic elements most of which are seemingly unipolar. Many models have been proposed to explain their formation. It is likely that a key mechanism is a strong slow shock formation in the chromosphere, irrespective of its original energy sources, e.g., a p-mode acoustic wave leakage into the chromosphere, MHD waves including torsional Alfven waves launched in the photosphere, or magnetic reconnection in the lower chromosphere. The formation mechanism should explain not only their tall height but also their narrow width; large aspect ratio of length to width, their multi-thread structure typically double-thread. It is likely that the some spicules are rooted in the upper photosphere since their roots show up as tiny jets in Dopplergrams in Na I D and Mg I b lines close to the limb and even on the limb. This fact indicates that the spicules start below the chromosphere and therefore, the pressure waves need to be formed there. I summarize the observational facts for which spicule models have to explain, suggesting possible mechanism for the spicule formation.

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Akiko Tei, Kwasan and Hida Observatories, Kyoto University

Title: Dynamic Response of the Chromosphere in a Solar Flare Based on Spectroscopic Observations

Abstract: Dynamic phenomena occur in the chromosphere in response to flares, while details of their dynamics and mechanism of energy injection are still unknown. A detailed study of flare kernels will lead us to a new understanding of heating mechanism of the chromosphere and, therefore, energy transport and release process in the corona. We performed coordinated observations of AR 12205, which produced a C-class flare on 2014 November 11, with the

Interface Region Imaging Spectrograph (IRIS) and the Horizontal Spectrograph (HS) of the Domeless Solar Telescope (DST) at Hida Observatory. These observations provided us spectroscopic information of the flare in chromospheric lines such as Mg II h&k/C II/Si IV by IRIS and Hα/Ca II K/Ca II 8542A by DST/HS, by which we are able to investigate the temporal and spatial evolutions of the flaring chromosphere. We detected bright features (flare kernels) apparently moving along the IRIS slit during the impulsive phase of the flare. The time series of the Mg II h spectra of the flare kernels showed intensity enhancement in the blue wing (blue asymmetry) prior to a drastic change of the intensity. The blue asymmetry of Mg II h lasted for about 30 – 50 sec, and was followed by a strong red asymmetry with a significant increase of the intensities in all chromospheric lines. We conclude that the observed dynamics can be explained by an upflow of chromospheric temperature plasma caused by the precipitation of non-thermal electrons deeper in the chromosphere.

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Sanjiv Tiwari, CSPAR/UAH & NASA/MSFC

Title: Magnetic Setting, Spinning, and Coronal Emission of Large Penumbral Jets: Hinode and IRIS Observations

Abstract: Recent observations from Hinode (SOT/FG) revealed the presence of large penumbral jets (widths ≥500 km, larger than normal penumbral microjets) repeatedly occurring at the same locations in a sunspot penumbra, at the tail of a filament or where the tails of several penumbral filaments apparently converge (Tiwari et al. 2016, ApJ). These locations were observed to have mixed-polarity flux in Stokes-V images from SOT/FG. These large penumbral jets displayed direct signatures in AIA 1600, 304, 171, and 193 channels; thus they were heated to at least transition region temperatures. But because the large jets could not be detected in AIA 94 Å, whether they had any coronal-temperature plasma remains unclear. In the present work, we use IRIS (Mg II k 2796 Å slit jaw images and spectra) and magnetograms from Hinode SOT/FG and SOT/SP to examine large penumbral jets in another sunspot near disk center, and investigate the following: whether they are again rooted in mixed-polarity flux in this penumbra; whether they spin, similar to spicules and jets in the quiet Sun and coronal holes; and whether they produce discernible coronal emission (e.g., in AIA 94 Å images). If they spin and if they have mixed-polarity flux at their base, then large penumbral jets might be driven the same way as X-ray jets and CMEs, by the eruption of a magnetic arcade carrying a twisted flux rope inside.

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Tom Van Doorsselaere, KU Leuven

Title: Transverse Wave Induced Loop Turbulence and its Observability

Abstract: As was previously found, transverse kink waves are Kelvin-Helmholtz unstable. Because of that, loops driven with transverse waves form a layer of turbulent roll-ups, or are

even completely turbulent. I will present 3D numerical models that show this phenomena, and discuss the associated energetics for heating the coronal loops. Moreover, I will show forward models based on the 3D models, which allow to determine if the models are compatible with observations (e.g. filling factors, DEM, spectral line modelling). Indeed, we find that the 3D numerical models of turbulent loops are fully compatible with the observations. Based on the forward models, I will formulate some challenges for observational studies.

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Gregal Vissers, Institute for Solar Physics, Stockholm University

Title: On the Connection of UFS Loops to the Evolution of Weak Magnetic Fields

Abstract: Early IRIS observations of quiet Sun regions uncovered low-lying loops that brighten transiently in the Si IV and C II slit-jaw images and that may account for one component of what previously has been called "unresolved fine structure" (UFS). Although simulations indicate that UFS loops are unlikely to attain coronal temperatures, their impulsive heating character and associated high velocities, in combination with the heights they reach, suggest they may nonetheless be an important piece in the coronal heating puzzle. Understanding the role that the evolution of weak magnetic fields may play in their formation is therefore of particular interest. Here we combine IRIS observations with magnetograms obtained with the Hinode/SOT Narrowband Filter Imager, targeting several quiet Sun regions at viewing angles ranging from close to disc centre to the limb. UFS loops are identified semi-automatically in the Si IV slit-jaw image sequences and we track the emergence, fragmentation and cancellation of magnetic features using a modified version of YAFTA. We perform a statistical analysis of UFS loop morphology and dynamics, and investigate their potential connection to the evolution of the underlying magnetic fields.

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Amy Winebarger, NASA/MSFC

Title: The Importance of XRT Observations in Discriminating between Impulsive and Footpoint Heating

Abstract: Observations of solar coronal loops have identified several common loop characteristics, including that loops appear to cool and have higher than expected densities. Two potential heating scenarios have been suggested to explain these observations. One scenario is that the loops are formed of many strands, each heated independently by a series of small-scale impulsive heating events, or nanoflares. Another hypothesis is that the heating is quasi-steady and highly-stratified, i.e., ``footpoint heating''; such heating can drive thermal non-equilibrium in some structures depending on the scale height and magnitude of the energy deposition, and geometry of the structure. Studies of both types of heating have found that they can qualitatively reproduce the observed loop properties. In this presentation, we use one-dimensional models to identify observables that can be used to differentiate between these two heating scenarios. We find that the expected time lag between the

appearance of the loop in an XRT channel and one of the cooler AIA channels is significantly different in footpoint and impulsive heating, implying that broadband, high temperature observations, like those currently available in XRT, are particularly useful in discriminating between these two heating scenarios. This is a preliminary study, using only a single loop geometry, but we hope to inform future, large-scale, comparative studies of the types of observables that can be useful to consider.

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Magnus Woods, Mullard Space Science Laboratory

Title: Investigations of Pre-flare Activity with Hinode/EIS and IRIS

Abstract: On the 29 March 2014 NOAA active region (AR) 12017 produced an X1 flare which was simultaneously observed by an unprecedented number of observatories. In this talk, we present the results of an investigation into the pre-flare period of this flare from 14:00 UT until 19:00 UT using joint observations made by the Interface Region Imaging Spectrometer (IRIS) and the Hinode Extreme Ultraviolet Imaging Spectrometer (EIS). Spectral lines providing coverage of the solar atmosphere from chromosphere to the corona were analysed to investigate pre-flare activity within the AR. We have revealed evidence of strongly blue-shifted plasma flows, with velocities up to 200 km/s, being observed 40 minutes prior to flaring. These flows are located along the filament present in the active region and are both spatially discrete and transient. In order to constrain the possible explanations for this activity, we undertook non-potential magnetic field modelling of the active region. This modelling indicates the existence of a weakly twisted flux rope along the polarity inversion line in the region where a filament and the strong pre-flare flows are observed. We then discuss how these observations relate to the current models of flare triggering and conclude that the most likely drivers of the observed activity are internal reconnection in the flux rope, early onset of the flare reconnection, or tether cutting reconnection along the filament. We also discuss the early results of a further study into the pre-flare period of another flare utilising IRIS and Hinode/EIS slot data, analysed using the new method of Harra et. al. (2017).

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Masaki Yoshida, The Graduate University for Advanced Studies

Title: Study in the Cusp Region of 7 March 2015 Solar Flare with IRIS and SDO Observations

Abstract: We focus on dynamic properties of plasma in the cusp region of the M9.2-class eruptive flare that was observed on 2015 Mar 7 with the Interface Region Imaging Spectrograph (IRIS) and SDO. We examine the cusp structure using SDO/AIA 131 Å filter images and IRIS spectra. From the SDO/AIA 131 Å filter imaging observations that contain an emission from Fe XXI for 10 MK plasmas, we found apparent plasma motions in the plane of sky toward the low altitude with a velocity of ~200 km/s max in the upper part of the cusp structure. We found that the Fe XXI line profiles observed with the IRIS spectral data contain the non-thermal velocity of 30-70 km/s in the cusp structures and 10-40 km/s line of sight

Doppler velocity. In particular, at the time close to the GOES Soft X-ray peak, the average intensity of the SDO/AIA 131 Å filter image in IRIS slit scan region increased at the timing when downflow passed through that region, and at the same Doppler velocity also increased. This means that the bright downflow could be captured simultaneously by imaging observation and spectroscopic observation. On the contrary, the large non-thermal velocity was found in low intensity region which corresponds to the valley bottom of a biforked cusp structure. Therefore, we speculate that turbuent structure was generated by the interaction of dark downflow from the reconnection region with the cusp region as the numerical simulation by Guo et al. (2014) suggested.

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Peter Young, George Mason University

Title: UV Bursts in Active Regions - New Insights on Magnetic Reconnection

Abstract: UV bursts are intense, transient brightenings that are seen in IRIS 1400 angstrom slitjaw movies of active regions. They are compact (< 2") with lifetimes from one minute to one hour, and their intensities continually flicker. Most bursts exhibit strongly broadened Si IV line profiles, with a subset showing the chromospheric absorption lines characteristic of IRIS bombs. Bursts occur in a range of magnetic field scenarios, including moving magnetic features around sunspots, light bridges, and emerging flux regions, and they are generally directly associated with moving, small-scale magnetic flux elements. Bursts are most likely explained by magnetic reconnection occurring at low heights, a regime quite different to that for the coronal magnetic reconnection that occurs in nanoflares and flares. The complex line profiles from bursts may give unique access to reconnection physics that is not possible from coronal reconnection events. In this presentation, I summarize recent findings obtained by an ISSI International Team studying bursts. Examples of bursts will be shown and the properties summarized; their relation to chromospheric bursts such as Ellerman bombs, Mg II wing bursts and AIA 1700 bursts will be discussed; and results from modeling of line profiles and 3D MHD codes will be given.

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Posters

Agnes J. Ancheta, The Catholic University of America

Title: Cross Calibration of Hinode/EIS and EUNIS-2013

[Jeffrey W. Brosius1,2, Adrian N. Daw2, Peter R. Young2,3, 1Department of Physics, The Catholic University of America, 2NASA Goddard Space Flight Center, Code 670, 3George Mason University]

Abstract: The Extreme-Ultraviolet Normal-Incidence Spectrograph (EUNIS) sounding rocket payload was flown on 2013 April 23 with two independent channels covering the 300-370 Å

and 525-635 Å wavebands. The 660-arcsecond long EUNIS slit scanned two regions on the solar disk that included quiet sun, active regions, and a micro-flare. The active region AR 11726 was co-observed with the EUV Imaging Spectrometer (EIS) on Hinode. The absolute radiometric response of EUNIS was measured in the laboratory using a NIST-calibrated photodiode and hollow cathode discharge lamp. A density- and temperature- insensitive line intensity ratio technique is used to derive an in-flight calibration update of Hinode/EIS, that is, the observed ratios of EIS emission lines with respect to EUNIS for AR 11726 provide a comparison between the calibrations of the two instruments.

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Graham Barnes, NWRA/CoRA

Title: Estimating the Lorentz Force at the Photosphere

Abstract: Although solar flares are thought of as coronal phenomena, the energy to power them ultimately comes from the photosphere and below. There is compelling evidence, however, that what happens in the corona can also impact the photosphere, from initiating seismic pulses that propagate into the solar interior, to permanent changes in the photospheric magnetic field configuration of the host active region. The Lorentz force at the photosphere has been invoked in 1) the formation of strongly sheared polarity inversion lines, which are commonly associated with major flares, and 2) the initiation of seismic emission associated with some flares. Previous investigations have used strong assumptions about the horizontal scale of the magnetic field to estimate the Lorentz force from SDO/HMI vector magnetograms. We compare these estimates to those made from Hinode/SP vector magnetograms to test the validity of the assumptions.

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Patricia Bolan, Harvard-Smithsonian Center for Astrophysics

Title: Sigmoids in the Latest Solar Cycle: An Updated Catalog with Statistical Properties from Hinode and Nonlinear Force-Fr

Abstract: Sigmoids, or S-shaped structures on the corona of the sun, can be analyzed to reveal unique magnetic properties and determine any correlations with coronal mass ejections. From the commencement of data collection by the X-Ray Telescope (XRT) on the Hinode spacecraft in 2006, there is now data on coronal sigmoids for nearly a complete solar cycle. In this study, images from XRT were scanned by eye for sigmoids, and properties of each were recorded, including the active region, hemisphere, orientation, and time of emergence and dissipation or eruption. The survey resulted in 272 sigmoids from January of 2007 through September 2016. We performed a statistical analysis on the set of sigmoids to determine trends in properties such as position and lifetime. We also look for differences in the properties of sigmoids with the "expected" shape in each hemisphere versus sigmoids with the "unexpected" shape. In addition to the statistical analysis of the complete catalog, a thorough study was done of the magnetic structure of two sigmoids, one with the expected shape for its hemisphere and one with the unexpected shape. Nonlinear force-free field models were constructed of the sigmoids using the flux-rope insertion method. Using these models we compare the properties of these two sigmoids, such as the free energy.

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Elizabeth Butler, University of Colorado, Boulder

Title: Comparison of C II and Fe II Emission Lines in an X-class Solar Flare

Abstract: The origin of the near UV continuum radiation during solar flares is not well understood; it is still uncertain whether the continuum radiation results from heating of the chromosphere, the photosphere, or a combination. Singly ionized emission lines provide constraints on the temperature and velocity stratification that can be compared to radiative hydrodynamic models. We conduct a comparison study of the C II and Fe II profiles in the 2014 October 25 flare (SOL20141025T17:18), which was observed in high-cadence sit-and-stare mode by IRIS. Here we present preliminary results on relationships between the line profile shapes, intensity ratios, and the locations of common flaring pixels. The full spectra readout of the data provides a unique comprehensive characterization of the velocity field and whether the continuum intensity originates from chromospheric condensations.

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Rebecca Centeno, High Altitude Observatory (NCAR)

Title: Evidence for the Onset of Solar Cycle 25 in High Latitude Small-scale Activity Bands

Abstract: Years before the official end of the current solar cycle, evidence for the next cycle can be seen in the spatial distribution of bright points and small-scale magnetic fields at high latitudes (40-55 degrees, see McIntosh and Leamon 2017). The location of these early activity bands has been shown to aid in the prediction of the timing of the next solar minimum (McIntosh et al 2014). The small-scale activity in these bands presents a ~27 day modulation in its early stages, with the North and the South hemispheres offset by a few days. This modulation is thought to change as the bands progress equatorwards, eventually morphing into the new sunspot activity belts. This observation inspired the design of the IRIS-Hinode Observing Program (IHOP) 336, to further assess the magnetic characteristics, the periodicity and the long-term evolution of these early activity bands. IHOP 336 started running in March 2017, and preliminary results will be shown at the meeting.

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Tamar Chaghiashvili, Ilia State University

Title: Flare-related Changes in Active Region NOAA 11429

Abstract: Solar magnetic field interaction with plasma controls the most dynamical processes and topological changes in various coronal structures. Even small variations in dense photospheric plasma and/or magnetic field may lead to the most catastrophic eruptions, such as solar flares and CMEs. Moreover, plasma and magnetic field interaction has its important effect on the photosphere itself. The good example of it is the White light flare. White light flares are rare phenomena. They were believed to occur only with high energy flares. But recent high-resolution detectors revealed that they are characteristic for all flares. It is crucial to study WLFs to understand the physical and morphological changes of the solar photosphere. The subject of my research is White-Light Flares which occur after high- energy X- and M –class flares. Particularly, I am interested in the behavior of the photospheric changes and its characteristics. For this reason, we studied the evolution of the well-developed sunspot of NOAA Active Region 11429. The active region hosted two X 5.4 and X 1.3 flares on March 7, 2012. They occurred in one hour interval with starting times 00:02 and 01:05 respectively. The first flare lasted 40 minutes and the second - 17 minutes. We studied flare related white light emission, calculated their movement, measured energies and built the model which may explain the movement of the emission. Visual and methodological (running difference image, time slicing method) investigation of the observational data of HMI/SDO satellite revealed, that during the flares, because of the strong back-warming effect, white-light emissions emerge in the HMI continuum and crosses the sunspot (in the HMI magnetogram they are seen as the magnetic polarity change - in the black part the white pattern and in the white part, the black pattern). During the first flare, the brightening cropped up after the 11 minute of the flares start-time (recorded by GOES), traversed the sunspot and disappeared before the flare ended. In second case, the brightening began after a minute of flare starting time, continued 11-13 minutes and ended 6 minutes before the flare-end time. The patterns are seen in the white – light continuum were co-spatial and co-temporal with the flare ribbons (in all EUV wavelengths of AIA).

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Ed DeLuca, Smithsonian Astrophysical Observatory

Title: Mid-IR Coronal Spectroscopy with AIR-Spec

Abstract: The Mid-IR wavelength region (1.4-4um) has been opened up by the availability of high quality detectors. The Airborne InfraRed Spectrograph (AIR-Spec) will fly on the NCAR GV HIAPER aircraft during the upcoming 2017 Eclipse. The objective is to characterize magnetically sensitive emission lines that can be candidates for future spectropolarimetry observations. AIR-Spec will target five emission lines: Si X: 1.43 μm, Si XI: 1.92 μm, Fe IX: 2.86 μm, Mg VIII: 3.03 μm, Si IX: 3.94 μm with a multi-channel slit spectrometer. AIR-Spec eclipse goals and future plans will be discussed.

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Marc DeRosa, Lockheed Martin Solar and Astrophysics Laboratory

Title: Global Topology of the Coronal Magnetic Field above Flaring Active Regions

Abstract: The global environment surrounding flaring active regions is likely to play a role in whether an associated coronal mass ejection occurs and the subsequent trajectory of the eruption. A topological analysis of several dozen models of potential fields overlying flaring active regions reveals that the domains of connectivity surrounding the regions possess complex shapes. The open-field domains that may facilitate matter streaming outward during such eruptions are often particularly convoluted. We present visualizations of open-field domains located near several flaring active regions, and discuss the implications of these structures as they pertain to observations of actual coronal magnetic fields.

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George Doschek, Naval Research Laboratory

Title: Variations of Coronal Elemental Abundances Due to the FIP Effect in an Active Region

Abstract: The elemental abundances in the corona and in the photosphere differ due the First Ionization Potential (FIP) Effect. Elements with a FIP less than about 10eV are about 3-4 times more abundant in the corona than in the photosphere. This is generally regarded as a uniform condition in the corona. However, I show that abundances between photospheric and coronal can be found in small areas in an active region. The analysis is based on the intensity ratio of an Ar XIV (high-FIP) line to a Ca XIV (low-FIP) line formed at about the same temperature (about 4 MK). The spectra were obtained by the Extreme-ultraviolet Imaging Spectrometer (EIS) on the Hinode spacecraft. Variations of the FIP effect are expected based on the Laming FIP/inverse-FIP model.

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Bernhard Fleck, ESA

Title: First Results from the 2016-2017 MOTH-II South Pole Campaign

[S. Jefferies1,2, N. Murphy3, W. Giebink2, F. Berrilli4, B. Fleck5, R. Forte4, W. Rodgers6
1Georgia State University, 2University of Hawaii, 3JPL, 4Università di Roma Tor Vergata, 5ESA, 6Eddy Company]

Abstract: We deployed and operated an advanced version of the Magneto-Optical Filters at Two Heights instrument (MOTH-II) at the South Pole during the austral summer of 2016/2017. MOTH-II provides full disk Dopplergrams and magnetograms taken simultaneously in K 7700 Å (formed in the middle photosphere) and Na D2 5896 Å (formed in the lower chromosphere) at high spatial (1.7”) and high temporal (5 s) resolution. Each of the two channels is fed by a 20 cm aperture telescope. Two 3k × 3k CMOS cameras are used in each channel to record the left- and right-hand circularly polarized light in the blue and red

wings of the lines. Together with data from SDO/HMI, MOTH-II yields detailed information about the velocity and magnetic field from the low photosphere up to the lower chromosphere, allowing novel investigations of the structure and dynamics of the Sun's atmosphere and interior as well as to search for triggers of space weather events: How do emerging magnetic fields and flows interact to trigger flares and coronal mass ejections? What changes in the magnetic field configuration precede these eruptive events? What role do atmospheric gravity waves play in driving flows? We describe the instrument, give an overview of this year's South Pole campaign, and present some initial results.

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David Graham, LMSAL

Title: Spectral Signatures for Multi-layered Heating and Condensation in a Solar Flare: IRIS Observations and Modelling

Abstract: Continuing our recent analysis of the X-Class flare SOL2014-09-10T17:45, where we studied with IRIS the impulsive phase dynamics of tens of individual flaring kernels (in both coronal, Fe XXI, and chromospheric, MgII, lines at high cadence), we concentrate here on the chromospheric aspect of the phenomenon, extending the analysis to multiple spectral lines of Mg II, Fe II, Si I, and C I. We show that many flaring kernels display high velocity downflows in the spectra of all of these chromospheric lines, manifesting 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. We show that the characteristics of the two spectral components are sensitive to the model beam parameters.

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Michael Hahn, Columbia University

Title: Quantifying the Density Structure of the Solar Corona

Abstract: Images show that the solar corona is highly structured, with density variations transverse to the magnetic field on scales down to the resolution limit of the instruments. This suggests unresolved structure at yet smaller length scales as well. Understanding this density structure is important for modeling coronal heating and predicting solar wind properties. We present a new method for quantifying the density structure using EUV line intensities to derive a density irregularity parameter that measures the relative amount of structure along the line of sight. We interpret the irregularity using a simple model in order to relate our results to physical quantities such as filling factor and density contrast. For quiet Sun regions and interplume regions of coronal holes, we find density contrasts of at least a factor of three to ten with filling factors of about 10-20%.

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Iain Hannah, University of Glasgow

Title: A Small Microflare Observed with NuSTAR and IRIS

[Hannah, Kleint, Krucker, Glesener, Grefenstette]

Abstract: We present observations of a small microflare observed in X-rays with NuSTAR, UV with IRIS and EUV with SDO/AIA. NuSTAR observed a weak unnamed active region near the East limb between 23:27UT and 23:37UT 26-July-2016, finding mostly quiescent emission except for a small microflare lasting for about a minute. This increase in NuSTAR counts matches a little brightening loop observed with IRIS SJI 1400Å and SDO/AIA 94Å/Fe XVIII. Fortuitously the IRIS slit was on this microflaring loop and we find that the IRIS spectrum shows increased emission in Si IV 1394Å, O IV 1402Å and Si IV 1403Å but only average line widths and velocities. From the NuSTAR spectrum we will show the higher temperature heating during this microflare and will also discuss the overall energetics of this event.

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Iain Hannah, University of Glasgow

Title: Microflare Heating of an Active Region Observed with NuSTAR, Hinode/XRT and SDO/AIA

[Paul J. Wright, Iain G. Hannah (presenting), Grefenstette, Glesener, Krucker, Hudson, Smith, Marsh, White, Kuhar]

Abstract: We present the first joint observation of a GOES equivalent A0.2 microflare that occurred on the 29 Apr 2015 with Hinode/XRT and NuSTAR. During the three hours of combined observation we observe distinctive loop heating in the soft X-rays from Hinode/XRT, and the hottest channels from SDO/AIA. Crucially the impulsive phase of this microflare was also observed by NuSTAR, a highly sensitive hard X-ray (2.5-80 keV; Harrison et al. 2013) focussing optics imaging spectrometer. The NuSTAR spectrum before and after the microflare is well-fitted by a single thermal model of about 3.3 - 3.5 MK, but at the impulsive phase shows additional material up to 10 MK. This higher temperature emission is confirmed when we produce the DEM using a combination of SDO/AIA, Hinode/XRT, and NuSTAR data. During the impulsive phase of the microflare we determine the heating rate to be about 3e25 erg/s. Although non-thermal emission is not detected we find upper-limits that are consistent with the required heating rate.

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Louise Harra, UCL-MSSL

Title: Measuring Velocities in the Early Stage of an Eruption: Using 'overlappogram' Data from Hinode EIS

Abstract: In order to understand the onset phase of a solar eruption, plasma parameter measurements in the early phases are key to constraining models. There are two current instrument types that allow us to make such measurements: narrow-band imagers and spectrometers. In the former case, even narrow-band filters contain multiple emission lines, creating some temperature confusion. With imagers, however, rapid cadences are achievable and the field of view can be large. Velocities of the erupting structures can be measured by feature tracking, although these are constrained to the plane of the sky. In the latter case, slit spectrometers can provide spectrally pure images by 'rastering' the slit to build up an image. This method provides limited temporal resolution, but the plasma parameters can be accurately measured, including velocities along the line of sight. Both methods have benefits and are often used in tandem. In this talk we demonstrate for the first time that data from the wide slot on the Hinode EUV Imaging Spectrometer (EIS) can be used to deconvolve velocity information at the start of an eruption, providing rapid cadence line of sight velocities across an extended field of view. Using He II 256 Å slot data at flare onset we observe extended features along the dispersion axis that indicate a broadening or shift(s) of the emission line of up to 280km s^{-1} in both the red and blue Doppler velocity directions. We discuss the potential of these wide slot datasets for future studies, and how the observations will benefit from joint campaigns with IRIS.

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Takahiro Hasegawa, University of Tokyo / Institute of Space and Astronautical Science, JAXA

Title: Reversed Rotation of the Sunspot Associated with the X2.1 Flare in AR12297

Abstract: We study the evolution of the magnetic field in the active region NOAA 12297 before and after the X2.1 flare. In the initial stage, the main sunspot of this region rotated in the clockwise direction. However, due to the shear flow by fast flux emergence between the sunspot and another emerging region, the Lorentz force was enhanced and the sunspot started to rotate counterclockwise. As magnetic flux emerged, the twist of the magnetic field enhanced is more and magnetic non-potentiality developed. This rotational motion of the sunspot injected the magnetic helicity opposite to the global magnetic helicity of the active region. Soon after the occurrence of the X2.1 flare on 2015 March 11 the rotation rate began to decrease. On 2015 March 13, the sunspot rotated in the clockwise direction again. Based on this observation, we advocate that the fast rotation of a sunspot has the key role for energy build-up and the occurrence of great flares. Our result implies that a reversed rotation of a sunspot on the photosphere and helicity injection opposite to that of global structure is important for the destabilization of magnetic field and the onset of solar flares.

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Zhenyong Hou, Inst. of Space Sciences, Shandong University

Title: Narrow-line-width UV Bursts in the Transition Region above Sunspots Observed by IRIS

Abstract: Various small-scale structures abound in the solar atmosphere above active regions, playing an important role in the dynamics and evolution therein. We report on a new class of small-scale transition region structures in active regions, characterized by strong emissions but extremely narrow Si IV line profiles as found in observations taken with the Interface Region Imaging Spectrograph (IRIS). Tentatively named as narrow-line-width UV bursts (NUBs), these structures are located above sunspots and comprise one or multiple compact bright cores at subarcsecond scales. We found six NUBs in two data sets (a raster and a sit-and-stare data set). Among these, four events are short-lived with a duration of about 10 minutes, while two last for more than 36 minutes. All NUBs have Doppler shifts of 15-18 km/s, while the NUB found in sit-and-stare data possesses an additional component at about 50 km/s found only in the C II and Mg II lines. Given that these events are found to play a role in the local dynamics, it is important to further investigate the physical mechanisms that generate these phenomena and their role in the mass transport in sunspots.

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Kiyoshi Ichimoto, Kyoto University

Title: Development of Wide-band Imaging Spectro-polarimeter for Future Space Missions

Abstract: Aiming to realize the high precision and high cadence observation of vector magnetic fields in the photosphere and the chromosphere from space, we have developed key optical components for the wide-band imaging spectro-polarimetry. One is a universal tunable filter to extract narrow-band lights in spectral lines, and the other is a wide-band waveplate to modulate the polarizations in linear and circular states. Both of which are applicable in arbitrary wavelength in 500 – 1100nm, and will be robust enough against the space environment. Details of the design and specifications will be presented together with the performance obtained from experiments.

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Ryoko Ishikawa, National Astronomical Observatory of Japan

Title: CLASP2: High-Precision Spectro-Polarimetry in Mg II h & k

[R. Ishikawa (NAOJ), D. McKenzie (NASA/MSFC), J. Trujillo Bueno (IAC), F. Auchere (IAS), L. Rachmeler, (NASA/MSFC), T. J. Okamoto, R. Kano, D. Song, M. Kubo, N. Narukage, M. Yoshida, T. Tsuzuki, H. Hara, K. Shinoda, Y. Suematsu, M. Goto (NAOJ), S. Shin-nosuke T. Sakao (ISAS), K. Kobayashi, A. Winebarger (NASA/MSFC), C. Bethge (USRA), B. De Pontieu (LMSAL), M. Carlsson (UiO), J. Leenaarts (IFS), L. Belluzzi (IRSOL), J. Stepan (ASCR), T. del Pino Aleman (HAO), E. Alsina Bellester, A. Asensio Ramos (IAC)]

Abstract: The magnetic field measurement in outer atmosphere has been driven by the need to quantitatively understand the dynamical phenomena in those regions. The international team is promoting the CLASP2 (Chromospheric LAyer Spectro-Polarimeter 2) sounding rocket experiment, which is the re-flight of CLASP in 2015. In this second flight, we will refit the existing CLASP instrument to measure all Stokes parameters in Mg II h & k lines, and aim at inferring the magnetic field information in the upper chromosphere combining the Hanle and Zeeman effects. CLASP2 project has been approved by NASA in December 2016, and is now scheduled to fly in 2019. The coordinated observations with IRIS, Hinode, and ground-based observatories are critically important, and have to be arranged to maximize our scientific output. In this poster presentation, we will discuss the scientific motivation, instrument design, progress of the development, and planned observations.

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Ryohtaroh Ishikawa, Tohoku University

Title: Temporal and Spatial Scales in Coronal Rain

Abstract: Coronal rains, cool coronal blobs accreting toward solar surface, are often observed above solar active regions. Coronal rain occurs due to thermal instability in the corona and falls down into the lower atmosphere in a short timescale. Although the rain usually fragments into smaller blobs while falling down, the specific spatial and temporal scales of this process are not clear yet. In addition, the impact of the rain with the lower atmosphere (i.e. chromosphere) remains unclear. We investigated the time evolution of velocity and intensity of coronal rain above a sunspot in NOAA AR 12567, by analyzing SDO/AIA coronal images as well as Slit-Jaw Image (SJI) and spectrograph (SG) data obtained by the IRIS satellite. We identified bright threads moving toward the umbra in AIA images and co-spatial chromospheric brightenings and redshifts in the Mg II k 2796 Å, Si IV 1394 Å, and C II 1336 Å spectrum lines observed with IRIS/SG. The brightenings and redshifts occurred almost concurrently in all of the three lines, which clearly demonstrated a causal relationship between coronal rain and chromospheric brightenings. Furthermore, we detected about 25 seconds periodicity in the time evolutions of Mg II k, Si IV and C II spectra obtained by IRIS/SG, which indicates that the specific length of coronal rain is about 2.3 Mm. These temporal and spatial scales may reflect the physical process leading to the small-scale structure of coronal rain.

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Patricia Jibben, Harvard-Smithsonian Center for Astrophysics

Title: Cavity Structures and Prominence Horns seen with Hinode & AIA

Abstract: We describe the results of a study of a polar crown coronal cavity and prominence system. Using XRT and EIS we present the thermal emission properties and coronal velocity structures of the coronal cavity. We investigate the interaction of cavity structures with cool prominence plasmas using SOT and AIA data. Combined, these observations demonstrate coronal cavities are isolated coronal features that are dynamically connected to the cool

prominence material they encompass. We conclude the best model for the prominence-cavity system is that of a flux rope.

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Nishu Karna, Harvard-Smithsonian Center for Astrophysics

Title: NonLinear Force-Free Modeling of a Coronal Sigmoid

[Nishu Karna, Antonia Savcheva, Svetlin Tassev]

Abstract: In this study we present a magnetic configuration of a coronal sigmoid observed on February 13, 2017 at the disk center in STEREO-B that produced a CME. The sigmoid was associated with the NOAA active region 1012. We constructed Non Linear Force Free Field (NLFFF) model using the flux rope insertion method. The NLFFF model produces the three-dimensional coronal magnetic field constrained by observed coronal loop structures and photospheric magnetogram. SOHO/MDI magnetogram was used as an input for the model. The high spatial and temporal resolution of the STEREO-B and Hinode/XRT allows us to select best-fit models that match the observations. In addition, we perform a topology analysis of the models in order to determine the location of quasi-separatrix layers (QSLs). QSLs are used as a proxy to determine where the strong electric current sheets are developed in the corona and also provide important information about the connectivity in complicated magnetic field configuration. We present the major properties of the 3D QSL and FLEDGE maps and the evolution of 3D coronal structures during the magnetofrictional process. This is the first model in a series of models of the time evolution of their active regions that produced several eruptions over its disk passage, which we are also analyzing in other presentations.

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Yukio Katsukawa, National Astronomical Observatory of Japan

Title: Temporal and Height Evolution of Spectrum Line Profiles in Penumbral Microjets

Abstract: High-resolution imaging observations revealed small-scale jet-like brightenings, penumbral microjets (PMJs), occurring frequently in the chromosphere above a sunspot penumbra. The PMJs are an important phenomenon to understand how magnetic reconnection heats the ambient atmosphere. We carried out observations to resolve temporal and spatial evolution of spectral line profiles in PMJs. We used two instruments for spectral observations of chromospheric lines; Interferometer Bidimensional Spectropolarimeter (IBIS) at DST/NSO for observing the Ca II 854 nm line and the Interface Region Imaging Spectrograph (IRIS) satellite for observing the Mg II 280 nm line. Owing to high temporal resolution faster than 5 sec, we can see time variation of the spectral line profiles starting from the wings of the chromospheric lines on the inner side of PMJs, i.e., lower chromosphere. Intensity enhancements are found also at the line center near the end of the jet duration. This suggests that energy released by magnetic reconnection in the lower chromosphere propagates upward and heats the upper chromosphere in a short time scale. The propagation speed is often faster

than 100 km/s, which is possibly interpreted as an MHD wave. This study provides an important constraint in the heating mechanism by the chromospheric jets.

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Yeon-Han Kim, Korea Astronomy and Space Science Institute (KASI)

Title: IRIS Brightening Associated with the Ellerman Bomb Occurred in the NOAA AR 12127 on 2014 July 31

Abstract: Since the launch of Interface Region Imaging Spectrograph (IRIS), a variety of brightenings were observed around the large-scale active region in the solar atmosphere. Some brightenings appear to be transient heating (up to almost 100,000K) of small pockets of plasma embedded in the cool photosphere and the brightenings are called as “hot explosions” or “IRIS bombs (IBs)”, due to the similar characteristics with Ellerman bombs (EBs) such as wing brightening, magnetic field properties, and sites of occurrence. Up to now, there have been several researches on the connection between IBs and EBs, but the clear relationship is still controversial. In this study, we present one more case of IRIS brightenings associated with EBs. The New Solar Telescope (NST) in Big Bear Solar Observatory (BBSO) made a joint observation with IRIS instrument for the NOAA AR 12127 from 20:00 UT to 22:00 UT on 2014 July 31. Around the sunspot several IRIS brightenings were observed through 3-channels of slit-jaw images (SJI_2796, SJI_1400, and SJI_1330). The Fast Imaging Solar Spectrograph (FISS) of NST observed an Ellerman bomb in the upper right side of the sunspot. The Ellerman bomb is clearly coincident with the IRIS brightening at the same location. The result of simultaneous observations by IRIS and NST instruments will be presented.

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Adam Kowalski, University of Colorado Boulder & The National Solar Observatory

Title: Comprehensive Constraints on the Atmospheric Response to High Heating Rates in Solar Flares: From IRIS to DKIST

Abstract: 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. The models that successfully reproduce the IRIS spectral data will be tested with future optical spectra from the Daniel K. Inouye Solar Telescope in order to determine if such large ambient electron densities from high heating rates occur in the brightest kernels of solar flares.

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Masahito Kubo, National Astronomical Observatory of Japan

Title: 3D Magnetic Field Configuration of Magnetic Flux Cancellations by IBIS - Hinode - IRIS Campaign Observations

Abstract: The coordinated observation of IBIS with Hinode and IRIS was performed from June 1 to June 10 in 2016. The magnetic flux cancellations in a network region (June 9) and beside a big dark filament in the quiet Sun (June 7) were successfully observed with IBIS under good seeing conditions. The spectropolarimetric mode observations of Fe I 617.3 nm (photosphere), Na I D 589.6 nm (temperature minimum), and Ca II 854.2 nm lines (chromosphere) were done with IBIS. We find that small dark threads develop in the chromosphere toward opposite polarity magnetic element when these magnetic elements approach each other in the photosphere. After then, the downward convex dark threads recurrently appear during the magnetic flux cancellation. In the case of the cancellations beside the big dark filament, these dark threads develop to a long dark filament over the flux cancellation site and then merge with the pre-existing big dark filament. Some brightenings are observed in the chromosphere or the transition region in the cancellation site but their duration is much shorter than the duration of the magnetic flux cancellation in the photosphere. These results suggest that U-shaped magnetic field configurations are formed at the cancellation site, and then magnetic reconnection takes place near the solar surface at least for the magnetic flux cancellation in the quiet Sun.

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Masahito Kubo, National Astronomical Observatory of Japan

Title: Discovery of Short-timescale Oscillations in the Transition Region by CLASP

Abstract: High cadence spectroscopic observations by the Chromospheric Lyman-Alpha Spectro-Polarimeter (CLASP) reveal that intensity fluctuations of blue and red peaks of the hydrogen Lyman-alpha line (121.57 nm) recurrently appear in the quiet Sun at short timescale. The intensity fluctuations of the blue and red peaks are opposite in phase to each other: the blue peak is enhanced during the decease of the red peak, and vice versa. Such alternate intensity changes of the blue and red peaks are more clearly observed in the bright areas and in the period without the intensity disturbances around the slit in the Ly-alpha images taken by the slit-jaw optics system of CLASP. The timescale of each intensity enhancement is less than 30s. The short timescale fluctuations also can be seen in the Doppler shift of a central dip of the Lyman-alpha line, and their range is within +/-10 km/s. When the central dip of the Lyman-alpha line moves redward, the blue peak tends to be enhanced. This means that the alternate intensity changes of the blue and red peaks are caused by the short-timescale Doppler shifts of the central dip of the line. The center of the Ly-alpha line originates in the chromosphere-corona transition region. These results suggest that short-timescale oscillatory or torsional phenomena take place only in the transition region or the upper chromosphere.

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Matej Kuhar, FHNW, Switzerland

Title: A NuSTAR X-ray Brightening from Outside of Active Regions: Thermal or Nonthermal?

Abstract: 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, as well as SXI instrument onboard GOES. The NuSTAR flux above 2.5 keV shows an intriguing time evolution with two peaks, which are also seen in the AIA UV channel at 1600A. The EUV channels of AIA, on the other hand, show only a single peak at the time of the second NuSTAR peak (hot channels) or with a time lag (cooler channels). This suggests that the X-ray brightening has a nonthermal component as generally seen in solar flares. We will discuss the results of the combined spectral analysis of NuSTAR, AIA and GOES SXI observations to further investigate the potential for the nonthermal origin of the X-ray emission detected by NuSTAR, and present the implications of these results on the energetics and the importance of such brightenings for coronal heating.

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David Kuridze, Queens University, Belfast

Title: Spectroscopic Inversion of the Ca ii 8542 Å Line in a C-class Solar Flare

Abstract: We study an C8.4 class solar flare using high-resolution time-series of spectral imaging in the Ca ii 8542 Å line obtained with the CRISP imaging spectropolarimeter on the Swedish 1-m Solar Telescope. From spectroscopic inversions of the Ca ii 8542 Å line with non-LTE NICOLE code we constructed flare models and investigated the evolution of the temperature and velocity structure of the observed lower solar atmosphere. The differences between temperature stratifications of the flaring and non-flaring areas show that there is a strong footpoint heating during the flare peak in the upper photosphere and chromosphere. The temperature stratification of the non-flaring areas is unchanged by the flare. The total energy released by the flare in the Ca ii 8542 Å formation height is estimated as ~ 10^25 erg.

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Martin Laming, Naval Research Laboratory

Title: FIP and Inverse FIP Effects in the Solar Corona

Abstract: The solar corona and both the slow and fast solar wind show a degree of elemental abundance fractionation according to the First Ionization Potential (FIP) pattern. Elements with FIP below about 10 eV (e.g. Fe, Si, Mg) are enhanced in abundance relative to photospheric values, by a factor of about 3-4 in the slow speed wind, and by about 1.5 in the fast wind, relative to those elements (e.g. H, N, O, Ar) with higher FIP. Further, helium, the element with highest FIP, is often observed to be depleted in abundance relative to e.g. H, N,

O, Ar, by varying amounts. More recently, an Inverse FIP Effect, with low FIP elements depleted, has been discovered in the corona above a sunspot by Hinode. A compelling explanation for these abundance anomalies invokes the ponderomotive force arising as Alfven and fast modes waves propagate through or reflect from the chromosphere. These are fundamentally magnetic waves, and provide the necessary ion-neutral separation. A careful consideration of the element abundance produced in a closed loop shows that the best match to observed values arise for a wave on resonant with the loop, i.e. the wave travel time from one footpoint to the other is an integral number of wave half-periods. This strongly suggests a coronal origin for the Alfven waves, where such a resonance would arise naturally, as opposed to waves being generated in the photosphere or below and propagating up to the corona through the loop footpoints, as in open field regions. This scenario is investigated further, by evaluating the ponderomotive force arising in 3D compressible MHD simulations of coronal loops designed to understanding their heating mechanism(s). Conversely such resonance is not required for Inverse FIP fractionation. This can arise as waves excited deep in the solar atmosphere propagate upwards and are reflected back downwards by the increasing Alfven speed in the chromosphere.

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Eunkyung Lim, Korea Astronomy and Space Science Institute

Title: A Large-scale Quasi-circular Secondary Flare Ribbon in Association with Two Successive M-class Flares and a Halo CME

Abstract: A flare ribbon provides an important clue to the magnetic reconnection process and the associated magnetic field topology. We detected a large-scale secondary flare ribbon in a circular shape that developed in association with two successively occurring M-class flares and one CME eruption. The secondary ribbon detected from the SDO/AIA data revealed very interesting properties such as 1) the ribbon is quasi-circular shape enclosing the central active region 2) with the size as large as 500 by 650 arcsec, 3) the ribbon shows a successive brightenings in clockwise direction at the speed of 160km/s starting from the nearest position to the flaring sunspots, 4) and the ribbon also shows the radial contraction or expansion in the northern or the southern part, respectively at speeds of 10km/s or less. From the multi-channel observations using data from SDO, RHESSI and SOT, along with the magnetic field extrapolations, we found that 1) the secondary ribbon location is consistent with the field line footpoints of fan-shaped structure that fanning out from the leading spot and connects both trailing delta-spot and background decayed magnetic field. 2) Between two successive M-class flares, the first M2.0 flare started from the sigmoid lying on the trailing delta-spot, then later M2.6 flare occurred when the expanding coronal loops initiated by the first flare encounters the polarity inversion between leading spot and the background decayed field. 3) Just after the M2.6 flare, both the secondary flare ribbon around the active region and significant dimmings near both north and south part of the sigmoid developed. Based on our findings, we suggest that the additional reconnection process between expanding active region field and overlying background field that is driven by the main flare may play an important role in formation of the observed quasi-circular secondary flare ribbon. Both the morphological and

dynamical properties of the ribbon seem to be closely related with the topology of the associated magnetic field.

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Ivan Loboda, P.N. Lebedev Physical Institute of the Russian Academy of Sciences

Title: Variations of the EUV Jets' Properties

Abstract: EUV jets, often referred to as macrospicules, although having been observed for several decades, still remain a poorly understood solar phenomenon. They show a broad variability of properties, which complicates their identification and modeling. In this study, we examined a large dataset of the full-cadence AIA observations in the 304, 171 and 193 Å channels, spanning from the beginning of its operation in May 2010 to May 2016. We used the 304 Å channel data for identification of individual off-limb jets, for which we extracted a number of quantitative and qualitative parameters. Based on the distributions of these values, we were able to divide these jets into a number of groups, which show different spatial and dynamical characteristics. The first group is represented by narrow collimated flows of plasma with no discernible internal structure. Their dynamics are very similar to that of the chromospheric spicules, which leads us to believe that these jets most deserve the name of macrospicules. The jets from the second group are noticeably larger, with complex internal dynamics most probably resulting from rapid changes in the underlying magnetic structure. Interestingly, some of their characteristics show similar correlations to that of the small-scale quiescent and quiescent-eruptive prominences. Finally, an intermediate group of jets was identified, showing up as a collection of several collinear upward flows, thus being similar to the first group in dynamics, but substantially wider and slightly taller, approaching the second group in size.

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Nariaki Nitta, Lockheed Martin Advanced Technology Center

Title: What Distinguishes Eruptive and Non-eruptive Flares?

Abstract: The solar flare is sometimes used as a proxy for the coronal mass ejection (CME), but SOHO LASCO and accompanying coronal images have clearly demonstrated that "flareless" CMEs and "CMEless" flares are not uncommon. We are also informed about low coronal signatures that often accompany a CME, such as dimming, EUV waves, post-eruption arcades, etc. They are based on large-scale morphology and qualitative information. Here, we define flares as eruptive or non-eruptive on the basis of their association with a CME, and try to look for the signatures that may distinguish them, not only in the low corona but also in the transition region and chromosphere, especially in the flare core regions. A handful of flares observed by both Hinode SOT and IRIS are selected that represent the two types, for which we compare the flare ribbon properties that yield reconnection rates and the timings of various signatures of dynamic motions in IRIS spectral data.

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Navdeep Panesar, NASA/MSFC

Title: The Triggering Mechanism of Quiet-region Coronal Jet Eruptions: Flux Cancelation

Abstract: Coronal jets are frequent transient features on the Sun, observed in EUV and X-ray emissions. They occur in active regions, quiet Sun and coronal holes, and appear as a bright spire with base brightenings. Recent studies show that many coronal jets are driven by the eruption of a minifilament. Here we investigate the magnetic cause of jet-driving minifilament eruptions. We study ten randomly-found on-disk quiet-region coronal jets using SDO/AIA intensity images and SDO/HMI magnetograms. For all ten events, we track the evolution of photospheric magnetic flux in the jet-base region in EUV images and find that (a) a cool (transition-region temperature) minifilament is present prior to each jet eruption; (b) the pre-eruption minifilament resides above the polarity-inversion line between majority-polarity and minority-polarity magnetic flux patches; (c) the opposite-polarity flux patches converge and cancel with each other; (d) the cancelation between the majority-polarity and minority-polarity flux patches eventually destabilizes the field holding the minifilament to erupt outwards; (e) the envelope of the erupting field barges into ambient oppositely-directed far-reaching field and undergoes external reconnection (interchange reconnection); (f) the external reconnection opens the envelope field and the minifilament field inside, allowing reconnected-heated hot material and cool minifilament material to escape along the far-reaching field, outflow appears as the jet spire. In summary, we found that each of our ten jets resulted from a minifilament eruption following flux cancelation at the magnetic neutral line under the pre-eruption minifilament. These observations show that flux cancelation is usually the trigger of quiet-region coronal jet eruptions.

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Jacob Parker, Montana State University Physics

Title: Modeling a Propagating Sawtooth Flare Ribbon Structure as a Tearing Mode in the Presence of Velocity Shear

Abstract: On April 18, 2014 (SOL2014-04-18T13:03) an M-class flare was observed by IRIS. The associated flare ribbon contained a quasi-periodic sawtooth pattern that was observed to propagate perpendicular the the IRIS spectral slit with a phase velocity of approximately 15 km/s (Brannon et al. 2015). This motion resulted in periodicities in both intensity and Doppler velocity along the slit. These periodicities were reported by Brannon et al. (2015) to be approximately plus-minus .5 arcseconds in position and plus-minus 20 km/s in velocity and were measured to be approximately 180 degrees out of phase with one another. This quasi-periodic behavior has been attributed by others to bursty or patchy reconnection (Brosius & Daw 2015; Brosius et al. 2016) and slipping occurring during three-dimensional magnetic reconnection (Li & Zhang 2015; Li et al. 2016). While able to account for periodicities in both

intensity and Doppler velocity these suggestions do not explicitly account for the phase velocity of the entire sawtooth structure, or for the relative phasing of the oscillations. Here we propose that the observations can be explained by a tearing mode instability occurring at a current sheet across which there is also a velocity shear. We suggest a geometry and local plasma parameters for the April 18 flare which would support our hypothesis. Under this proposal the IRIS observations of this flare may provide the most compelling evidence to date of a tearing mode occurring in the solar magnetic field.

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Elena Provornikova, UCAR/Naval Research Laboratory

Title: Search for the Source of Suprathermal Ions in the Corona: Magnetic Reconnection Regions

Abstract: Several observational and theoretical studies suggest that suprathermal ions exist in the corona and are a necessary component for the production of high-intensity SEP events. Magnetic reconnection regions are the likely source of such suprathermal ions. However the acceleration mechanisms and observational characteristics of the sources are still not understood. We explore the effectiveness of the first order Fermi acceleration of ions in converging magnetized flows at a reconnection site. The spectral index of accelerated particles is related to the total plasma compression within a reconnection region. The higher the compression the harder the spectrum of accelerated particles. A hard spectrum of suprathermal particles is believed to be necessary to initiate the particle acceleration process at low Mach number coronal mass ejection shocks close to the Sun where the SEP events originate. We present several resistive MHD simulations of reconnection regions in different magnetic configurations and coronal plasma parameters. We demonstrate that only for some magnetic topologies, corresponding in particular to 3D magnetic nulls, the high compression ratios in the reconnection region can be achieved. For efficient Fermi acceleration of ions in reconnection current sheets a turbulent component of magnetic field scattering ions is necessary. We discuss the reflection and refraction of magnetosonic waves in the vicinity of a current sheet which are presumably generated by reconnection process and scatter particles across the reconnection region.

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Kathy Reeves, Harvard-Smithsonian Center for Astrophysics

Title: Signatures of Reconnection Observed in a Candle-Flame Solar Flare at the Limb

Abstract: We examine a well-observed flare that occurred on the limb of the Sun on March 7, 2015 in order to find possible signatures of a termination shock due to outflows from reconnecting magnetic fields. Images of this flare from Hinode/XRT and the SDO/AIA 131 bandpass show a cusp-shaped morphology. The IRIS slit was positioned in the region of the current sheet, above the flare loops. Fe XXI is detected in the IRIS spectra with an average Doppler velocity of about 20 km/s. The non-thermal widths in IRIS decrease steadily from

23:00 UT on the 7th until 00:20 UT the next day. This decrease correlates well with the microwave radio flux observed by the Nobeyama Radioheliograph (NoRH), which is primarily due to thermal free-free emission based on the examination of NoRH images at 17 GHz and 34 GHz. Temperatures of the loop-top source derived from RHESSI and XRT also show a steady decrease during this time. We measure downflow velocities in the cusp region in the AIA 131 A bandpass, and find that from 22-23 UT the flows are about 300-400 km/s, and they slow down to about 100 km/s after 23 UT. This work supported by NASA Grant NNX15AJ93G.

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Fatima Rubio da Costa, Stanford University

Title: A Parametric Study for Understanding the Formation of the MgII h and k Lines during Solar Flares

Abstract: Solar flares show highly unusual spectra, in which the thermodynamic conditions of the solar atmosphere are encoded. Current models are unable to fully reproduce the spectroscopic flare observations. We aim at understanding the formation of the optically thick chromospheric MgII h and k lines in flares, especially their single-peaked spectral profiles. Using the RH radiative transfer code, we perform a parametric study by varying the thermodynamic parameters in a model atmosphere to study their effects on the spectral lines. We reproduce the typical spectral shape of the single-peaked MgII h and k lines during a flare by increasing the electron density, temperature or downflow velocity at the formation height of the line core. This leads to a coupling of the source function with the Planck function. None of the simulations can explain the very broad line wings commonly observed in flares. Our results will be discussed under the perspective of diagnosing atmospheric dynamics in solar flares.

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Steven Saar, SAO

Title: Data Mining the Effect of Flux Emergence on Flare Properties

Abstract: We conduct a large data mining experiment to explore the effect of nearby emerging flux (EF) on flares from 2011-2016. Events from several databases, including the Hinode flare catalog, GOES flares, HEK EF, active region and filament eruption databases are intercompared. A flare was considered EF triggered if Q = B_EF^2/(dr dt) is larger than some threshold, where B_EF is the maximum magnetic flux in the EF region, dr is the EF - flare spatial separation, and dt is the time separation of the EF emergence and the flare start. A total of 3768 flares were studied, of these, 591 were discarded due to uncertainties in the EF detection. Of the remaining flares, ~35% occured outside of AR; of which ~22% were EF triggered. The outside AR EF triggered flares tended to have higher peak fluxes, suggesting the EFs enhance the total flare energy. About 27% of AR flares were EF triggered; these flares are about 2x more likely to be temporally associated with a filament eruption. We briefly discuss some implications and future enhancements of this work.

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Sabrina Savage, NASA/MSFC

Title: Determining the Frequency of Coronal Heating with the Marshall Grazing Incidence X-ray Spectrometer

[Sabrina Savage, Amy Winebarger, Ken Kobayashi, David McKenzie, Patrick Champey (University of Alabama – Huntsville), Peter Cheimets, Leon Golub, Ed DeLuca, Paola Testa, Katherine Reeves (Smithsonian Astrophysical Observatory), Harry Warren (Naval Research Lab), Stephen Bradshaw (Rice University), Helen Mason, Giulio Del Zanna (University of Cambridge), Robert W. Walsh (University of Central Lancashire)]

Abstract: The discovery of the million-degree corona by Edlen and Grotrian in the 1930s sparked an extensive ongoing debate over the mechanisms responsible for transfering heat and energy into the solar atmosphere. The frequency with which energy is released into the corona is a critical measurement needed for distinguishing between the physical processes contributing to coronal heating. Soft X-ray spectroscopy of the corona is a direct way for obtaining these key measurements, but such observations are technically challenging due to low signal throughput associated with traditional grazing incidence X-ray designs. Using a novel implementation of corrective optics, the Marshall Grazing Incidence X-ray Spectrometer (MaGIXS), a sounding rocket instrument scheduled to fly in 2018-2019, will measure, for the first time, the solar spectrum from 6 – 24 Angstroms with a ~6″ resolution (2.8″/pixel) over an 8′ slit. This innovative set of observations can definitively determine the frequency of heating in an active region core through line-based diagnostics and the exploration of non-thermal electron distributions.

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Roger Scott, University of Dundee

Title: Application of the Integrated Transport Method to Global Estimates of the Magnetic Squashing Factor

Abstract: Unlike the fast solar wind, which is thought to emanate from within coronal holes, the source and nature of the slow solar wind is not yet clear. One possibility is that an ongoing interchange reconnection process allows for the continuous exchange of material between open and closed flux domains, which might explain both the composition and variability of the slow solar wind. In order to characterize this effect, we have undertaken a survey of quasi-separatrix layers (QSLs) in global field models, in order to identify likely candidate geometries for simulations of interchange reconnection. The size and geometry of the numerical domain in global models, combined with the need for adaptive refinement, make the QSL Squasher code (Tassev & Savcheva, 2016) an ideal platform for this study. In addition to various optimization techniques in the code, one of the key features of QSL Squasher is its novel approach to characterizing the mapping — rather than constructing the mapping explicitly through field line tracing, the code tracks the separation between “adjacent” field lines, and

then integrates these to get the deformation of the mapping. But while this technique is fast, its derivation is predicated on a perturbative description of the magnetic field, and so the accuracy of the method is not, as yet, well understood. Here, we present an alternate formulation, which makes rigorous the connection between the deformation of the field and the transport of vectors along individual field lines, thereby validating the method of Tassev & Savcheva (2016) and also generalizing it for mappings between surfaces of arbitrary orientation. We then consider a worked example, which demonstrates the exact analytical solution in the familiar case of a linear magnetic null, and we offer a comparison to numerical results obtained from the QSL Squasher code. We then go on to apply the method to a global field model, identifying a variety of topologically interesting structures that are connected to the heliospheric current sheet, making them ideal candidates for the study of interchange reconnection as a potential driver of the slow solar wind.

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Takuya Shibayama, ISEE, Nagoya University

Title: Plasmoid Structure Formation in a 3D Current Sheet

Abstract: CME and dark filament is manifestation of confined plasma in a flux rope. Plasma blob or plasmoid is also sometimes observed accompanied with solar flare. These magnetic field structures are typically formed in a reconnecting current sheet or at the edge of reconnection region. Plasmoid formation in a reconnection region has been mostly studied using 2D numerical simulation or 2D theory. In the actual 3D system, however, there are instable modes that are not taken into account in the 2D theory. Oblique tearing mode, whose wave vector is parallel to the reconnecting magnetic field, is one of 3D instability modes related to the formation of plasmoid. There are cases where the oblique tearing mode have higher growth rate than 2D mode (Baarlad et al. 2012). Oblique plasmoid will dominate the reconnection in the case. It is, therefore, not clear if 2D theory of plasmoid formation is directory applicable also to the actual 3D system. On the other hand, observed flux tube or plasmoid usually have coherent 2D-like structure. We conducted large scale numerical MHD simulation to study plasmoid formation and interaction in a 3D system. We observe growth of oblique plasmoid and the oblique structure dominate the system. They change their structure through coalescence and reconnection. The resultant middle-scale structure is somewhat 2D-like and we observed formation process of 2D-like structure in larger scale through interaction of 3D structure in small scale.

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Donguk Song, National Astronomical Observatory of Japan

Title: Chromospheric Plasma Ejections in a Light Bridge

Abstract: It is well-known that light bridges (LBs) inside a sunspot produce small-scale plasma ejections and transient brightenings in the chromosphere, but the nature and origin of such phenomena are still unclear. Utilizing the high- spatial and high-temporal resolution spectral data taken with the Fast Imaging Solar Spectrograph and the TiO 7057 Å broadband filter images installed at the 1.6 m New Solar Telescope of Big Bear Solar Observatory, we report arcsecond-scale chromospheric plasma ejections (1. ′′7) inside a LB. Interestingly, the ejections are found to be a manifestation of upwardly propagating shock waves as evidenced by the sawtooth patterns seen in the temporal-spectral plots of the Ca II 8542 Å and Hα intensities. We also found a fine-scale photospheric pattern (1′′) diverging with a speed of about 2km/s two minutes before the plasma ejections, which seems to be a manifestation of magnetic flux emergence. As a response to the plasma ejections, the corona displayed small-scale transient brightenings. Based on our findings, we suggest that the shock waves can be excited by the local disturbance caused by magnetic reconnection between the emerging flux inside the LB and the adjacent umbral magnetic field. The disturbance generates slow-mode waves, which soon develop into shock waves, and manifest themselves as the arcsecond-scale plasma ejections. It also appears that the dissipation of mechanical energy in the shock waves can heat the local corona.

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Xudong Sun, Stanford University

Title: On the Force-freeness of Vector Magnetograms

Abstract: A self-consistent force-free coronal magnetic field model requires force-free lower boundary input, a condition that is not usually met by photospheric magnetograms. We investigate the force-freeness of photospheric vector data and their potential bias from several observatories (Hinode/SP, HMI, and SOLIS/VSM). A particular systematic bias arises from the different noise levels in the line-of-sight and the transverse field component, which should be taken into account during coronal field modeling.

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Aki Takeda, Montana State University

Title: Recent Status of Hinode/XRT On-orbit Calibration for Quantitative Analysis

Abstract: After 10 years of on-orbit operation, Hinode/XRT continues to work properly to provide soft X-ray images of the Sun to research community and to the public. While recent XRT data remain to be useful for quantitative analysis, they require some extra calibration work to deal with updated instrumental status and to be up-to-date with the new analysis environment. Here are our recent progress: (1) Better removal of visible stray light component (affects on Ti-poly and C-poly filter images taken after 9-May-2012): We finalized the values of daily coefficient applied for subtracting stray-light component, by using the intensity correlation between Ti-poly(stray-light affected) and Al-mesh(non-affected) images. (2) Improved CCD contamination thickness database: We newly took into account the effect of persistent layer, the component that is not cleared by regular CCD bakeout operations, and renewed the contamination thickness data base in SSWDB for the period since 1-Jan-2008. (3) Update of XRT response function based on the most recent atomic data: We calculated a

new solar spectral model using the latest version of Chianti atomic database (ver. 8.0), and prepared the software to handle the new spectra for temperature and emission measure analysis.

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Aki Takeda, Montana State University

[Aki Takeda, Chunming Zhu and Keiji Yoshimura (Montana State University)]

Title: Introduction to Hinode/XRT Level0 Data Mpeg Movie Archive

Abstract: We recently developed a new web-based service, "XRT level0 data Mpeg Movie Archive" (http://solar.physics.montana.edu/HINODE/XRT/lev0_mma). This web site provides movies of XRT level0 data (data category for uncalibrated data) organized by month. The aim of this service is to provide users of XRT data a quick method to check data availability and quality before accessing the actual data archive. Specifications of our movies are as follows. (1) Movies are provided in mpeg-4 format and created using the ffmpeg software. (2) Movie files are created for each filter pair and for certain time periods ranging from 3 days to the whole month depending on the data volume obtained for that month. (3) The movies are scaled using a red and white reversed color table with log intensity to see faint structures better. (4) Movies are created for two different field of views (FOVs): - partial frames with 512"x512" and smaller, and - partial frames larger than 512"x512" and full frame readouts. (5) The pointing information is corrected for using the co-alignment database that is applied in XRT_PREP. (6) Images NOT included in the movie: - Dark frames, - Images with the G-band filter, and - Flare Detection Images (8x8 binning full frame readouts).

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Lucas Tarr, US Naval Research Laboratory

Title: Shocks and Current Sheets in a Stratified, 2D Simulation of the Photosphere to Low Corona Containing a Magnetic Null

Abstract: We numerically solve the full equations for resistive MHD on a 2D Cartesian grid using the LARE2D code. The simulation has a gravitationally stratified atmosphere extending from the photosphere to the low corona. The magnetic field has several concentrations that give rise to a single magnetic null point, which models a slice through plage or a small ephemeral region. The field therefore has strong spatial gradients. We introduce an initially acoustic wavepacket at the lower boundary and quantify its interaction with the inhomogeneous atmosphere and magnetic field in terms of wave mode conversion and the local dissipation of shocks and current sheets. Our results are substantially different compared to the case of uniform or slowly varying fields, which are typically used for simple sunspot models. We find that substantial conversion near the null point leads reconnection at the null and downward propagating slow shocks confined to field lines near the separatrix. Ohmic and shock dissipation raise the temperature in these regions by 25-50%. While the total amount

of wave energy that reaches the null depends strongly on the background stratification and properties of the wavepacket, the efficiency of mode conversion at the null is remarkably consistent at around 50-70% in each case we consider.

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Ryan Timmons, Lockheed Martin Solar and Astrophysics Laboratory

Title: Coordinated Solar Observation and Event Searches using the Heliophysics Events Knowledgebase (HEK)

Abstract: We present capabilities of the HEK allowing for joint searches, returning overlapping data from multiple instruments (IRIS, Hinode) that also include particular solar features and events (active regions, flares, sunspots, etc.), along with improvements in the event search tools. The new search tools aid the process of finding observations of particular interest from non-synoptic instruments. They also include processed datacubes of SOT-FG and AIA data coaligned with IRIS.

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Shin Toriumi, National Astronomical Observatory of Japan

Title: Magnetic Properties of Solar Active Regions that Govern Large Solar Flares and Eruptions

Abstract: Solar flares and coronal mass ejections (CMEs), especially the larger ones, emanate from active regions (ARs). With the aim to understand the magnetic properties that govern such flares and eruptions, we systematically survey all flare events with GOES levels of >=M5.0 within 45 deg from disk center between May 2010 and April 2016. These criteria lead to a total of 51 flares from 29 ARs, for which we analyze the observational data obtained by the Solar Dynamics Observatory. More than 80% of the 29 ARs are found to exhibit delta-sunspots and at least three ARs violate Hale's polarity rule. The flare durations are approximately proportional to the distance between the two flare ribbons, to the total magnetic flux inside the ribbons, and to the ribbon area. From our study, one of the parameters that clearly determine whether a given flare event is CME-eruptive or not is the ribbon area normalized by the sunspot area, which may indicate that the structural relationship between the flaring region and the entire AR controls CME productivity. AR characterization show that even X-class events do not require delta-sunspots or strong-field, high-gradient polarity inversion lines. An investigation of historical observational data suggests the possibility that the largest solar ARs, with magnetic flux of 2x10^23 Mx, might be able to produce "superflares" with energies of order of 10^34 erg. The proportionality between the flare durations and magnetic energies is consistent with stellar flare observations, suggesting a common physical background for solar and stellar flares.

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Shin Toriumi, National Astronomical Observatory of Japan

Title: Largest Sunspots in History: Magnetic Flux Content, Emergence Rate, and Generation Mechanism

Abstract: Sunspots are strong conglomerates of magnetic fields, which harbor various types of activity phenomena, including flares and CMEs. The key questions we have in this study are: What are the total magnetic flux of the largest sunspot groups in history? How are they created? Are they created by the "regular" dynamo? In order to answer to these questions, we analyze sunspot records of more than 140 years since the late 19th century. We first survey catalogs of spot areas provided by Royal Greenwich Observatory, Kopecky & Kotrc (1974), Kopecky (1982), and USAF/NOAA, and pick up 264 regions with >=1500 MSH (millionths of solar hemisphere). For recurrent regions, only the maximum areas are used. Then, by comparing the NOAA spot areas and the total unsigned magnetic fluxes measured by SDO/HMI from May 2010, we obtain the equation that relates spot areas and total magnetic fluxes. We convert the historical spot areas using this equation and found that the largest sunspot region in history, RGO 11886 with a spot size of 6132 MSH (April 1947), might have a total flux of 4.4x10^23 Mx. It is also found that the emergence rates of the largest sunspots follow the power-law that was suggested by Thornton & Parnell (2011) to span over six magnitudes from 10^16 Mx to 10^22 Mx. This result may indicate that the historical largest sunspots may be also created from the "regular" dynamo, i.e., the same turbulent convection mechanism as the usual-sized sunspots. Moreover, since there is no strong evidence that shows the saturation of the power law, we can assume that the power continues further.

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Shin Toriumi, National Astronomical Observatory of Japan

Title: Various Local Heating Events in the Earliest Phase of Flux Emergence

Abstract: Emerging flux regions (EFRs) are known to exhibit various sporadic local heating events in the lower atmosphere. To investigate the characteristics of these events, especially to link the photospheric magnetic fields and atmospheric dynamics, we analyze Hinode, IRIS, and SDO data of a new EFR in NOAA AR 12401. Out of 151 bright points (BPs) identified in Hinode/SOT Ca images, 29 are overlapped by an SOT/SP scan. Seven BPs in the EFR center possess mixed-polarity magnetic backgrounds in the photosphere. Their IRIS UV spectra (e.g., Si IV 1402.8 A) are strongly enhanced and red- or blue-shifted with tails reaching +/- 150 km/s, which is highly suggestive of bi-directional jets, and each brightening lasts for 10 - 15 minutes leaving flare-like light curves. Most of this group show bald patches, the U-shaped photospheric magnetic loops. Another 10 BPs are found in unipolar regions at the EFR edges. They are generally weaker in UV intensities and exhibit systematic redshifts with Doppler speeds up to 40 km/s, which could exceed the local sound speed in the transition region. Both types of BPs show signs of strong temperature increase in the low chromosphere. These observational results support the physical picture that heating events in the EFR center are due to magnetic reconnection within cancelling undular fields like Ellerman bombs, while the

peripheral heating events are due to shocks or strong compressions caused by fast downflows along the overlying arch filament system.

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Harry Warren, NRL

Title: Simulating High-Temperature Active Region Emission

Abstract: Here we present an update on our effort to model solar active regions as an ensemble of impulsively heated loops. This modeling combines a extrapolation of the magnetic field with a volumetric heating rate for each field line that depends on the mean field strength and loop length. We find that by adopting a power-law distribution of heating event magnitudes and a waiting time between events that is proportional to energy we can reproduce both the distribution of temperatures and the temporal variability observed in a wide variety of active regions. Here we highlight some of the limitations of the modeling, such as the prediction of very short, rapidly cooling loops that are not observed, and the difficulty of simultaneously reproducing both the apex temperatures and densities observed with EIS, XRT, and AIA and the moss intensities observed with IRIS . The magnetic topology of the field is also critical to the modeling. We compare the magnetic field extrapolations derived from potential field, traditional non-linear force-free techniques, and the forward fitting method of Aschwanden et al.

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Jean-Pierre Wuelser, Lockheed Martin Solar & Astrophysics Lab

Title: IRIS Calibration Status

Abstract: The IRIS team has been providing calibrated data to the community since the beginning of the mission and continues to update and improve the calibrations applied. This poster summarizes the current status and highlights recent improvements to the IRIS calibrations.

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Dae Jung Yu, Centre for Mathematical Plasma Astrophysics, Department of Mathematics, KU Leuven

Title: Resonant Damping of the Slow Surface Sausage Mode and the Surface Kink Modes under Magnetic Pore Conditions

Abstract: The fast and slow modes of sausage and kink modes are often observed in solar atmospheric structures. The wave damping in the resonant layer in the lower solar atmosphere is of interest since it is related to the transport of wave energy into the upper solar atmosphere. We study theoretically the effect of the slow continuum on resonant damping of the slow surface sausage mode and the effect of the Alfven continuum on resonant damping of the slow surface kink and fast surface kink modes, by assuming infinitely long and thin cylindrical flux tubes where a thin inhomogeneous layer is between the internal and external homogeneous mediums. We derive general analytical formulas for the damping rate for any m mode, by using the connection formula at the resonance surfaces (Sakuarai et al. 1991; Goossens et al. 1992). We assume that the density and the pressure are linear functions in the inhomogeneous medium. Whilst the damping effect in the slow resonance is thought to be negligibly small compared to the Alfven resonance in the upper solar atmosphere, we find that it could be efficient for slow sausage mode under photospheric (magnetic pore) conditions. We compare our results with the recent observation of rapid damping of a sausage mode in a magnetic pore by Grant et al. (2015). For the surface kink mode, the resonant damping in the Alfven resonance is found to be relatively stronger for the fast mode than for the slow mode, We discuss a possible relevance for the recent observation of the slow kink (m=1) mode in a sunspot by Jess et al. (not yet published).

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Vasyl Yurchyshyn, Big Bear Solar Observatory/NJIT

Title: High Resolution Observations of a White Light Flare with NST

Abstract: Using high resolution data from the New Solar Telescope (NST) we studied the fine spatial and temporal structure of an M1.3 white light (WL) flare, which was one of the three homologous solar flares (C6.8, M1.3, and M2.3) observed in a close proximity to the west solar limb. The RHESSI photon spectra for the M1.3 flare showed strongly accelerated electrons with energies above 100 keV. Comparison of HXR photon spectra for the three flares suggests that high energy electrons (>50 keV) may be necessary to produce a WL flare observed with the TiO filter. The strong and compact WL cores were approx. 0.15 Mm across with an area of about 10^14 cm sq. The observed TiO enhancements are not normally distributed and are structured by the magnetic field of the penumbra. Several of the TiO cores were not co-spatial with the H-alpha emission, which suggests that the TiO and chromospheric emission did not originate in the same chromospheric volume as some models suggest. We thus conclude that fine temporal and spatial structure of the WL flare was largely defined by the associated magnetic fields, which favors the direct heating models, where the flare energy is directly deposited in the temperature minimum region by the accelerated electrons.

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Vasyl Yurchyshyn, Big Bear Solar Observatory/NJIT

Title: Sporadic Revival of a Coronal Loop Rooted in a Sunspot

Abstract: Dense and possibly hot (non-flaring) coronal loops are not uniformly distributed in the corona above sunspots. Only some of the loops rooted in the sunspot appear bright in AIA images and their footpoints are often bundled and co-spatial with bright Si IV clusters seen the umbra. We focus on one sunspot loop that several times completely revived in 17 Dec

2015 AIA images so it can be traced from one footpoint to another. We used AIA images, IRIS spectral data and HMI magnetograms to describe the phenomenon and understand its causes. We find that the revival of the loop was associated with magnetic field activity at the remote (non-sunspot) footpoint of the loop, which led to periodic injection of plasma into the loop as the magnetic activity intensified. HMI data indicate that the plasma injection was apparently driven by magnetic reconnection as signatures of small-scale opposite polarity were detected at the edge of an extended plage region.

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Chunming Zhu, Montana State University

Title: Two-phase Heating in Flaring Loops

[Chunming Zhu, Jiong Qiu, Dana W. Longcope, and Sarah Pearce, Physics Department, Montana State University]

Abstract: We model a C5.7 solar flare observed by SDO/AIA and GOES on 2011 December 26. We reconstruct around 7,000 flaring half loops whose footpoints instantaneously brightened in the UV 1600 A during the flare, and simulate the evolution of their coronal temperatures and densities by utilizing the model of "enthalpy-based thermal evolution of loops". The empirical heating function for each loop consists of two phases: an impulse followed by a gradual tail, both of which are constructed from the 1600 A lightcurve at the footpoint of each half loop. The synthetic differential emission measures and total fluxes agree favorably with those observed by SDO/AIA and GOES. The role of slow heating and its related physical mechanisms are discussed.

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E-Posters

Joel Allred, NASA/Goddard Space Flight Center

Title: Modeling Nanoflare Heating of AR 11726 Using Observations from EUNIS and EIS

Abstract: Impulsive nanoflares are thought to be an important heating source in the solar corona of active regions. They are frequent but relatively small bursts caused by the dissipation of magnetic energy and can quickly heat the local corona to greater than 10 MK. The Extreme Ultraviolet Normal Incidence Spectrograph (EUNIS) has a bandpass with many lines formed over a wide temperature range (0.1 MK - 10 MK). This makes it an ideal instrument to characterize the emission measure distribution of coronal active regions. EUNIS was flown aboard a sounding rocket in April 2013 and observed AR 11726 with coordinated observations by Hinode/EIS and the suite of SDO instruments. Here we report on the results of a large scale parameter study designed to constrain the frequency and energy distribution of nanoflares and how those scale with local magnetic field strength. We have characterized the 3D magnetic field in AR 11726 using a non-linear force free field extrapolation and performed 1D simulations of nanoflare heating within numerous individual flux tubes lying along field lines. The predicted emission in the lines observed by EUNIS and EIS are modeled using the CHIANTI atomic database with differential emission measures obtained from the simulations. By comparing predicted with observed emission, we have constrained the energy distribution of nanoflares in the active region.

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Luis Bellot Rubio, Instituto de Astrofisica de Andalucia – CSIC

Title: Magnetic Properties of Lateral Downflows in Sunspot Penumbral Filaments

Abstract: We have inverted a time sequence of full Stokes spectropolarimetric measurements of a sunspot at the disk center to determine the magnetic properties of the weak downflows that occur at the edges of penumbral filaments. The observations were acquired in the Fe I 6173 line with the CRISP instrument at the Swedish 1m Solar Telescope under superb seeing conditions. They reveal the existence of lateral downflows with unprecedented clarity and allow their temporal evolution to be studied in detail. We find regular two-lobed circular polarization profiles at the position of the downflows. These profiles have small asymmetries and can be inverted sucessfully in terms of one-component magnetic atmospheres with constant parameters along the line of sight. The inversions show that the polarity of the vector magnetic field is usually the same in the downflows and the hosting filament. Sometimes we observe a third weak lobe in the red wing of the circular polarization profile, indicating the presence of opposite polarity fields. This suggests that the downflows drag the field lines but do not change their polarity except on rare occasions. Our results set constraints on the magnetic structure of sunspots that need to be reproduced by 3D MHD simulations.

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Feng Chen, High Altitude Observatory / NCAR

Title: Realistic Simulations of Active Region Formation and Solar Eruptions

[Feng Chen, Matthias Rempel, Yuhong Fan]

Abstract: We present a comprehensive realistic numerical model of emergence of magnetic flux generated in a solar convective dynamo from the convection zone to the corona. The magnetic and velocity fields in a horizontal layer near the top boundary of the solar convective dynamo simulation are used as a time-dependent bottom boundary to drive the radiation magnetohydrodynamic simulations of the emergence of the flux bundles through the upper most convection zone to more than 100 Mm above the surface of the Sun. The main results are: 1) Before the emerging flux bundles reaches the photosphere, the mixed polarity magnetic field maintained by the small scale dynamo in the convection zone can provide

sufficient energy to heat the Quiet Sun corona to over one million K. 2) The emerging flux bundles fragment into small scale magnetic elements that further rise to the photosphere and give rise to several bipolar pairs of sunspots. 3) While the active regions are forming in the photosphere, the coronal plasma is further heated to a few million K, which leads to a clear dimming in synthetic AIA images in lower temperature channel (e.g, 171A and 193A) as seen in observations. Loops formed in the core of an active region can reach temperatures above 10 million K. 4) The simulation produces a lot of dynamical features, such as coronal bright points, jets, waves and propagating disturbances, as well as flares and mass ejections. In the first 30 hours of the evolution more than 10 flares, most of which are in B and C class, happens and one flare reaches M2. The M class flare is accompanied by an ejection of a strongly twisted flux rope. The ejected magnetic field and plasma set off from the polarity inversion line of a bipolar pair of sunspots and arrive at 100 Mm height in about 10 min. The post-flare loops show a cusp-like shape and are filled with plasma of 10 to 100 MK.

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Georgios Chintzoglou, LMSAL/UCAR

Title: Bridging the Gap: Capturing the Lyman Alpha Counterpart of a Type-II Spicule and Its Heating Evolution with VAULT2.0 and IRIS Cam

Abstract: We present the analysis of data from the observing campaign in support to the VAULT2.0 sounding rocket launch on September 30, 2014. VAULT2.0 is a Lyman alpha (1216 Angstroms) spectroheliograph capable of providing fast cadence spectroheliograms of high-spectral purity. The objective of the VAULT2.0 project is the study of the chromosphere-corona interface. VAULT2.0 observations probe temperatures between 10,000 and 30,000 K, a regime not accessible by Hinode, IRIS or the Solar Dynamics Observatory. Lyman alpha observations are, therefore, ideal, for filling in this gap. The observing campaign was closely coordinated with the IRIS mission. Taking advantage of this simultaneous multi-wavelength coverage of target AR 12172 and by using state-of-the-art MHD simulations of spicules, we are able to perform a detailed investigation on a type-II spicule that was recorded in the joint observations during VAULT2.0's flight. Our unique observations suggest that spicular material exists suspended in lower temperatures until it rapidly gets heated and becomes visible in transition-region temperatures as a type-II spicule.

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Alfred de Wijn, NCAR/HAO

Title: First Detection of Sign-reversed Linear Polarization from the Forbidden [O I] 630.03 nm Line

Abstract: We report on the detection of linear polarization of the forbidden [O I] 630.03 nm spectral line. The observations were carried out in the broader context of the determination of the solar oxygen abundance, an important problem in astrophysics that still remains unresolved. We obtained spectro-polarimetric data of the forbidden [O I] line at 630.03 nm as

well as other neighboring permitted lines with the Solar Optical Telescope of the Hinode satellite. A novel averaging technique was used, yielding very high signal-to-noise ratios in excess of 105. We confirm that the linear polarization is sign-reversed compared to permitted lines as a result of the line being dominated by a magnetic dipole transition. Our observations open a new window for solar oxygen abundance studies, offering an alternative method to disentangle the Ni I blend from the [O I] line at 630.03 nm that has the advantage of simple LTE formation physics.

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Hirohisa Hara, National Astronomical Observatory of Japan

Title: High-speed Flow and Turbulent Structures in Eruptive Flares

Abstract: Magnetic reconnection is a fundamental process in converting the magnetic energy to the thermal and kinetic energy of hot flare plasmas and the accelerated particles. Based on the Hinode EIS observations of eruptive flares, we show the high-speed flow and turbulent structures of highly-ionized ion motions near the site of magnetic reconnection. The importance of future higher-cadence spectroscopic observations is discussed for understanding the heating and dynamics near the reconnection site.

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Neal Hurlburt, Lockheed Martin Solar & Astrophysics Laboratory

Title: Statistics of Solar Eruptions and Related Solar Phenomena

Abstract: A method for automatically identifying eruptions near the solar surface (either from filaments or otherwise) has recently been developed and integrated into the Heliophysics Events Knowledgebase. Here we present a survey of eruptions identified by the EruptionPatrol and EruptionCharacterize modules run over six years of SDO/AIA 30.4 nm images. Over twenty-thousand distinct eruptions were identified with velocities ranging from 4-120km/sec, sizes from 20 to 1,000Mm and durations from 2 to 180 minutes. We explore their behaviors and relationship to other solar phenomena.

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Sarah Jaeggli, National Solar Observatory

Title: Using Hinode/SP to Determine the Precision of Ad Hoc Methods for Determining Polarization Cross-talk

Abstract: The symmetry and anti-symmetry of the linearly and circularly polarized light from atomic absorption lines sensitive to the Zeeman effect in the strong magnetic field of sunspots makes it possible to estimate the amount of polarization cross-talk that is introduced by the optical system used for observation. Several techniques to derive the polarization cross-talk

exist, and rely on determining the correlation of signals in the different measured polarized states. These techniques are currenly being considered as the primary techniques for deriving the polarization cross-talk from the primary and secondary mirror of the Daniel K. Inouye Solar Telescope. However, it is not known to what accuracy or precision these techniques perform. Because these techniques assume symmetric line profiles, they fail when polarized line profiles show the effects of strong vertical gradients in velocity or when multiple magnetic components are present in a single resolution element. The Hinode Spectropolarimeter (SP) on the Solar Optical Telescope was calibrated to a high level of accuracy on the ground, and it provides stable observations of the Fe I line pair at 630.2 nm. We derive the cross-talk parameters using the large archive of sunspots observed with the SP to determine if residual polarization cross-talk is present. In addition, we explore using a Milne-Eddington inversion including cross-talk parameters to see if we can achieve better parameter accuracy.

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Yusuke Kawabata, The University of Tokyo

Title: Non-potential Field Formation in the X-shaped Quadrupole Magnetic Field Configuration

Abstract: Some types of solar flares are observed in X-shaped quadrupolar field configuration. For understanding the magnetic energy storage in such a region, we studied the non-potential field formation in an X-shaped quadrupolar field region formed in active region NOAA 11967, which produced three X-shaped M-class flares on 2 February 2014. Nonlinear force-free field (NLFFF) modeling was applied to the time series of vector magnetic field maps from Hinode SOT/SP and SDO/HMI. Our analysis of temporal 3D magnetic field evolution shows that the sufficient free energy had already been stored more than 10 hours before the occurrence of the first M-class flare and that the storage was observed in the localized region, rather than in the entire X-shaped quadrupolar field. In the localized region, quasi-separatrix layers (QSLs) started to develop gradually from 9 hours before the first M-class flare. One of the flare ribbons appeared in the M-class flare was co-spatial with the location of the QSLs, suggesting that the formation of the QSLs is important in the process of energy release. These QSLs do not appear in the potential field calculation, suggesting that the non-potential field created these QSLs. The QSLs were formed associated with the transverse photospheric motion of the pre-emerged flux and the emergence of a new flux. This observation indicates that the occurrence of the flares needs the formation of QSLs in the non-potential field where the free magnetic energy is stored in advance.

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Madeline Kelly, Montana State University

Title: Spectroscopic Diagnostics of Solar Flare Dynamics using IRIS

Abstract: The recently launched Interface Region Imaging Spectrograph (IRIS) provides high-resolution slit-jaw images as well as spectra in the ultraviolet (UV) wavelength range. It has captured hundreds of solar flares since 2013. Here we study an M2.3 flare observed by

IRIS on November 9th, 2014. In this observation, the slit of IRIS cut across both the north and south ribbons of the flare, where the footpoints of the flare loops are rooted. We present temporal evolution maps of the intensity, velocity, and linewidth of the Si IV, C II, and Mg II spectra along the slit based upon moment analysis. Different dynamics along with different shapes of the line profile are found between the ribbons and the loops. We also track the two ribbons that separate from each other over time. In general, we find that the intensity, velocity, and linewidth are all peaked around the flare peak time and fall off during the decay phase. In addition, we investigate a temporal evolution of the dynamics at some fixed ribbon pixels, seeing chromospheric condensation manifested in the cool Si IV, C II, and Mg II lines and also chromospheric evaporation in the hot Fe XXI line. Some implications of these dynamics are given in this study.

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Kyoung-Sun Lee, National Astronomical Observatory of Japan

Title: Spectroscopic and Stereoscopic Observation of a Loop-top Source of an M1.3 Limb Solar Flare

Abstract: We have investigated an M1.3 flare on 2014 January 13 around 21:48 UT observed at the west limb using the Hinode, SDO, and STEREO. Especially, the Hinode/EIS scanned the flaring loop covering the loop-top region over the limb, which is a good target to investigate the dynamics of the flaring loop with their height. Using the multi-wavelength observations from the Hinode/EIS and SDO/AIA, we found a very hot emission above the loop-top observed in Fe XXIV (94Å channel). Measuring the intensity, Doppler velocity and line width for the flaring loop, we found that hot emission observed at the cusp like shape of loop-top region which shows strong redshift about 500 km/s in Doppler velocity and strong enhancement of the non-thermal velocity (line width enhancement) larger than 100 km/s. Combining with the STEREO observation, we also discuss the 3D structure and velocity distribution of the loop-top region.

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Juan Martinez Sykora, BAERI

Title: On the Origin of Type II Spicules

Abstract: In the lower solar atmosphere, the chromosphere is permeated by jets, in which plasma is propelled at speeds of 50-150 km/s into the Sun's atmosphere or corona. Although these spicules may play a role in heating the million-degree corona and are associated with Alfvén waves that help drive the solar wind, their generation remains mysterious. Our study uses simulations created with the radiative-MHD Bifrost code. We implemented in the code the effects of partial ionization using the generalized Ohm's law. This code also solves the full MHD equations with non-grey and non-LTE radiative transfer and thermal conduction along magnetic field lines. The ion-neutral collision frequency is computed using recent studies that improved the estimation of the cross sections under chromospheric conditions (Vranjes &

Krstic 2013). Self-consistently driven jets (spicules type II) in magnetohydrodynamic simulations occur ubiquitously when magnetic tension is amplified and transported upwards through interactions between ions and neutrals, and impulsively released to drive flows, heat plasma and generate Alfvén waves. This mechanism explains how spicular plasma can be heated to millions of degrees and how Alfvén waves are generated in the chromosphere. We compare the simulated spicules with observations from IRIS and SST.

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Tiago Pereira, Institute of Theoretical Astrophysics, University of Oslo

Title: A Chromospheric View of Transition Region Low-lying Loops

Abstract: Low-lying transition region (TR) loops observed by IRIS are suspected to be the previously unresolved fine structures that were predicted decades ago to explain the excess emission in TR lines. Besides being magnetically isolated from the corona, little is known about these structures. We observed low-lying loops TR with IRIS and the Swedish 1-m Solar Telescope, and studied their evolution through chromospheric and TR lines. While we often find some chromospheric signal of the loops in Halpha spectra, the full picture is not yet complete. There are many intriguing and puzzling details. Halpha Dopplergrams often show a reverse Y shape, suggesting magnetic reconnection. Yet in all occurrences the reverse Y shape is observed above the hot loop. Spectra indicate strong chromospheric velocities, some in excess of 50 km/s. Intermittent blobs along the chromospheric part may also indicate the presence or passage of waves. We discuss our results and scenarios for the driver of such loops, and comment on a possible association with spicules.

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Antonia Savcheva, Harvard-Smithsonian Center for Astrophysics

Title: Non-Linear Force-Free Field Modelling of Solar Coronal Jets in Theoretical Configurations

Abstract: Coronal jets occur frequently on the Sun, and may contribute significantly to the solar wind. With the suite of instruments available now, e.g. on IRIS, Hinode and SDO, we can observe these phenomena in greater detail than ever before. Modeling and simulations can assist further in understanding the dynamic processes involved, but previous studies tend to consider only one mechanism (e.g. emergence or rotation) for the origin of the jet. In this study we model a series of idealised archetypal jet configurations and follow the evolution of the coronal magnetic field. This is a step towards understanding these idealised situations before considering their observational counterparts. Several simple situations are set up for the evolution of the photospheric magnetic field: a single parasitic polarity rotating or moving in a circular path; as well as opposite polarity pairs involved in flyby (shearing), cancellation or emergence; all in the presence of a uniform, open background magnetic field. The coronal magnetic field is evolved in time using a magnetofrictional relaxation method. While magnetofriction cannot accurately reproduce the dynamics of an eruptive phase, the structure of the coronal magnetic field, as well as the build up of electric currents and free magnetic

energy are instructive. Certain configurations and motions produce a flux rope and allow the significant build up of free energy, reminiscent of the progenitors of so-called blowout jets, whereas other, simpler configurations are more comparable to the standard jet model. The next stage is a comparison with observed coronal jet structures and their corresponding photospheric evolution.

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Heesu Yang, Korea Astronomy and Space Science Institute

Title: Motions of the Photospheric Elongated Granule-like Features associated with Ellerman Bombs

Abstract: Ellerman bombs are thought to be a response of the magnetic reconnection in the solar low atmosphere. It is known that they are associated with the small-scale photospheric and magnetic field structures. We observed nine EBs using the 1.6m New Solar Telescope at Big Bear Solar Observatory. They all were accompanied by elongated granule-like features (EGFs) showing transverse motions prior to the EBs with an average speed of about 3.8 km/s. We identified the bi-directional and uni-directional expanding motions of the EGFs in the TiO images. Each of the expending motions was found to be accompanied by an emerging flux(EF) or a moving magnetic feature (MMF). Our result suggests that the magnetic reconnection forced by EFs or MMFs that are frequently manifested by EGFs triggers the EBs.

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Kai Yang, Nanjing University/Montana State University

Title: Using Observations of Slipping Velocities to Test the Hypothesis that Reconnection Heats the Active Region Corona

[Kai Yang, Dana Longcope, Yang Guo, and M. D. Ding]

Abstract: Numerous proposed coronal heating mechanisms have invoked magnetic reconnection in some role. Testing such a mechanism requires a method of measuring magnetic reconnection coupled with a prediction of the heat delivered by reconnection at the observed rate. In the absence of coronal reconnection, field line footpoints move at the same velocity as the plasma they find themselves in. The rate of coronal reconnection is therefore related to any discrepancy observed between footpoint motion and that of the local plasma — so-called slipping motion. We propose a novel method to measure this velocity discrepancy by combining a sequence of non-linear force-free field extrapolations with maps of photospheric velocity. We obtain both from a sequence of vector magnetograms of an active region (AR). We then propose a method of computing the coronal heating produced under the assumption the observed slipping velocity was due entirely to coronal reconnection. This heating rate is used to predict density and temperature at points along an equilibrium loop. This in turn is used to synthisize emission in EUV and SXR bands. We perform this analysis using a sequence of HMI vector magnetograms of a particular AR and compare synthesized images to

observations of the same AR made by SDO and Hinode. We also compare differential emission measure inferred from those observations to that of the modeled corona.