IRIS-7 Workshop

Apr. 11-15, 2016, Weihai, China

Contents

Simultaneous observations of hot explosions by NST and IRIS

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In this talk, we present the simultaneous observations of the so-called hot explosions in the cool atmosphere of the Sun made by New Solar Telescope (NST) of Big Bear Solar Observatory (BBSO) and Interface Region Imaging Spectrograph (IRIS) in space. The data obtained during joint IRIS-NST observation on 2014 July 30. We examined the SDO data also. The explosion started around 19:20 UT and lasted for about 10 minutes. Our findings are as follows: (1) the IRIS brightening related to the explosion was observed in 3 channels of slit-jaw images; (2) IRIS spectra show highly blue- and red-shifted wing profiles for C II, Si IV, Mg II lines; (3) from NST Fast Imaging Solar Spectrograph (FISS) data, wing brightening occurred in H-alpha and Ca II bands and related surge was observed in both bands; (4) from SDO data, we observed the brightening in AIA 1600 angstrom images which is consistent with the IRIS brightening; (5) regarding the hot explosion, we found a significant variation of positive flux from HMI and NST Near IR Imaging Spectropolarimeter (NIRIS) data. These observations suggest that the hot explosion contain high up and downward moving plasma and occur by magnetic reconnection in the lower atmosphere of the Sun. Additionally, we will give more examples of the simultaneous observations of hot explosions and discuss physical implications of the hot explosion.

Keyword: hot explosion, IRIS brightening, magnetic reconnection

Are IRIS bombs connected to Ellerman bombs?

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Recent observations by IRIS have revealed pockets of hot gas (8×104 K) resulting from magnetic reconnection in the partially ionized lower solar atmosphere (IRIS bombs). Using joint observations between IRIS and the Chinese New Vacuum Solar Telescope, we have identified ten IRIS bombs. We find that three are unambiguously and three others are possibly connected to Ellerman bombs, which show intense brightening of the extended Hα wings without leaving any obvious signature in the Hα core. These bombs generally reveal the following distinct properties: (1) The O iv 1401.156 A and 1399.774 A lines are absent or very weak; (2) The Mn i 2795.640 A line reveals as an absorption feature superimposed on the greatly enhanced Mg ii k line wing; (3) The Mg ii k and h lines show intense brightening in the wings and no dramatic enhancement in the cores; (4) Chromospheric absorption lines such as Ni ii 1393.330 A and 1335.203 A are very strong; (5) The 1700 A images obtained with the Atmospheric Imaging Assembly on board the Solar Dynamics Observatory reveal intense and compact brightenings. These properties support the formation of these bombs in the pho- tosphere, demonstrating that Ellerman bombs can be heated to 8×10^4 K, one to two orders of magnitude higher than the temperature enhancement predicted from Ellerman bomb modelings. We also demonstrate that the Mg ii k and h lines can be used to investigate Ellerman bombs similarly to the Hα line, which opens a promising new window for Ellerman bomb studies since the Mg ii data are routinely acquired in seeing-free IRIS observations. The rest four IRIS bombs obviously have no connection to Ellerman bombs and they do not have the properties mentioned above, suggesting a higher formation layer possibly in chromosphere. We also find that IRIS bombs generally reveal no obvious coronal signature and that most of them are sitting at the magnetic field polarity inversion lines.

Keyword: reconnection, Ellerman bombs

Fine-Scale Photospheric Connections of the Ellerman bombs

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We investigate the photospheric features and magnetic features accompanied by the Ellerman bombs (EBs) using the 1.6 meter New Solar Telescope at Big Bear Solar Observatory. Among nine EBs we observed, eight are accompanied by the elongated granule-like features (EGFs) that show transverse motions with an average speed of about 3.8 km s−1 prior to the EBs. Most of EGFs shows the sub-arcsecond sized bright feature surrounded by a dark lane around their moving front. The bright features appeared in the TiO broadband filter images as well as far wings of Hα / Ca ii 8542 A lines. The EGFs of four EBs developed into elongated shape as both tips moved farther from each other, and those EGFs were found to be accompanied by emerging fluxes (EFs) . The EGFs of the other four EBs were developed at the end of the penumbra as they were detached from the end of the penumbra with moving magnetic features (MMFs). Our observation indicates that the magnetic reconnection in the low chromosphere driven by the EFs and MMFs, may be responsible for the EBs.

Keyword: Ellerman bombs, Magnetic Reconnection

Spectral observations of Ellerman bombs and fitting with a two-cloud model

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We study the H alpha and Ca II 8542 Å line spectra of four typical Ellerman bombs (EBs) in active region NOAA 11765 on 2013 June 6, observed with the Fast Imaging Solar Spectrograph installed at the 1.6 meter New Solar Telescope at Big Bear Solar Observatory. Considering that EBs may occur in a restricted region in the lower atmosphere, and that their spectral lines show particular features, we propose a two-cloud model to fit the observed line profiles. The lower cloud can account for the wing emission, and the upper cloud is mainly responsible for the absorption at line center. After choosing carefully the free parameters, we get satisfactory fitting results. As expected, the lower cloud shows an increase of the source function, corresponding to a temperature increase of 400--1000 K in EBs relative to the quiet Sun. This is consistent with previous results deduced from semi-empirical models and confirms that a local heating occurs in the lower atmosphere during the appearance of EBs. We also find that the optical depths can increase to some extent in both the lower and upper clouds, which may result from either a direct heating in the lower cloud, or illumination by an enhanced radiation on the upper cloud. The velocities derived from this method, however, are different from those obtained using the traditional bisector method, implying that one should be cautious when interpreting this parameter. The two-cloud model can thus be used as an efficient method to deduce the basic physical parameters of EBs.

Keyword: line: profiles,radiative transfer,Sun: chromosphere,Sun: photosphere

The formation of common Ellerman Bombs and hot explosions ($\gtrsim 8\times10^4$~K) by magnetic reconnection in the low solar atmosphere

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In order to study the physical mechanisms of the hot explosions ($\gtrsim 8\times10^4$~K) observed at around the temperature minimum region by IRIS, we simulate several magnetic reconnection processes in the low solar chromosphere/photosphere, the radiation cooling, heat conduction and ambipolar diffusion are all included. Our numerical results indicate that both the high temperature explosions ($ \gtrsim8\times10^4$~K) observed by IRIS and the low temperature common Ellerman bombs ($\lesssim 10^4$~K) can be formed in a magnetic reconnection process in the low solar atmosphere ($100\sim600$~km above the solar surface). The plasma β controlled by plasma density and magnetic fields is one important factor to decide how much the plasma can be heated up. The common low temperature Ellerman bombs are formed in a high β magnetic reconnection process, Joule heating is the main mechanism to heat plasma and the maximum temperature increase is only several thousand Kelvin. The high temperature explosions can be generated in a low β magnetic reconnection process, slow and fast-mode shocks attached at the edges of the well developed plasmoids are the main physical mechanisms to heat the plasma from several thousand Kelvin to over 8×10^4~K. Gravity in the low chromosphere can strongly hinder the plasmoind instability and the formation of slow-mode shocks in a vertical current sheet. Only small secondary islands are formed; these islands, however, are not well developed as those in the horizontal current sheets and no higher order plasmoids are formed.

Keyword: magnetic reconnection, (magnetohydrodynamics) MHD, shocks, activity, low solar atmosphere

Formation and Initiation of Pre-structure of Coronal Mass Ejections Observed by SDO and IRIS

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Magnetic flux rope (MFR), a coherent magnetic structure with all magnetic field lines wrapping around its central axis, is believed to be a fundamental structure of coronal mass ejections, existing prior to and driving the solar eruptions. In this talk, I will present recent new results on CMEs observed by IRIS, in particular, on spectral characteristics of the formation and early eruption of the MFR.

Keyword: CME, Flare

Quasi-periodic Slipping Magnetic Reconnection During an X-class Solar Flare Observed by the SDO and IRIS

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We firstly report the quasi-periodic slipping motion of flare loops during an eruptive X-class flare on 2014 September 10. The slipping motion was investigated at a specific location along one of the two ribbons and can be observed throughout the impulsive phase of the flare. The apparent slipping velocity was 20-110 km/s and the associated period was 3-6 min. The footpoints of flare loops appeared as small-scale bright knots observed in 1400 Å, corresponding to fine structures of the flare ribbon. These bright knots were observed to move along the southern part of the longer ribbon and also exhibited a quasi-periodic pattern. The Si IV 1402.77 Å line was redshifted by 30-50 km/s at the locations of moving knots with a 40-60 km/s line width, larger than other sites of the flare ribbon. We suggest that the quasi-periodic slipping reconnection is involved in this process and the redshift at the bright knots is probably indicative of reconnection downflow. The emission line of Si IV at the northern part of the longer ribbon also exhibited obvious redshifts of about 10-70 km/s in the impulsive phase of the flare, with the redshifts at the outer edges of the ribbon larger than those in the middle. The redshift velocities at post-flare loops reached about 80-100 km/s in the transition region.

Explosive Chromospheric Evaporation in a Circular-ribbon Flare

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We report our multiwavelength observations of the C4.2 circular-ribbon flare in active region 12434 on 2015 October 16. The short-lived flare was observed in Hα, ultraviolet, extreme-ultraviolet, soft X-ray, and hard X-ray by ground-based telescope, Atmospheric Imaging Assembly aboard the \textit{Solar Dynamic Observatory} (\textit{SDO}), \textit{Interface Region Imaging Spectrograph} (\textit{IRIS}), \textit{GOES}, and \textit{RHESSI}. The flare was triggered by the eruption of a mini-filament and was accompanied by a blowout jet. The flare featured a closed circular flare ribbon (CFR) and an inner flare ribbon (IFR) within it, which are associated with positive magnetic polarities and negative polarity inside, as revealed by the photospheric line-of-sight magnetograms observed by the Helioseismic and Magnetic Imager aboard \textit{SDO}. Such magnetic pattern is strongly indicative of a magnetic null-point and spine-fan configuration in the corona. \textit{IRIS} raster observations show upflow at speed of 35$-$120 km s^{-1} in the Fe {\sc xxi} line ($\log T\approx7.05$) and downflow at speed of 10$-$60 km s^{-1} in the Si {\sc iv} line ($\log T\approx4.8$) at certain locations of the CFR and IFR during the impulsive phase of flare, indicating explosive chromospheric evaporation. Coincidence of the single HXR source at 12$-$25 keV with the IFR suggests that the explosive evaporation is driven by nonthermal electrons. To the best of our knowledge, this is the first report of explosive chromospheric evaporation in circular-ribbon flares. The results of this work shed light on the particle acceleration in solar null-point reconnection region and precipitation in the chromosphere.

Keyword: chromosphere, flare

Tether-cutting Reconnection between Two Filaments Triggering Outflows and a Coronal Mass Ejection

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Triggering mechanisms of solar eruptions have long been a challenge. A few previous case studies have indicated that preceding gentle filament merging via magnetic reconnection may launch following intense eruption, according to the tether-cutting (TC) model. However, the detailed process of TC reconnection between filaments has not been exhibited yet. In this work, we report the high-resolution observations from the Interface Region Imaging Spectrometer (IRIS) of TC reconnection between two sheared filaments in NOAA active region 12146. The TC reconnection commenced on 15:35 UT on 2014 August 29 and triggered an eruptive GOES C4.3-class flare 8 minutes later. An associated coronal mass ejection appeared in the field of view of the Solar and Heliospheric Observatory/LASCO C2 about 40 minutes later. Thanks to the high spatial resolution of IRIS data, bright plasma outflows generated by the TC reconnection are clearly observed, which moved along the subarcsecond fine-scale flux tube structures in the erupting filament. Based on the imaging and spectral observations, the mean plane-of-sky and line-of-sight velocities of the TC reconnection outflows are separately measured to be 79 and 86 km s−1, which derives an average real speed of 120 km s−1. In addition, it is found that spectral features, such as peak intensities, Doppler shifts, and line widths in the TC reconnection region are evidently enhanced compared to those in the nearby region just before the flare.

Keyword: filaments, prominences, flares

Co-observation of a filament formation with NST and IRIS

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The filament formation always associates with plasma heating and material transportation. In this work we present a newly formed filament located inside the NOAA 12403 on 2015 Aug. 21. It was co-observed by the New Solar Telescope (NST) at Big Bear Solar Observatory (BBSO) and the Interface Region Imaging Spectrograph (IRIS) from 17:00:00 UT to 19:00:00. The NST and IRIS observed the two endpoints of the filament respectively. In Hα images cold material is seen to be transported to the filament spine. Associating with the material transportation, some bright points can be observed at the endpoint of the filament. These bright points may be the source region of the cold material. Furthermore, the phenomenon called counter-streaming was observed in different Hα filtergrams. At the other endpoint of the filament, the bright ribbon can also be seen in MgII line images. The spectral analysis indicates the blue-shift motion from the bright ribbon. The counter-streaming can also be seen in the velocity field obtained from MgII spectra. For understanding the mechanism, we made a 1-D simulation to explain the phenomenon.

Keyword: filament, formation

Cool transition region loops observed by IRIS

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We report on the first Interface Region Imaging Spectrograph (IRIS) study of cool transition region loops, a class of loops that has received little attention in the literature. A cluster of such loops was observed on the solar disk in active region NOAA11934, in the Si IV 1402.8 Å spectral raster and 1400 Å slit-jaw images. We divide the loops into three groups and study their dynamics. The first group comprises relatively stable loops, with 382–626 km cross-sections. Observed Doppler velocities are suggestive of siphon flows, gradually changing from −10 km/s at one end to 20 km/s at the other end of the loops. Nonthermal velocities of 15 25 km/s were determined. Magnetic cancellation with a rate of 10^15 Mx/s is found at the blue shifted footpoints. These physical properties suggest that these loops are impulsively heated by magnetic reconnection, and the siphon flows play an important role in the energy redistribution. The second group corresponds to two footpoints rooted in mixed-magnetic-polarity regions, where magnetic cancellation with a rate of 10^15 Mx/s and explosive-event line profiles with enhanced wings of up to 200 km/s were observed. In the third group, interaction between two cool loop systems is observed. Evidence for magnetic reconnection between the two loop systems is reflected in the explosive-event line profiles and magnetic cancellation with a rate of 3x10^15 Mx/s observed in the corresponding area. The IRIS has provided opportunity for in-depth investigations of cool transition region loops. Further numerical experiments are crucial for understanding their physics and their roles in the coronal heating processes.

Keyword: sun: chromosphere, sun: transition region

Small Scale transients as seen by IRIS

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With the advent of IRIS we are observing many more small-scale transients. These transients can play a crucial role in the heating of the chromosphere and the acceleration of the wind. Transients can also trigger the generation of waves. In the context of Coronal bright point formation and evolution these transients can also play a role. I will present these new class of events as observed with IRIS and discuss about the implications of these new results.

Keyword: Jets, Bright points

Origin Of Both The Fast Hot Jet And The Slow Cool Jet From Magnetic Flux Emergence And Advection In The Solar Transition Region

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In the solar atmosphere, jets are ubiquitous and found at various spatial-temporal scales. They are signicant to understand energy and mass transport in the solar atmosphere. Recently, the high-speed transition region jets are reported from the observation. Here, with two dimensional magnetohydrodynamics model, which includes thermal conduction and optically thin cooling, we conduct a numerical simulation to investigate the mechanism in their formation. Dierent from the previous works by Yang et al., both magnetic flux emergence and advection are implemented here to drive the magnetic reconnection between the magnetic loop and the background open flux occurring in the transition region. The simulation results show that not only a fast hot jet, much resemble the found transition region jets, but also a adjacent slow cool jet, mostly like classical spicules, is launched. The force analysis shows that the fast hot jet is continually driven by the Lorentz force around the reconnection region, while the slow cool jet is induced by an initial kick through the Lorentz force associated with the emerging magnetic flux. Also, the features of the driven jets change with the amount of the emerging magnetic flux, giving the varieties of both jets. These results will inspire our understanding of the formation of the prevalence of both the fast hot jet and slow cool jet from the solar transition region and chromosphere.

Keyword: solar jet, numerical simulation

Statistical study of network jets observed in the solar transition region: A comparison between coronal holes and quiet sun regions

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Recent IRIS observations have revealed a prevalence of intermittent small-scale jets with apparent speeds of 80-250 km/s , emanating from small-scale bright regions inside network boundaries of coronal holes. We find that these network jets appear not only in Coronal Holes but also in Quiet Sun regions. Using IRIS 1330 Angstrom (C II) slit-jaw images, we extract several parameters of these network jets, e.g. apparent speed, length, lifetime and increase in foot-point brightness. Using several observations, we find that some properties of the jets are very similar but others are obviously different between the quiet sun and coronal holes. For example, our study shows that the coronal hole jets appear to be faster and longer than those in the quiet sun. This can be directly attributed to a difference in the magnetic configuration of the two regions with open magnetic field lines rooted in coronal holes and magnetic loops often present in quiet sun. We have also detected compact bright loops, likely transition region loops, mostly in quiet sun. These small loop-like regions are generally devoid of network jets. In spite of different magnetic structures in the coronal hole and quiet sun in transition region, there appears to be no substantial difference for the increase in foot-point brightness of the jets, which suggests that the generation mechanism of these network jets is likely the same in both regions.

Keyword: Chromosphere, Transition region, Coronal Holes, Solar Jets

Cusp-shape structure of a Jet

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On 29 August 2014, the trigger and evolution of a blowout jet was captured in details for the first time by IRIS slit-jaw imager. A prominence rose from low atmosphere and came into collision with an overlying loop-like system. This collision resulted in a breakout of the system and then a cusp-shape structure formed. Subsequently the cusp-shape structure developed into a standard jet which consisted of a spire and an arch-base. In the spire, brightening blobs originating from the joint between the spire and the arch-base moved upward in a spinning manner at first, then the blobs moved directly upward. In the arch-base, dark material tracked a fan structure and the majority of the material moved downward along the fan's threads. At the later phase of the jet, bi-directional flows emptied the arch-base, meanwhile downflows emptied the spire, thus made the jet vanish. The detailed observations shed new light on understanding the evolution from a cuspshape structure to a jet, and provided a helpful complementarity for present jet models.

Keyword: chromosphere, corona

DYNAMICS OF THE QUIET SUN BRIGHT POINT AS SEEN BY IRIS AND SDO

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We study the quiet Sun bright point as seen by the SDO/AIA, SDO/HMI, IRIS/SJI and from IRIS spectral line data. We focus on the morphological changes associated with bright point seen in different atmospheric layers, and there photospheric magnetic field changes. We explore the unique data set, consisting seven hour long time series spectral data covering three arc-seconds of bright point, near one of the foot point. Long period oscillations in the intensity of the bright point are probed. We explore on the source/sources of the observed quasi-periodic oscillations in the context of repeated reconnection scenario.

Keyword: coronal bright points, quasi-periodic oscillations

Hinode-IRIS observation and MHD modeling of sunspot light bridges

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Light bridges, the bright structures dividing umbrae in sunspot regions, are known to produce wide variety of activity events. In order to reveal the nature of light bridges, we first analyze observational data of a light bridge in NOAA AR 11974 obtained by Hinode and IRIS. From the Hinode/SOT data, we find that the bridge has a relatively weak horizontal field, which is transported to the solar surface by a large-scale convective upflow. This horizontal field is sandwiched between strong vertical fields of surrounding pores, showing a strong current layer. Above the bridge, we observe repeated chromospheric brightenings and dark surge ejections into the coronal heights. The IRIS spectrum suggests that they are caused by magnetic reconnection in the chromosphere. The detailed magnetic and velocity structures are then investigated by analyzing an MHD simulation data of a light bridge that appear in an emerging flux region. It is found that, during the formation of an active region, strong vertical fields trap a plasma upflow, which transports a weak horizontal field to the surface layer and creates a light bridge. The striking correspondence between observational and numerical results provides a consistent physical picture that the various activity events observed above the light bridges are caused by repeated magnetic reconnection that is driven by continuous magneto-convective evolution within the bridges.

Keyword: Hinode, IRIS, MHD simulation, sunspot light bridges

Observational study of the propagating modes of umbral waves

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We study the umbral waves as observed by the chromospheric imaging observations of two sunspots with the New Solar Telescope at the Big Bear Solar Observatory. We find that the wavefronts rotate clockwise and forms one-armed spiral structure in the first sunspot, whereas two- and three-armed structures arise in the second sunspot where the wavefronts rotate anti-clockwise and clockwise alternately. All the spiral arms display propagation outwards and become running penumbral waves once they cross the umbral boundaries, suggesting that the umbral and penumbral waves propagate along the same inclined field lines. We propose that the one-armed spiral structure may be produced by the wavefront reflections at the chromospheric umbral light bridge, and the multi-armed spirals may be related to the twist of the magnetic field in the umbra. It indicates that these disturbances are slow magnetoacoustic waves in nature, and that they propagate upward along the inclined lines with fast radial expansions causing horizontal velocities of the running waves.

Keyword: sunspots-oscillation, Sun: chromosphere

Forced field extrapolation of chromosphere fine structure and coronal loops

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We present a careful assess of the forced field extrapolation using Solar Dynamics Observatory/Helioseismic and Magnetic Imager (SDO/HMI) magnetograms as input. The results show the lorentz force can not be ignored under 1500 km height above the photosphere. Above 1500km, the magnetic field can be considered force free. Comparison of the results with the images of New Vacuum Solar Telescope (NVST) and Atmospheric Imaging Assembly (AIA) shows field lines are appeared to be aligned with most Halpha fibrils and coronal loops. We note the pattern of Halpha fibrils are much more consistent with our results than that are computed by NLFFF extrapolation, which shows the excellent ability of our method in reconstructing the low lying magnetic field.

Keyword: magnetic field, magnetohydrodynamics

Particles Acceleration in Converged Two Shocks

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Observations show that there is a proton spectral ``break" with E$_{break}$ at 1-10MeV in some large CME-driven shocks. However, the understanding of this energy spectral ``break" from the diffusive shock acceleration theory still remains uncertain. Although previous numerical methods can hardly predict this ``break" from current theoretical models due to high computational expense, the present paper focuses on simulating this energy spectrum in converged two shocks by Monte Carlo numerical method. Considering the Dec 13 2006 CME-driven shock interaction with an Earth bow shock, we examine whether the energy spectral ``break" could occur on an interaction between two shocks. As result, we indeed obtain the maximum proton energy up to 10MeV, and we further find a proton spectral ``break" appears distinctly at the energy $\sim$5MeV.

Keyword: acceleration of particles, coronal mass ejections, diffusive shock

Oscillatory Response of the Solar Chromosphere to a Strong Downflow Event in a Sunspot

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We report that a strong downflow event caused three-minute oscillations in the solar atmosphere. We used the Fast Imaging Solar Spectrograph of the 1.6 m New Solar Telescope and the Interface Region Imaging Spectrograph. The strong downflow is identified in the chromospheric lines and transition region lines above a sunspot umbra. After the downflow event, oscillations occur at the same position. The amplitudes of the oscillations are 2 km/s at all of the lines and decrease with time. Initially the period of the oscillations is 2.7 minutes and gradually increase to 3.3 minutes. In the IRIS slit-jaw 1330 images, we identify a transient brightening near the footpoint of the downflow detected in the Hα+0.5Å image. The characteristics of the downflowing material are consistent with a sunspot plume, but the temperature of the material we observed is lower than that of the typical sunspot plumes. Based on our findings, we suggest that the gravitationally stratified atmosphere came to oscillate with three minute period in response to the impulsive downflow event as was theoretically suggested by Chae & Goode (2015).

Keyword: chromosphere, oscillations

Supersonic downflows in the transition region above sunspots

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The transition region (TR) above sunspots was not well understood in the past due to the lack of high-resolution observations. IRIS observations have revealed new insight into the structure and dynamics of the TR above sunspots. For instance, IRIS data clearly shows the presence of acoustic shock waves in sunspots and small-scale energy release events primarily in the penumbra. In addition, IRIS has detected clear signals of supersonic downflows in the TR above sunspots. We have performed a very comprehensive statistical study of these TR downflows and found that they are a very common phenomena in sunspots. Through visual inspection of all the sunspot rasters made during the first 1.5 years after the first light of IRIS, we found that these supersonic downflows are present in ~80% of sunspots. These downflows are observed mostly in the transition region lines, although some of them also appear in the C II and Mg II lines. We have designed a six-component Gaussian fitting algorithm to quantify the intensity and velocity of these downflows in the Si IV 1402 and O IV 1399/1401 lines.

Keyword: sunspots, downflows

Diagnosing flare dynamics through the Fe XXI 1354.08 line

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The Fe XXI 1354.08 line is the only strong emission line formed above 10 MK in the spectral range of IRIS. It has been demonstrated to be very useful in diagnosing flare dynamics. For instance, the complete evolution of chromospheric evaporation has been well observed and it appears to correlated with the energy deposition rate in many flares, which provides critical constraint to models of chromospheric evaporation. The Fe XXI line has also been successful in observing reconnection outflows, revealing important insight into the flare reconnection process. Moreover, global MHD oscillations have been detected in flare loops, both in the intensity and Doppler shift of the Fe XXI line, allowing accurate mode identification that is crucial for coronal seismology.

Keyword: flares, oscillations

Magnetic reconnection electric field in intense solar flares

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It is generally believed that the magnetic reconnection in the corona is responsible for the energy release in solar flares. Therefore, the electric field in the reconnection current sheet would play a significant role in the particle acceleration, especially during the impulsive phase of intense flares. More particles are accelerated to higher energies by larger reconnection electric field and then precipitate into low chromosphere to produce stronger non-thermal emissions. Such electric field can be deduced from the change rate of photospheric magnetic flux in the newly brightened areas of flaring ribbons. Besides the magnitude of reconnection electric field, we particularly pay attention to the temporal correlation of electric field with the emissions in multiple wavelengths. By combining the HMI magnetograms and RHESSI hard X-ray observations with the AIA and IRIS multi-wavelength measurements, several intense flares will be investigated to characterize the temporal and spatial associations between reconnection electric field and flare emissions.

Analysis for X-ray coronal sources during the limb flares

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Keyword: X-ray,solar flares

Ultra-narrow Negative Flare Front Observed in Helium-10830 using the 1.6 m New Solar Telescope

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Solar flares are sudden ashes of brightness on the Sun and are often associated with coronal mass ejections and solar energetic particles which have adverse effects in the near Earth environment. By definition, flares are usually referred to bright features resulting from excess emission. Using the newly commissioned 1.6 m New Solar Telescope at Big Bear Solar Observatory, here we show a striking “negative” are with a narrow, but unambiguous “dark” moving front observed in He I 10830 Å, which is as narrow as 340 km and is associated with distinct spectral characteristics in Hα and Mg II lines. Theoretically, such negative contrast in He I 10830 Å can be produced under special circumstances, by nonthermal-electron collisions, or photoionization followed by recombination. Our discovery, made possible due to unprecedented spatial resolution, conrms the presence of the required plasma conditions and provides unique information in understanding the energy release and radiative transfer in astronomical objects.

Keyword: Sun: flares, Sun: infrared radiation

A Numerical Investigation Of The Recurrent High-speed Jets As A Possibility Of Solar Wind Origin

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In the solar atmosphere, jets are prevalent and they are significant for the mass and energy transport. Here we conduct numerical simulations to investigate the mass and energy contributions of the recently observed high-speed jets to the solar wind. With a one-dimensional hydrodynamic solar wind model, the time-dependent pulses are imposed at the bottom to simulate the jets. The simulation results show that without other energy source, the injected plasmas are accelerated effectively to be a transonic wind with a substantial mass flux. The rapid acceleration occurs close to the Sun, and the resulting asymptotic speed, number density at 0.3 AU, as well as mass flux normalized to 1 AU are compatible with in situ observations. As a result of the high speed, the imposed pulses generate a train of shocks traveling upward. By tracing the motions of the injected plasma, it is found that these shocks heat and accelerate the injected plasma to push part of substances therein upward and eventually allow them to escape. The parametric studies show that increasing the speed of the imposed pulses or their temperature gives a considerably faster, denser, and hotter solar wind, while increasing their number density or decreasing their recurring period only bring a denser solar wind. These studies provide a possibility that the ubiquitous high-speed jets are a substantial mass and energy contributions to the solar wind.

Keyword: solar jet, numerical simulation

Flux Emergence In Triggering Recurrent Solar Jets

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Solar jets are believed to contribute to mass and energy exchange between the corona and the lower cool atmosphere. As they are thought to be triggered by magnetic reconnection, how the free magnetic energy is built up and released then is vital to understanding the energy and mass transport between the chromosphere and the corona. n simulations, free magnetic energy can be introduced by at least two ways: flux emergence/cancellation, or footpoint region rotational/shearing motion. The questions are whether it is true of the above two situations and which dominates in the real solar atmosphere. We employ the combination of photospheric magnetic field observation by SDO/HMI, UV/EUV observations of the chromosphere and the corona by SDO/AIA, spectral observations from the chromosphere to the transition region of IRIS, to analyze the photospheric flux evolution of recurrent solar jets and their corresponding thermal properties.

Keyword: Solar Jets, Flux Emergence

Fine-scale Photospheric Motion and Plasma Ejection in a Light Bridge

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We report on a fine-scale photospheric motion and the associated chromospheric plasma ejection in a light bridge. Our analysis were carried out with the high-spatial and hightemporal spectral data taken with the Fast Imaging Solar Spectrograph (FISS) and TiO broadband filter working in 7057Å wavelength installed at 1.6 meter New Solar Telescope of Big Bear Solar Observatory. The size of the photospheric motion is about 750 km that is smaller than the size of typical granular cells. This photospheric motion pattern is closely related to the occurrence of the chromospheric plasma motion. We plan to discuss the interaction and the nature of the photospheric motion and the plasma ejection in the chromosphere.

Keyword: Light Bridge

MULTIPLE ERUPTIONS FROM A CONFINED MAGNETIC STRUCTURE

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We have studied the multiple eruptions from NOAA 11444 consisting of a single magnetic polarity in the center surrounded by the other polarity using AIA and HMI on board SDO. The most obvious feature in the pre-eruption stage is thermal heating rather than magnetic field change. During the first eruption a long filament encircling almost one third of the active region was lifted up leaving a two ribbon flare underneath. The second eruption was caused by the propagating flare ribbons, and the third eruption occurred in a similar pattern as the first one. Through the nonlinear force-free field (NLFFF) modeling, we found that the eruption initiated in a region of complex connectivity and at the coronal height where the enhanced magnetic twist changes sign. The region of the most intense flare emission coincides with that of the largest magnetic free energy. It is after the multiple eruptions that the coronal images exhibit a fan-dome structure more clearly. We measured the expansion of UV ribbons as a proxy for the open-closed boundary of the coronal fields and determined the associated coronal magnetic restructuring.

Keyword: eruption, flare

Cool transition region brightenings in active region observed by IRIS

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By analyzing observations taken by the Interface Region Imaging Spectrograph (IRIS), we report on a group of small-scaled compact brightenings in the solar transition region above Sunspots, which present extremely narrow spectral profiles (less than half of the width of the background spectrum) and strong emission. They locate in the tail of the intensity-line width distribution. For comparison, the average non-thermal velocity of the active region is about 20 km/s, while the non-thermal velocities of these brightenings are less than 10 km/s. Six such brightenings are identified and two of them are short-lived with lifetime less than 5 minutes, one about 8 minutes, two about 16 minutes and one remains for more than 36 minutes. We also analyze their evolution in the IRIS slit-jaw images and their response in the chromospheric spectra. These events are possible resulted from ejection of cool plasma and/or unidirectional particle motion caused by the strong magnetic field in the Sunspots.

Keyword: Sun: transition region, Sun: small-scale brightenings, Line: profiles, Methods: imaging and spectroscopy

Self-absorption in the solar transition region

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Transient brightenings in the transition region of the Sun have been studied for decades and are usually related to magnetic reconnection. Recently, absorption features due to chromospheric lines have been identified in transition region emission lines raising the question of the thermal stratification during such reconnection events. We analyse data from the Interface Region Imaging Spectrograph (IRIS) in an emerging active region. Here the spectral profiles show clear selfabsorption features in the transition region lines of Si iv. While some indications existed that opacity effects might play some role in strong transition region lines, self-absorption has not been observed before. We show why previous instruments could not observe such self-absorption features, and discuss some implications of this observation for the corresponding structure of reconnection events in the atmosphere. Based on this we speculate that a range of phenomena, such as explosive events, blinkers or Ellerman bombs, are just different aspects of the same reconnection event occurring at different heights in the atmosphere.

Keyword: transition region, chromosphere, UV radiation, spectroscopic