The 6th NAOJ Symposium
Hinode-16/IRIS-13

Abstract book

Toki Messe Niigata Convention Center

September 25 (Mon) – 29 (Fri), 2023

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Time table

The 6th NAOJ Symposium Hinode-16/IRIS-13
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Day 0 September 24 (Sun)

17:00-19:00	Registration
17:00-19:00	Welcome reception at Befco Bakauke Observatory Room (31F)

Day 1 September 25 (Mon)

08:30-			Registration
09:00-09:30	30		Opening
Atmospheric heating and solar wind acceleration (1)			
09:30-09:55	25	I-1	Stephanie Yardley (U. Reading) Solar Wind Connection Science with Solar Orbiter, Hinode and IRIS
09:55-10:20	25	I-2	Cosima Breu (MPS) A solar coronal loop in a box: Energy generation and heating
10:20-10:35	15	O-1	Haruhisa Iijima (Nagoya U.) Radiative MHD simulation of solar wind formation
10:35-11:30	55		Poster/Coffee
11:30-11:45	15	O-2	Kyuhyoun Cho (BAERI/LMSAL) Statistical characteristics of small-scale transient brightening as a nanoflare signature observed by the IRIS.
11:45-12:00	15	O-3	Daniel Nóbrega-Siverio (IAC) Unraveling the heating of Coronal Bright Points: a fundamental block in the solar atmosphere
12:00-12:15	15	O-4	Johannes Tschernitz (U. Graz) Simulation of coronal heating of a loop above a sunspot group
12:15-14:00	105		Lunch
Flares, CMEs, and their consequences (1)			
14:00-14:25	25	I-3	Chengcai Shen (CfA) 3D MHD Model of Underdense Plasma Downflows Associated with Magnetic Reconnection in Solar Flares
14:25-14:50	25	I-4	Sargam Mulay (U. Glasgow) Behaviour of cool UV emission from molecular hydrogen in three solar flares
14:50-15:05	15	O-5	Juraj Lorincik (BAERI/LMSAL) Importance of Cadence: Probing dynamics of fast flare ribbon kernels using the Interface Region Imaging Spectrograph
15:05-15:20	15	O-6	Elizabeth Butler (QUB) Decay Timescales of Chromospheric Condensations in Solar Flares
15:20-16:45	85		Poster/Coffee (including 5-min tutorial on EISPAC)
16:45-17:00	15	O-7	Graham Kerr (CU/NASA GSFC) An Optically Thin View of the Flaring Chromosphere: Nonthermal widths in a chromospheric condensation during an X-class solar flare
17:00-17:15	15	O-8	Ryan French (NSO) IRIS and STIX Observations of Oscillations in a Solar Flare Fan
17:15-17:30	15	O-9	Seray Sahin (Northumbria U.) Flare-driven rain mediated reconnection as a secondary heating source in flare loops
17:30-17:45	15	O-10	Takato Otsu (Kyoto U.) Multiwavelength Sun-as-a-star Analysis of the M8.7 Flare on 2022 October 2 with H-alpha and EUV Using SMART/SDDI and SDO/EVE

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Day 2 September 26 (Tue)

The Sun to the heliosphere (1)			
09:30-09:55	25	I-5	Aki Takeda (MSU) Topics from Hinode/XRT irradiance study: correlation with photospheric magnetic field, possible latitudinal variation, etc.
09:55-10:20	25	I-6	Gordon Petrie (NSO) Solar Polar Magnetic Fields: Comparing Full-Disk and High-Resolution Spectromagnetograph Data
10:20-10:35	15	O-11	Minami Yoshida (U. Tokyo/ISAS/JAXA) Importance of low-latitude photospheric magnetic fields in solving the open flux problem
10:35-11:30	55		Poster/Coffee
Small-scale features in lower atmospheres (1)			
11:30-11:45	15	O-12	Ryohko Ishikawa (NAOJ) 3D mapping of the magnetic field in the whole atmosphere of an active region plage using spectropolarimetric observations with CLASP2.1 and Hinode
11:45-12:00	15	O-13	Suresh Babu Balaji (VIT Bhopal U.) Statistical Spectroscopic Diagnosis of the Footpoints of Cool Loops
12:00-12:15	15	O-14	Ryohtaroh Ishikawa (Nagoya U.) Origin of line broadening in fading granules: influence of small-scale turbulence
12:15-14:00	105		Lunch
Atmospheric heating and solar wind acceleration (2)			
14:00-14:25	25	I-7	Michael Hahn (Columbia U.) Spectroscopic Investigations into the Origin and Acceleration of the Solar Wind
14:25-14:50	25	I-8	Takeru Suzuki (U. Tokyo) Recent progress in solar wind modeling
14:50-15:05	15	O-15	Elena Petrova (KU Leuven) Torsional Alfvén waves in Solar Orbiter EUI observations
15:05-15:20	15	O-16	Shun Ishigami (SOKENDAI/NAOJ) Study of heating distribution and heating mechanism of coronal loops using Hinode/EIS
15:20-16:45	85		Poster/Coffee (including 5-min tutorial on XRTpy)
Small-scale features in lower atmospheres (2)			
16:45-17:00	15	O-17	Adam Kobelski (NASA/MSFC) Even Small Events Involve the Entire Solar Atmosphere.
17:00-17:15	15	O-18	Aditi Bhatnagar (RoCS/UiO) Transition Region response to Quiet Sun Ellerman Bombs
17:15-17:30	15	O-19	Tetsu Anan (NSO) Magnetic field structures at the X point of an Ellerman bomb
17:30-17:45	15	O-20	Reetika Joshi (RoCS/UiO) Exploring solar jet dynamics using coordinated high-resolution observations

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Day 3 September 27 (Wed)

Flares, CMEs, and their consequences (2)			
09:30-09:55	25	I-9	Hui Fu (Shangdong U.) The high helium abundance and charge states of the interplanetary CME and its material source on the Sun
09:55-10:20	25	I-10	Li Feng (PMO) Introduction to the ASO-S mission and early observational results
10:20-10:35	15	O-21	Jessie Duncan (NASA/GSFC) NuSTAR, XRT, and AIA Differential Emission Measure Analysis of an Alternately Quiet and Flaring Active Region
10:35-11:00	25		Poster/Coffee
The Sun to the heliosphere (2)			
11:00-11:15	15	O-22	David Fouhey (NYU/U. Michigan) SuperSynthIA: Bringing Hinode/SOT-SP Vector Magnetograms to the Full Disk at High Cadence
11:15-11:30	15	O-23	Yajie Chen (MPS) Solar coronal magnetic field measurements using spectral lines available in Hinode/EIS observations: strong and weak field techniques and temperature diagnostics
11:30-11:45	15	O-24	David Williams (ESA/ESAC) Coordinating Observations with Solar Orbiter
13:00-18:00			Excursion
18:30-20:30			Banquet at Hotel Nikko Niigata / TOKI (4F)

Day 4 September 28 (Thu)

Atmospheric heating and solar wind acceleration (3)			
09:30-09:55	25	MTA	Serena Lezzi (INAF/OACN) Dark Halos around Active Regions: emission properties of the Dark Halo around NOAA 12706
09:55-10:10	15	O-25	Hidetaka Kuniyoshi (U. Tokyo) Can the solar p-modes contribute to the high-frequency transverse oscillations of spicules?
10:10-10:25	15	O-26	Takayoshi Oba (NAOJ) EUV synthesis toward the measurement of transition-region temperature distribution with SOLAR-C
10:25-11:30	65		Poster/Coffee
Flares, CMEs, and their consequences (3)			
11:30-11:45	15	O-27	Andy Shu Ho To (MSSL/UCL) Spatially Resolved Plasma Composition Evolution in an X-class Flare
11:45-12:00	15	O-28	Teodora Mihailescu (UCL/MSSL) Evolution of Plasma Composition During an M-class Flare
12:00-13:30	90		Lunch
SOLAR-C, MUSE, and beyond (1)			
13:30-13:55	25	I-11	Toshifumi Shimizu (ISAS/JAXA) The SOLAR-C mission: Toward a new era of high-resolution solar physics research
13:55-14:20	25	I-12	Bart De Pontieu (LMSAL) The Multi-slit Solar Explorer (MUSE)
14:20-14:45	25	I-13	Shinsuke Imada (U. Tokyo) Scientific Objectives of SOLAR-C and Strategies to Achieve
14:45-15:10	25	I-14	Ignacio Ugarte-Urra (NRL) Addressing SOLAR-C/EUVST science: observations + models
15:10-16:20	70		Poster/Coffee
16:20-16:45	25	I-15	Dipankar Banerjee (ARIES) Aditya L1 mission updates and possible Synergies with Solar C
16:45-17:10	25	I-16	Sarah Jaeggli (NSO) DKIST, the High-Resolution Solar Polarimeter, Early Results and Science Connections to EUVST and MUSE
17:10-17:25	15	O-29	Marie Dominique (ROB/STCE) How can IRIS and Solar-C improve our understanding of the campfires observed by Solar Orbiter/EUI?
17:25-17:40	15	O-30	Paul Bryans (HAO) CMEx: The Chromospheric Magnetism Explorer

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Day 5 September 29 (Fri)

SOLAR-C, MUSE, and beyond (2)			
09:30-09:55	25	I-17	Mark Cheung (CSIRO) Numerical Modeling for the MUSE Mission
09:55-10:20	25	I-18	Kyoko Watanabe (NDA) SoSpIM overview
10:20-10:45	25	I-19	Akimasa Ieda (Nagoya U.) Solar radiation wavelength that directly generates the Earth's ionospheric E-layer
10:45-11:30	45		Coffee
11:30-11:55	25	I-20	Yoshizumi Miyoshi (Nagoya U.) Center for Heliospheric Science : a core center to promote heliospheric system science
11:55-12:20	25	I-21	Go Murakami (ISAS/JAXA) Contribution of the BepiColombo mission to heliospheric system science: overview of interplanetary cruise observations
12:20-12:30	10		Closing
13:30-17:00			Hinode SWG (invitation only)

Poster list

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P-1	Sanja	Danilovic	What drives peacock jets?
P-2	Arpit	Shrivastav	Properties of decayless oscillations in small-scale loops observed in quiet Sun and coronal holes
P-3	Kartika	Sangal	Investigating Wave Propagation above the Inter-Network Quiet Sun: A new insight from IRIS Observations
P-4	Nicolas	Poirier	Investigating the role of diffusion effects in the fractionation of minor elements in solar loops, using a multi-specie high-order 1-D model
P-5	Will	Barnes	Spectroscopic and time-dependent observational constraints on models of energy release in long-lived active region loops
P-6	Yuhang	Gao	Transverse Oscillations of Small Magnetic Loops in the Solar Transition Region and Corona
P-7	Adur	Pastor Yabar	Quiet-Sun magnetism and its relation to radiative losses
P-8	Zhenguang	Huang	The Average Energy Deposition Rate in the Open Field Regions
P-9	Vishal	Upendran	Flux emergence thermodynamics in Coronal Holes and Quiet Sun
P-10	Vishal	Upendran	Statistical impulsive heating signatures in the solar corona
P-11	Irina	Kitiashvili	3D Radiative MHD Modeling of the Solar Transition Zone and Corona
P-12	Irina	Kitiashvili	Acoustic Wave Excitation and Small-Scale Eruptive Activity in Quiet-Sun Regions
P-13	Irina	Kitiashvili	3D Radiative Hydrodynamic Modeling of Multi-Scale Flows Driven by Subsurface Turbulent Convection
P-14	Chi	Ma	Relationships between active regions and their associated solar wind
P-15	Antoine	Dolliou	Small EUV brightenings detected by HRI-EUV on board Solar Orbiter: estimation of their temperature with Solar Orbiter/SPICE and Hinode/EIS
P-16	Yingjie	Zhu	Spectroscopic Observations of the Solar Corona in the Visible, Extreme Ultraviolet, and Near-Infrared during the 2017 Total Solar Eclipse
P-17	Paola	Testa	High Resolution Observations of the Low Atmospheric Response to Small Coronal Heating Events in Active Regions
P-18	Patrick	Antolin	Fine structure and multi-wavelength variability associated with coronal rain - Results from Solar Orbiter/EUI & SPICE and 2.5-D rMHD simulationS
P-19	KIYOTO	SHIBASAKI	Temperature-dependent plasma up- and down-flows along magnetic field lines driven by the Kelvin force
P-20	Kosuke	Namekata	Scaling Relations for Sun-as-a-star XUV/FUV Spectrum and Magnetic Flux: Applications to Exoplanet-Hosting Sun-like Stars
P-21	David	Brooks	Spectroscopic Observations of Coronal Rain Formation and Evolution following an X2 Solar Flare
P-22	Wei	Liu	Thermal Instability Near Magnetic Null Points Leading to the Formation of Coronal Rain and Prominences
P-23	Wei	Liu	Coronal EUV Waves and Their Implications for Global Coronal Seismology
P-24	Micah	Weberg	Modeling In-Situ Measurements From Parker Solar Probe Encounter 12
P-25	Vartika	Pandey	New model atmospheric stratifications for MHD simulations.
P-26	Aparna	Venkataramanasastry	Investigating Heating in Active Region Coronal Loops in non-Eruptive Solar Active Regions
P-27	Teodora	Mihailescu	Two Diagnostic Study of Plasma Composition Evolution in a Solar Active Region
P-28	Petra	Kohutova	Damping of Coronal Oscillations in Self-Consistent 3D Radiative MHD Simulations of the Solar Atmosphere
P-29	Nicolas	Poirier	About the source of sustained kink oscillations in coronal loops: what do we know and what do we need from future observation campaigns?
P-30	Jaime	de la Cruz Rodriguez	The effect of non-Equilibrium Hydrogen ionization in the formation of ALMA mm-intensities
P-31	Maria	Madjarska-Theissen	Automatic computation of linear magneto-hydro-static equilibria and application to chromospheric, transition region, and coronal loops
P-32	Joao M.	da Silva Santos	Unraveling the role of acoustic waves in chromospheric heating through inversion analysis
P-33	Joao M.	da Silva Santos	Magnetic fields in plage regions: insights from DKIST/ViSP spectropolarimetry
P-34	Mats	Carlsson	An optically thin view of the solar chromosphere. IRIS observations of the O I 1355 spectral line
P-35	Will	Barnes	In Search of the "Smoking Gun" with MOXSI: Constraining Very Hot Active Region Plasma with Slitless Spectroscopy
P-36	Akiko	Tei	Are There Any Differences in the Chromosphere of Coronal Holes and Quiet-Sun?
P-37	Quentin	Noraz	Role of Poynting flux injection by magneto-convection on the chromospheric energy balance
P-38	Ziwen	Huang	EUV observation of small-scale dynamics in solar plumes
P-39	Yoshihiro	Naito	Spectroscopic study of Alfvén waves in the upper chromosphere as a source of solar wind acceleration in coronal holes
P-40	Keiji	Yoshimura	Revisiting the relationship between solar X-ray irradiance and magnetic flux using Hinode/XRT, SDO/HMI, and SOHO/MDI

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P-42	Sherry	Chhabra	Examining FIP Bias Turnovers in Flares Using XSM and EIS
P-43	Ryan	Milligan	Lyman-alpha Variability During Solar Flares
P-44	John	Unverferth	Improving Flare Models by Initializing Simulations with Retraction Signatures.
P-45	Viggo	Hansteen	3D rMHD Simulation of a small C-class flare; from convection zone to corona
P-46	Miki	Kurihara	X-ray Investigation of non-thermal plasma in "X10,000,000-class" flare of the RS CVn binary star
P-47	Crisel	Suarez	Plasma Diagnostics of Solar Flares from the Miniature X-ray Solar Spectrometer (MinXSS)-1 CubeSat and the Hinode/X-ray Telescope (XRT)
P-48	James	McKevitt	Non-Thermal Velocity and Magnetic Energy in X-Class Solar Flares: A High Temporal Resolution Study
P-49	Qiao	Li	Spectral and imaging observations of a C2.3 white-light flare observed by ASO-S and CHASE
P-50			(withdrawn)
P-51	Zihao	Yang	Sun-as-a-star spectroscopy of CME: observations and modeling
P-52	Zhichen	Jing	A statistical study of solar white-light flares observed by ASO-S/LST/WST
P-53	Soumya	Roy	Energetics of the November 29th, 2020 limb event
P-54	Guanglu	Shi	Thermal Evolution of a post-CME Current Sheet observed by the Metis on-board SolO
P-55	Shin	Toriumi	Turbulent convection injects significant amount of magnetic helicity for solar flares
P-56	Kathy	Reeves	Plasma properties of the loop top region of a solar flare
P-57	Junya	Natsume	Spectroscopic features on active phenomena in multiple chromospheric lines observed with Domeless Solar Telescope at Hida Observatory
P-58	Nariaki	Nitta	Hot magnetic flux ropes preceding solar flares from active regions far from the limb
P-59	Noriyuki	Narukage	Sounding rocket experiment FOXSI-4 for the focusing X-ray imaging spectroscopic observation of a solar flares
P-60	Zhengyuan	Tian	Observation and energy analysis of non-thermal precursor of an M5.4 flare
P-61	Zhengyuan	Tian	Lyα Emission Enhancement Associated with Soft X-Ray Microflares
P-62	Graham	Kerr	Prospects of Detecting Non-thermal Protons in Solar Flares via Lyman Line Spectroscopy: Revisiting the Orrall-Zirker Effect
P-63	Michael	Haahr	Towards Realistic Solar Flare Models
P-64	Juraj	Lorincik	Delays between transition region and chromospheric flare emission observed by the Interface Region Imaging Spectrograph
P-65	Harry	Warren	EIS Observations of the Transition Region During Solar Flares
P-66	Jonas	Faber	High-resolution observations of recurrent solar flares using SST and IRIS
P-67	Eilif	Øyre	Characteristics of accelerated particles in the solar corona
P-68	Denis	Cabezas	Breaking all the rules: NOAA AR 12665
P-69	Yeongmin	Kang	Data-driven modeling of an inclined solar eruption in NOAA active region 11283
P-70	Daiki	Yamasaki	Magnetic field solar dark filaments obtained from He I 1083 nm spectropolarimetric observation
P-71	Akira	Sasaki	Time-Series Prediction of SDO Ultraviolet Full-disk Images using a Video Prediction Method with Deep Learning
P-72	Karla	Lopez Araujo	Understanding the origin of the 30 THz emission in active regions and during solar flares
P-73	Keiji	Hayashi	MHD simulations of the CME near the Sun
P-74	Mariarita	Murabito	High resolution imaging and spectroscopy of an Active region Filament
P-75	Elena	Dzifcakova	Modeling of the Si IV emission as a response of the flare energy transport to the transition region
P-76	Ian	Berry	Searching for Photospheric Responses of Solar Eruptions with Near-UV Absorption Lines
P-77	KD	LEka	History Matters: NOAA AR 12665 and Testing for the Presence of a Magnetic Flux Rope
P-78	Yoshiaki	Sato	Evaluation of electron acceleration efficiency during solar flares using MHD+GCA test particle simulation
P-79	Takafumi	Kaneko	Impact of subsurface convective flows on the formation of sunspot magnetic field and energy build-up
P-80	Yuki	Kida	The mechanism of the formation and eruption of flux rope associated with the M2.8 flare that occurred in the active region 12871 on September 21, 2021

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P-83	Kouhei	Teraoka	Comparison of 3D coronal magnetic field structure between eruptive and confined flares observed in AR 12673 on September 6, 2017
P-84	Chin	Wu	Generation of EIT waves by coronal mass ejections: Global magnetohydrodynamic simulation
P-85	Alexander	Kosovichev	Spectro-Polarimetric Analysis and Modeling of Sunquake Sources
P-86	Georgios	Chintzoglou	Predicted appearance of Magnetic Flux Rope and Sheared Magnetic Arcade Structures before a Coronal Mass Ejection via three-dimensional radiative Magnetohydrodynamic Modeling
P-87	Lucas	Tarr	A multi-observatory view of chromospheric oscillations
P-88	Lucas	Tarr	Data-Driven Boundary Conditions for 3D Magnetohydrodynamic Photosphere to Corona Simulations of the Sun
P-89	Sanjiv	Tiwari	Investigation of Moving Magnetic Features using Coordinated Hinode/SOT-SP and IRIS Scans
P-90	Luc	Rouppe van der Voort	Ultra-high resolution observations of plasmoid-mediated magnetic reconnection in the deep solar atmosphere
P-91	Samuel	Evans	Does Big Heating Come in Small Sizes? Chromospheric Turbulence and Heating Due to the Thermal Farley-Buneman Instability
P-92	Navdeep K.	Panesar	IRIS Spectral Observations of a Jet-generating Minifilament Eruption
P-93	Quentin	Wargnier	MultiFluid simulations of magnetic reconnection in the lower solar atmosphere with a helium-hydrogen-carbon mixture
P-94	Andrea	Diercke	Evolution of an Ephemeral Active Region
P-95	Pablo	Santamarina Guerrero	Magnetic structure analysis by applying persistent homology to Hinode and SDO magnetograms
P-96	Henrik	Eklund	Investigation of small-scale brightening events in the solar atmosphere
P-97	Henrik	Eklund	Spatio-temporal deconvolution method for enhanced analysis of solar images
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P-99	Souvik	Bose	On the million-degree signature of spicules
P-100	Bryan	Yamashiro	How well can we estimate the open magnetic flux with Hinode/SP observation?
P-101	Aaron	Peat	MgII h&k Fine Structure Prominence Modelling and the Consequences for Observations
P-102	Sudheer	Mishra	Initiation of Quasi-Periodic Pulsation at the Base of Kink Unstable Jet via Periodic Magnetic Reconnection.
P-103	Kilian	Krikova	Formation of Hε in the Solar Atmosphere
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P-105	Damien	Przybylski	Non-LTE Simulations of the Chromosphere with MURaM
P-106	Saida	Díaz Castillo	Spectropolarimetric observations of an atmospheric vortex flow: Study of a collapsed magnetic bright point interacting with intergranular vortex associated with a chromospheric swirl and on-disk spicule release
P-107	Akie	MORITSUKA	Variation of the photospheric line shift toward the north and south limbs observed with Hinode SOT/SP
P-108	David	Long	IRIS observations of flux emergence in a decaying active region
P-109	Tiago	Pereira	The effects of 3D radiative transfer on the Ca II 854.2 nm line
P-110	Wei	Liu	Solar Prominence Bubbles and Associated Plasma Instabilities: Hinode, IRIS, and SDO/AIA Observations
P-111	Xudong	Sun	Large Photospheric Doppler Shift in Solar Active Region 12673
P-112	Ayla	Weitz	Penumbral Fine-Scale Bright Dots as a Precursor to Coronal Plumes? Solar Orbiter/EUI, IRIS, and SDO Observations
P-113	Isabella	Kraus	Statistics of Coronal Bright Points and Preparation of a CBP simulation with Hinode and SDO data
P-114	Marta	García Rivas	Analysis and comparison of the magnetic field properties in a decaying sunspot using Hinode/SOT and SDO/HMI data
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P-116	Takuma	Matsumoto	Predicting Spectro-polarimetric Observations of Chromospheric Jets using Radiative Magnetohydrodynamics Simulation
P-117	Susanna	Parenti	Understanding the stability of a highly dynamic dome-like feature as observed by Solar Orbiter
P-118	Changxue	Chen	Solar Prominence Bubble and Plumes Caused By an Eruptive Magnetic Flux Rope
P-119	Jeffrey	Reep	The Impact of Cross-Sectional Area Expansion on Flows through the Solar Atmosphere
P-120	Yukio	Katsukawa	SUNRISE III SCIP: a balloon-borne instrument for multi-line spectropolarimetry in the photo- and chromosphere

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P-123	Johannes	Hölken	Spectroflat - a novel calibration approach for spectro-polarimetric data
P-124	Hiroyuki	Masaki	Estimation of the structure of thermal convection inside the sun by machine learning using wide-domain radiative magnetohydrodynamic simulations as training data
P-125	Ryota	Shimada	Sub-Grid Scale Model with Small-Scale Dynamo
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P-127	Takero	Yoshihisa	Study of prominence formation considering shock and turbulent heating
P-128	Nabil	Freij	IRIS & AIA - Python Usertools and GUIs
P-129	Guanglu	Shi	Data-constrained coronal and interplanetary magnetic field models combining remote-sensing and in-situ observations
P-130	Marc	DeRosa	Images of High-Resolution, Full-FOV Hinode/SOT-SP Magnetic Fields
P-131	Elena	Dzifcakova	KAPPA: Impact Multi-Ionization and Suppression of Dielectronic Recombination by High-Energy Electrons
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P-134	Tetsuya	Watanabe	Emission Line Intensity Ratios of Fe XXV in Solar Flares Observed by Hinotori
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P-137	Ichimoto	Kiyoshi	Magnetic field structures of solar prominences obtained from spectropolarimetric observations in He I 10830 Å
P-138	Rhiannon	Fleming	Current Status and Future Modification of XRT Response Functions
P-139	Msahito	Kubo	Influence of magnetic filling factor estimation on the polar magnetic fields as observed with Hinode/SOT-SP
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P-143	Satoshi	NAKAHIRA	Distribution of HINODE archive data and development of a new web tool in conjunction with the HEK database by DARTS.
P-144	Takahiro	Miyoshi	Development of a robust and divergence-free scheme for the magnetohydrodynamic relaxation method
P-145	Shin'ichi	Nagata	On the flat filed of the tunable Lyot Filter using Liquid Crystal Variable Retarder
P-146	Riko	Shimizu	Soft X-ray High-Speed CMOS Camera System for the Solar Flare X-ray Imaging Spectroscopy onboard Sounding Rocket Experiment FOXSI-4
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P-148	Sophia	Sánchez-Maes	Improving the Soft X-ray Coronal Plasma Temperature Diagnostic Sensitivity by Including Low-FIP Elemental Abundance Variations
P-149	Xuefei	Zhang	The Correction of the Scattered Light of An Inner-occulted Coronagraph
P-150	Elizabeth	Butler	Flare Lyman-α Spectral Time Series from SORCE/SOLSTICE
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P-155	Satoshi	Masuda	Activities of the Hinode and SOLAR-C Science Center at ISEE in Nagoya University
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Day 1
September 25 (Mon)

I-1

Solar Wind Connection Science with Solar Orbiter, Hinode and IRIS

S. Yardley (U. Reading)

One of the main goals of the joint ESA/NASA Solar Orbiter mission, which was launched back in February 2020, is to provide a complete picture of the solar wind. Solar Orbiter's unique orbit and extensive suite of instruments, including six remote sensing and four in situ instruments, are now being utilised to trace solar wind plasma measured back to its solar source in order to answer open questions regarding the origin and formation of the solar wind, and how it is released and accelerated into the heliosphere. Given the limited spatial field of view of the high-resolution remote sensing instruments, and temporal observing windows due to its unique orbit, observations need to be planned and coordinated in advance through Solar Orbiter Observing Plans (SOOPs). In order to link remote sensing and in situ measurements of slow solar wind plasma originating at open-closed magnetic field boundaries the Slow Solar Wind Connection Science SOOP was designed, during which coordinated observations are taken by Solar Orbiter, Hinode and IRIS. The observations and results presented here are from the first and second instance of the SOOP, which operated prior to Solar Orbiter's first close perihelion passage in March 2022, when Solar Orbiter was at a heliocentric distance of 0.55--0.51 and 0.38--0.34 AU, respectively. The Slow Wind SOOP, despite presenting many challenges, was very successful and provides a blueprint for planning observation campaigns that rely on the magnetic connectivity of Solar Orbiter.

I-2

A solar coronal loop in a box: Energy generation and heating

C. Breu, H. Peter, R. Cameron (MPS),
S.K. Solanki (MPS/Kyung Hee U.), D. Przybylski (MPS), M. Rempel (HAO),
L.P. Chitta (MPS), and I. De Moortel (U. St. Andrews)

Coronal loops are the basic building block of the upper solar atmosphere. Comprehending how these are energized, structured, and evolve is key to understanding stellar coronae.
We investigate how the energy to heat the loop is generated by photospheric magneto-convection, transported into the upper atmosphere, and how the internal structure of a coronal magnetic loop forms.
In a 3D magnetohydrodynamics simulation conducted with the MURaM code, we study an isolated coronal loop modeled as a straightened magnetic flux tube rooted with both footpoints in a shallow layer within the convection zone.
The loop is heated by a Poynting flux that is self-consistently generated through small-scale motions within individual magnetic concentrations in the photosphere, such as vortices propagating from the photosphere to the corona.
With this model we can build a coherent picture of energy transport and heating in a coronal loop.
Future missions such as MUSE will provide information on intensity and flows in the corona with an unprecedented spatial and temporal resolution. Using synthetic spectra, I will discuss what MUSE could tell us about energy transport in coronal loops.

O-1

Radiative MHD simulation of solar wind formation

H. Iijima (Nagoya U.), T. Matsumoto (Nagoya U./NAOJ),
H. Hotta (Nagoya U.), and S. Imada (U. Tokyo)

We report the first comprehensive simulation of solar wind formation from the small-scale dynamo and wave excitation in the solar convection zone. Using the radiative MHD code RAMENS, we simulate a solar atmosphere with a numerical domain extending from 15 Mm below to 29 solar radii above the solar surface. The horizontal size of the numerical domain is 48 x 48 Mm^2, including a few super-granular scales. The simulated atmosphere spontaneously exhibits supersonic solar wind and a millionth-degree corona. Considering the coronal emission measure and solar wind speed, the realized atmosphere mimics a slow solar wind blowing from the coronal hole boundary. The detailed analysis shows the persistent magnetic release in the simulated corona, which conveys the magnetic energy from the closed coronal loops to the open field region. Our estimation shows that this cross-field energy transport accounts for about half the total energy input into the solar wind. These results suggest a significant contribution of interchange reconnection in the lower solar atmosphere.

O-2

Statistical characteristics of small-scale transient brightening as a nanoflare signature observed by the IRIS.

K. Cho (BAER/LMSAL), P. Testa (CfA),
B. De Pontieu (LMSAL/RoCS/U. Oslo),
and V. Polito (BAEL/LMSAL/Oregon State U.)

Moss regions are footpoints of hot coronal loops. Recent observational studies suggested that transient and tiny brightenings in moss regions are the result of nanoflares, and they may be one of the main contributors to coronal heating. To provide their general observational properties, we investigated the characteristics of the moss brightengings observed by the Interface Region Imaging Spectrograph (IRIS). We found 1082 pixels on the IRIS sit-and-stair slit positions which are spatiotemporally associated with small-scale moss brightenings in the four active regions dataset captured by the Atmospheric Imaging Assembly on board the Solar Dynamics Observatory. Several environmental and spectral properties were extracted from the Si IV 1403 Å, Mg II h&k, and Mg II triplet 2798 Å lines. Most of the spectral properties generally agree with previous studies analyzing a limited number of samples. Furthermore, we found that smaller events occur more frequently, and the flare-productive active region, which exhibits a complex magnetic field configuration and hot plasma exceeding 4 MK, generates more moss brightenings. They are generally consistent with the results from the RADYN numerical simulation with 13 different models, except the Si IV nonthermal velocity distribution. We also obtained a number of observational evidence for complex dynamics in the moss brightenings, e.g. asymmetric Mg II spectra and multiple velocity components of Si IV spectrum, which may be caused by nonthermal particles from nanoflares. Our results provide better constraints for more realistic numerical simulations and help us to understand the nature of the nanoflares.

O-3

Unraveling the heating of Coronal Bright Points: a fundamental block in the solar atmosphere.

D. Nóbrega-Siverio, F. Moreno-Insertis (IAC), K. Galsgaard (St. Andrews U.),
K. Krikova, L. Rouppe van der Voort, R. Joshi (RoCS), and M. Madjarska (MPS).

Coronal Bright Points (CBPs) are an important piece to address one of the most outstanding questions in astrophysics: the solar coronal heating. These common bright structures, with sizes of 5-40 megameters and composed of hot loops, stand out in the Sun by their enhanced X-ray and/or extreme-ultraviolet (EUV) emission for hours to days. Considered at the large-end of coronal heating events, CBPs can also be the source of jets and small-scale filament eruptions. However, disentangling their heating mechanisms has been challenging due to the need for comprehensive magnetohydrodynamics (MHD) experiments encompassing diverse space/time scales, as well as intricate atomic and radiative processes. Here we present a novel numerical radiative-MHD model that explains the sustained CBP heating during hours. In addition, we provide synthetic observables at different wavelengths to be compared with observations from Hinode, IRIS, SDO, Solar Orbiter, and SST. In this work, we have found that stochastic photospheric motions stress the field around the parasitic polarity, leading to important Joule and viscous heating around the CBP inner spine at the low atmosphere. Continuous upflows emanate from the CBP nullpoint with barely discernible signal in the EUV resembling observational dark EUV jets. Small-scale confined eruptions are also found when dense Halpha chromospheric fibrils rise up and interact with the reconnection site. Our results constitute a step forward in the understanding of the many different facets of the solar coronal heating problem.

O-4

Simulation of coronal heating of a loop above a sunspot group

J. Tschernitz (U. Graz), and Ph.-A. Bourdin (U. Graz)

Direct currents in the solar atmosphere and their subsequent Ohmic dissipation are a promising candidate to explain the very high temperatures of the coronal plasma. We describe this heating in models of the corona above two sunspots. We investigate the coronal plasma heating through current sheets. The shearing angle between adjacent magnetic field topologies is caused by stress induced from advective motions in the photosphere. Magnetic disturbances from the photosphere propagate along the field and eventually reach the corona.

We perform a numerical simulation of a hot coronal loop above a bi-polar active region. The simulation is driven with photospheric magnetograms obtained from Hinode/NFI. Our simulation domain covers 237×237×156 Mm^3 with 1024×1024×256 grid points. We use a photospheric velocity driver that consists of a small-scale velocity field generated by an artificial granulation, as well as a large-scale velocity field derived from photospheric motions. Both components lead to a vertical Poynting flux that can be either positive or negative. Observed magnetograms serve as the lower boundary condition, as well as for initializing our setup. The simulation then evolves self-consistently and the velocity driving will perturb the magnetic field inside the domain.

After 3600 seconds, enough stress has been applied to trigger the heating processes in the corona. The heating compensates for realistic coronal energy losses. Our model is able to sufficiently heat a coronal loop that reaches a height of 27 Mm. We observe that the loop's temperature rises to a maximum of about 1.7 MK while the the Ohmic heat input increases. We calculate synthetic EUV emission, their spectra, and Doppler shifts using the CHIANTI database. Finally, we compare our model output directly to co-spatial and co-temporal observations from the Hinode/EIS instrument of the Fe XII spectral line at 195.12 Å.

I-3

3D MHD Model of Underdense Plasma Downflows Associated with Magnetic Reconnection in Solar Flares

C. Shen (CfA), B. Chen (NJIT), K. K. Reeves (CfA), S. Yu (NJIT), V. Polito (BAER), and X. Xie (CfA)

Magnetic reconnection is the key mechanism for energy release in solar eruptions, where the high-temperature emissions are primary diagnostic objects for investigating the plasma properties during reconnection processes. A characteristic feature of magnetic reconnection is the production of fast reconnection outflows near the plasma Alfvén speeds. Dark finger-shaped plasma downflows, referred to as supra-arcade down-flows (SADs), moving toward the flare arcade have been commonly regarded as the principal observational evidence for such reconnection-driven outflows in eruptive solar flares. However, further exploration and analysis are necessary to better understand the origin and development of SAD-associated plasma flow in the context of standard flare models. In this work, we report a three-dimensional magnetohydrodynamics model of solar flares, which reveals plasma downflow features in high-temperature reconnection sheets and flare loop-top regions. The SADs-like dark downflows can self-consistently form in a turbulent interface region below the flare termination shock where the outflows meet the flare arcade. Our numerical model also indicates that the interface area hosts myriad turbulent flows, electron currents, and multiple shocks, which may play crucial roles in releasing magnetic energy.

I-4

Behaviour of cool UV emission from molecular hydrogen in three solar flares

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H. Hudson (U. Glasgow), and N. Labrosse (U. Glasgow)

Solar flares are energetic and explosive events which produce their signatures at all layers of the solar atmosphere. The energy deposition occurs at the lower layers, chromosphere and temperature minimum region (TMR). The plasma properties at these layers during flares could be studied using spectroscopic observations of cool lines. We have systematically investigated cool ultraviolet (UV) emission from molecular hydrogen (H2) using the Interface Region Imaging Spectrometer (IRIS), during three X-ray flares of C5.1, C9.7 and X1.0 classes on Oct. 25, 2014. Significant emission from five H2 spectral lines appeared in the flare ribbons, interpreted as photo-excitation (fluorescence) due to the absorption of UV radiation from two Si IV spectral lines. The H2 profiles were broad and consisted of two non-stationary components in red and in the blue wings of the line in addition to the stationary component. The red (blue) wing components showed small red-shifts (blue-shifts) of ~5–15 km/s (~5–10 km/s). The nonthermal velocities were found to be ~10–25 km/s. The interrelation between intensities of H2 lines and their branching ratios confirmed that H2 emission formed under optically thin plasma conditions. There is a strong spatial and temporal correlation between Si IV and H2 emission, but the H2 emission is more extended and diffuse, further suggesting H2 fluorescence, and - by analogy with flare “back-warming”- providing a means to estimate the depth from which the H2 emission originates. We find that this is 1871±157 km and 1207±112 km below the source of the Si IV emission, in two different ribbon locations.

O-5

Importance of Cadence: Probing dynamics of fast flare ribbon kernels using the Interface Region Imaging Spectrograph

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Solar flares and eruptions are powered by magnetic reconnection which occurs in three dimensions (3D) via a process known as slipping reconnection. This process involves sequential change of field line connectivity within quasi-separatrix layers (QSLs), hypothetical regions characterized by strong gradients of magnetic connectivity. Previous simulations utilizing 3D extensions to the standard flare model predicted rapid field line slippage surpassing speeds of thousands of kilometers per second. Observations of the apparent slipping motion of flare loops and kernels, which present the manifestation of the slipping reconnection, however failed to vindicate predictions of the model, reporting slippage speeds of a few hundred kilometers per second at most. In our study we focus on high-cadence observations of the C4.2-class SOL2022-09-25T06:12:00 flare made by the Interface Region Imaging Spectrograph. We examine the dynamics of flare kernels moving along one of the flare ribbons observed in the 1330 Å filter of the Slit Jaw Imager at a cadence of 1.8 seconds. By utilizing time-distance diagrams, we demonstrate that apparently-slipping flare kernels exhibit dynamics at speeds of thousands of kilometers per second. This result provides evidence that 3D magnetic reconnection indeed occurs in QSLs and is of a continuous nature, validating predictions of analytical and magnetohydrodynamic models of magnetic reconnection. We finally study the effect of instruments' resolutions on the detectability of fast flare kernels. To do so we compare time-distance diagrams generated using data obtained by instruments with varying spatial and temporal resolutions. A computer vision algorithm is employed to detect features that moving flare kernels imprint in the time-distance diagrams as well as to measure their speeds. Our results suggest that the resolution of fast flare ribbon dynamics can only be achieved through solar flare observations carried-out with a cadence of seconds at most.

O-6

Decay Timescales of Chromospheric Condensations in Solar Flares

E. Butler (QUB) and A. Kowalski (CU-Boulder)

Chromospheric condensations (CCs) are a distinctive feature of flare footpoint heating in the Standard Model. The ‘1 minute lifetime’ for their decay derived by Fisher (1989) is commonly used as a benchmark in the literature, but this and other analytics from Fisher (1989) have not been statistically examined in flare observations. Is 1 min truly typical in flare plasma or only for a subset of flare scenarios? Fisher (1989) demonstrated that the maximum velocity, v_max, is proportional to the deposited energy flux; does this lead to a correlation with observed decay time? IRIS’ high cadence provides a rich flare data set to begin examining these questions. We analyzed Doppler shifts in Mg II 2791 and Fe II 2814 from a sample of footpoint pixels observed by IRIS to compare with the analytics of Fisher (1989). We found an observational lifetime of 1 min occurs in 50% of the sample. Several pixels though show longer values in Mg II while Fe II is almost categorically shorter, indicative of the later’s lower formation height and thus probing a later point in the CC evolution. The lifetime of both lines grows with v_max, which is contrary to Fisher (1989). The decay halflife is commonly < 40 s and is inversely correlated with v_max, suggesting that the first half of the CC evolution has more efficient kinetic energy loss, perhaps due to occurring higher in the flare chromosphere. These observations also capture an acceleration phase to v_max, allowing us to calculate various quantities that can be used as flare model constraints and diagnostics: acceleration time (20-40 s), ‘seed mass’ initially accelerated (∼10^−4–10^−2 kg/m^2), its relative growth (around an order of magnitude), and its kinetic energy at v_max (10^23 ergs for an area equivalent to an IRIS pixel).

O-7

An Optically Thin View of the Flaring Chromosphere: Nonthermal widths in a chromospheric condensation during an X-class solar flare

G.S. Kerr (CUA / NASA GSFC), A.F. Kowalski (CU / NSO),
J.C. Allred (NASA GSFC), A.N. Daw (NASA GSFC), and M.R. Kane (CU)

The chromosphere is where the bulk of the energy released in a solar flare is deposited, and is the origin of the bulk of the enhanced radiative output. Flare ribbons and footpoints in the chromosphere therefore offer great diagnostic potential of the energy release and transport processes at work during solar flares. Much work has been done in recent years to exploit the high spatial, temporal and spectral observations from the IRIS spacecraft, which has transformed our view of the flaring chromosphere. However, the strong chromospheric lines observed by IRIS are optically thick, requiring forward modelling to fully appreciate and extract the information they carry. Reproducing certain aspects of the Mg II resonance lines remain frustratingly out of reach in state-of-the-art flare models. Primary among those is that models are unable to satisfactorily reproduce the very broad line profiles, with synthetic line widths that are much too narrow. A commonly proposed resolution to this is to assert that very large values of `microturbulence' is required. We asses the validity of that approach by analysing optically thin lines in the flare chromosphere from the X-class flare SOL2014-10-25T17:08:00 and using the observationally derived value of nonthermal width as inputs to our numerical models. Nonthermal widths of the order 5-12 km/s was found within the short-lived red wing components of three chromospheric lines, with relatively narrow stationary components. Radiation hydrodynamic simulations of this flare were produced, and in the post-processing steps to synthesise the IRIS lines we include within the downflows a microturbulence of 10 km/s. It was found that while we can reproduce the O I 1355.598 A line rather well with this set up, and we can capture the general shape and properties of the Mg II line widths, the synthetic lines are still too narrow.

O-8

IRIS and STIX Observations of Oscillations in a Solar Flare Fan

R. French (NSO), L. Hayes (ESA), and M. Kazachenko (NSO/CU Boulder)

We present simultaneous IRIS and X-ray observations of a coronal quasi-periodic pulsations (QPPs) source, within a loop-top fan structure in the impulsive phase of a long-duration solar flare. The strikingly coherent oscillations (of period 50 seconds) were observed in thermal emission from the Solar Orbiter STIX instrument, synchronized with GOES SXR emission. We also present contemporaneous observations of the fan structure oscillations in IRIS Fe XXI intensity, Doppler and non-thermal velocity, finding QPPs with matching periods, and in phase with, the X-ray data. A new sliding raster technique is introduced to push the cadence of the IRIS spectra time series, with implications for science possible with rastering MUSE slits. To our knowledge, this dataset is the first simultaneous UV and X-ray imaging of a coronal QPP source. By combining these multi-instrument datasets, we provide new insights into the origin of QPPs in the solar corona.

O-9

Flare-driven rain mediated reconnection as a secondary heating source in flare loops

S. Sahin, P. Antolin, and R. Sukarmadji (Northumbria U.)

Solar flares often display very puzzlingly long gradual phases, which has led to conjectures about their sub-structure and the existence of additional heating mechanisms besides the coronal magnetic reconnection. Similarly, little is known about the coronal rain often seen during the gradual phase, how does it differ from its quiescent counterpart and in particular its formation mechanism. 1D radiative MHD simulations clearly show that electron beams alone are not enough to generate it, and it is not clear whether additional long-duration heating mechanisms exist and/or whether multi-dimensional effects are necessary. In this study, we investigate a C-class flare with IRIS and SDO imaging data spanning chromospheric to coronal temperatures and pay particular attention to the flare-driven rain. We analyse its evolution, dynamics, and morphology, and compare it to quiescent rain in the same dataset. In response to the large energy release, compared to the pre-flare state, the amount of coronal rain doubles, the widths and lengths of clumps increase by 10-20%, and the projected velocities (downward and upward) increase by 30-10%. Using the DEM method, we also investigate the temperature evolution throughout the flare. The chromospheric evaporation is directly observed (also in the Fe XXI 1354 line) with projected speeds of up to 315 km/s, and with an average of 138 km/s for episodes lasting almost an hour. We observe a Kelvin-Helmholtz type vortex in the corona in response to the evaporation and a strong morphological correspondence between the evaporation and the (later occurring) rain shower. During the shower and co-located with it, we observe nanojets and a secondary increase in temperature to 7 MK. To our knowledge, this is the first time such a highly localised and strongly multi-thermal behaviour is observed and suggests that reconnection facilitated by the rain leads to significant energy release during the gradual phase.

O-10

Multiwavelength Sun-as-a-star Analysis of the M8.7 Flare on 2022 October 2 with H-alpha and EUV Using SMART/SDDI and SDO/EVE

T. Otsu, and A. Asai (Kyoto U.)

In recent years, sudden brightenings known as stellar flares have been observed in distant stars. To understand observations of stellar flares without spatial resolution, some studies have utilized spatially resolved data of the Sun through a method called “Sun-as-a-star analysis”, treating the Sun as if it were a distant star. Especially, spectroscopic Sun-as-a-star analysis is valuable to interpret flares and plasma motions on stellar surface (Namekata+ 2022). So far, such analyses have been performed mainly using either H-alpha (log(T/K) ~4) or extreme ultraviolet (EUV; log(T/K) > 5) spectra (e.g., Otsu+ 2022, Xu+ 2022). In the solar case, active phenomena often exhibit multi-temperature structures (e.g., Gutierrez+2021), and it is expected that similar structures are also present in stellar cases. Thus, spectroscopic Sun-as-a-star analysis simultaneously using multiwavelength lines with different formation temperatures is necessary to obtain deeper understanding of stellar active phenomena.

In this study, we performed a Sun-as-a-star analysis of the M8.7 flare and the associated filament eruption that occurred on 2022 October 2 in NOAA 13110 using SMART/SDDI (Halpha imaging spectroscopy) at Hida observatory, Kyoto University and SDO/EVE (EUV fulldisk integrated spectroscopy). Corresponding to the filament eruption in H-alpha images, a blueshifted absorption with a Doppler velocity up to ~300 km/s appeared in the spatially integrated H-alpha spectra. In addition, blueshifted emissions were observed in the EUV spectra such as O V 629.7Å (log(T/K) ~5.4) almost simultaneously with the absorption of the fast component in the H-alpha line. According to EUV imaging observations by SDO/AIA, the blueshifted components in EUV spectra are most likely attributed to the filament eruption. With a view of the application to stellar research, we will report the details of the time evolutions of these blueshifted components in the H-alpha and EUV lines. Additionally, we will discuss other phenomena such as coronal rains and CME-related dimming.

Day 2
September 26 (Tue)

I-5

Topics from Hinode/XRT irradiance study: correlation with photospheric magnetic field, possible latitudinal variation, etc.

A. Takeda (MSU)

Using pairs of Hinode/XRT full-Sun images, solar soft X-ray irradiance is calculated from the filter-ratio temperatures and emission measures assuming isothermal coronal spectrum. In the course of 16 years of operation in space, however, XRT's response functions need to be modified to properly correct the instrumental aging effect, i.e., increasing visible stray light component in the telescope and accumulating contamination layer on the CCD and X-ray filters. The improvement of atomic data also affects the XRT response. We will report the current status of the instrument and most recent modification of the response functions.

The mission-long XRT irradiance obtained with the most recent calibration was compared with the total unsigned photospheric total magnetic field obtained with SOHO/MDI and SDO/HMI. Applying the magnetic field cut-off at 60G, the XRT irradiance (from Al_mesh and Al_poly filter pairs) follows a single power law of total unsigned magnetic field with the exponent of ~1.28. With the smaller magnetic cut-off values, however, the single power law starts to break by forming a "knee" at the lower irradiance side of the scatter plots, which indicates the weak magnetic component that does not contribute to the X-ray brightness.

We investigated the fraction of XRT irradiance created by the solar disk portion (collected within 0.9 Rs) relative to the whole Sun irradiance (within 1.1 Rs). The fraction shows solar cycle variation: the fraction is large around the solar maximum and decreases toward the solar minimum and has the lowest value at the beginning of the rising phase, then increases again toward the solar maximum. A possible explanation for this is that the latitudinal variation of the X-ray irradiance affected by the appearance latitude of the active regions.

I-6

Solar Polar Magnetic Fields: Comparing Full-Disk and High-Resolution Spectromagnetograph Data

G. Petrie (NSO)

I will present a systematic comparison between photospheric polar magnetic field data from the high-resolution Hinode Solar Optical Telescope Spectro-Polarimeter (SOT/SP) and the NSO's full-disk Synoptic Optical Long-term Investigations of the Sun Vector Spectro-Magnetograph (SOLIS/VSM). Polar magnetic fluxes derived from longitudinal magnetic field measurements from both telescopes and from SOT/SP full-Stokes vector data will all be compared in the form of polar synoptic maps. Measurements taken over 35-day periods with advantageous rotation axis tilt angle will be used; observations extend to the poles, and no synthetic pole-filling is needed. Polar fluxes are derived from longitudinal data assuming an approximately radial field, whereas those derived from vector data are based on measured vector magnitude and direction. However, the full-vector measurements may have a detection problem: polar fields are observed as mostly transverse from (near) Earth, and Zeeman sensitivity to transverse fields is significantly lower than for longitudinal fields. Accordingly, the SOT/SP vector-based polar fluxes are lower than the longitudinal-based fluxes from both telescopes. Furthermore, the SOT/SP longitudinal-based fluxes are significantly higher than their VSM counterparts because of superior seeing-free spatial resolution and longer observation time. The SOT/SP longitudinal-based polar fluxes appear large enough to account for radial interplanetary field measurements whereas the SOT/SP vector-based and the VSM ones are generally too low. Full-Stokes polar observations from the 4m Daniel K. Inouye Solar Telescope (DKIST) will be discussed.

O-11

Importance of low-latitude photospheric magnetic fields in solving the open flux problem

M. Yoshida (U. Tokyo/ISAS/JAXA), T. Shimizu, and S. Toriumi (ISAS/JAXA)

The solar “open” magnetic field forms the interplanetary magnetic field (IMF), which evolves over the solar cycle. The global structure of IMF is a basic information for understanding transient events such as solar flares and coronal mass ejections. Thus, to connect the magnetic field between the Sun and interplanetary space, the open flux near the Earth estimated from the photospheric measurements has been compared to the “in-situ” IMF observation. However, there is an outstanding issue called the “open flux problem”, in which the extrapolated IMF is underestimated by a factor of 2-5 with respect to the observed IMF. In previous studies, polar photospheric fields have been focused on as a possible cause, although the open flux extended from the photosphere is not necessarily concentrated in the polar regions. In this study, we examined the actual components of the solar magnetic field contributing to IMF by decomposing the solar magnetic field into modes (l, m) of spherical harmonic function over the whole cycle 24 using the potential field source surface model based on the SDO/HMI data. We compared the solar dipole flux (l=1) and nondipole flux (l≧2) with the evolution of IMF observation. As a result, the trend of equatorial dipole flux (l, m)=(1, ±1) is close to that of IMF during solar maximum, while the trend of nondipole flux (l≧2) is close to that of IMF during solar minimum. This indicates that the low-latitude fields significantly contribute to the IMF evolution. In addition, by using Hinode SOT/SP, we limited the possibility of underestimation of the polar magnetic field compared to the disk center within a factor of 2. In conclusion, the open flux extending from the low-latitude magnetic field is more important than the polar field.

O-12

3D mapping of the magnetic field in the whole atmosphere of an active region plage using spectropolarimetric observations with CLASP2.1 and Hinode

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K. Kobayashi, A. Kobelski, G. Vigil, A. Winebarger (NASA/MSFC),
L. Rachmeler, (NOAA), C. Bethge (CU-Boulder), E. Alsina Ballester,
T. del Pino Aleman, H. Li (IAC), B. De Pontieu (LMSAL), L. Belluzzi (IRSOL),
T. Sakao (ISAS/JAXA), J. Stepan (ASCR)

Probing the magnetic field throughout the solar atmosphere is critically important for understanding the energy transfer from the photosphere to the corona. However, there is an overwhelming lack of empirical information on the magnetic field in the upper chromosphere and the layers above, where the magnetic pressure dominates the gas pressure ($\beta < 1$). To this end, a novel approach is to measure and model the polarization of magnetically-sensitive ultraviolet (UV) spectral lines. The series of sounding rocket experiments CLASP (2015), CLASP2 (2019) and CLASP2.1 (2021) have demonstrated that UV spectro-polarimetry is indeed a suitable diagnostic window for investigating the magnetic fields in the whole solar chromosphere. On October 8, 2021, CLASP2.1 measured the Stokes profiles of the 280 nm spectral region at 16 consecutive slit positions covering a two-dimensional field of view in an active region plage. In addition to several other lines, this near-UV spectral region contains the resonance lines of Mn I (which provide information on the lower chromosphere) and the Mg II h & k lines (which provide information on the middle and upper chromosphere). Through coordinated observations with the Solar Optical Telescope (SOT) aboard the Hinode satellite, we obtained a line-of-sight magnetogram covering a sunspot penumbra and a plage region at multiple heights in the solar atmosphere. In general, the magnetic fields in the observed active region become weaker and smoother as they expand with height. However, at some locations, the magnetic polarity changes between the top and middle chromosphere. The obtained magnetogram is compared with the high-resolution coronal images recorded by SDO/AIA, revealing the connectivity between the magnetic structure in the chromosphere and the coronal loops.

O-13

Statistical Spectroscopic Diagnosis of the Footpoints of Cool Loops

S. Balaji, P. Kayshap, S. C. Tripathi (VIT Bhopal U.),
P. Jelinek (U. South Bohemia), and B.N. Dwivedi (RGIPT)

Cool loops have been sparsely investigated using spectroscopic observations provided by the Interface Region Imaging Spectrograph (IRIS). The footpoints of these cool loops are important regions for understanding their nature, evolution, and dynamics. We conducted a statistical spectroscopic diagnosis of the footpoints of cool loops that occurred in β-type and β-γ-type active regions (ARs). The present work investigates 120 footpoints in β-type ARs and 80 footpoints in β-γ type ARs., i.e., a total of 200 footpoints from both types of ARs.

The average intensity and full width at half maximum (FWHM) of the footpoints of cool loops in β-γ type ARs are significantly higher than the corresponding intensity and FWHM in the β type ARs. However, the Doppler velocities of the cool loop's footpoints were the same in both types of ARs. Furthermore, we performed some correlations among the spectroscopic parameters of the footpoints of cool loops in both types of ARs and found the following: (i) intensity and line width are strongly correlated, (ii) Doppler velocity and line width are weakly correlated, and (iii) there is no correlation between intensity and Doppler velocity. The observed line ratios from two Si IV spectral lines significantly deviate from the theoretical value (i.e., 2.0). It suggests that Si IV lines are formed under optically thick conditions in the footpoints of both the ARs. At last, we observed that the footpoints of cool loops in β-γ type ARs are far more complex than those in β type ARs. In conclusion, we report that the nature, evolution, and dynamics of the footpoints of cool loops in β-γ and β ARs are significantly different from each other, which is well justified.

O-14

Origin of line broadening in fading granules: influence of small-scale turbulence

R.T. Ishikawa (Nagoya U.), and Y. Katsukawa (NAOJ)

In the quiet region of the solar photosphere, turbulent convective motions of the granular flows naturally drive the subgranular-scale flows. However, evaluating such small-scale velocities is challenging because of the limited instrumental resolution. Our previous study, Ishikawa et al. (2020), found line broadening events during fading process of granules; however, their physical mechanism has remained unclear. In the present study, we observed the fading granules with the Hinode-SOT/SP and performed spectral line inversions. Moreover, we investigated broadening events of synthesized spectra in fading granules reproduced by the MURaM simulation. Our results demonstrated that the small-scale turbulent motions are excited in the fading process and such turbulent flows contribute to line broadening. The spectral line widths can be potential tracers of the photospheric turbulent flows.

I-7

Spectroscopic Investigations into the Origin and Acceleration of the Solar Wind

M. Hahn (Columbia U.)

Spectroscopic measurements can reveal details of the origins of the solar wind and the processes through which the corona is heated and the solar wind accelerated. Measurements of the temperature, density, and elemental abundances at the Sun allow one to infer the source region for solar wind observed in-situ. Doppler velocity measurements can also indicate outflows that may represent the initial acceleration of the solar wind. Time-varying fluctuations in the Doppler velocity as well as intensity fluctuations and line shapes are diagnostics for waves and turbulence. I will discuss some recent results using these methods with an emphasis on the strengths and limitations of the existing data and some considerations for future instruments.

I-8

Recent progress in solar wind modeling

T. Suzuki (U. Tokyo)

In this talk, we plan to review recent progress in theoretical modeling and numerical simulations for the formation and acceleration of solar winds.

O-15

Torsional Alfvén waves in Solar Orbiter EUI observations

E. Petrova (KU Leuven), T. Van Doorsselaere (KU Leuven),
D. Berghmans (ROB), and S. Parenti (IAS)

Torsional Alfvén waves do not produce any observational coherent patterns and, therefore, pose a great challenge to make direct observations of those waves from the imaging instruments. Previously, Alfvén wave observations were reported throughout all the layers of the solar atmosphere using spectral imaging.

We present an observation of a torsional Alfvén wave detected in a so-called "Gandalf's hat" - feature observed with the HRI EIV instrument onboard Solar Orbiter in a 17.4 nm channel. The feature consists of two footpoints connected through short loops and a long spine with a length of 30 Mm originating from one of the footpoints.
Difference movies show clear signatures of propagating rotational motions in that spine. Propagation speeds measured constitute 136 km/s - 160 km/s which are consistent with expected Alfvén speeds observed in similar structures. The evidence of motions in a transverse direction with velocities of 26 km/s - 60 km/s serves as an additional indication of torsional waves present.

In the current work, we also make use of the simultaneous observations from two different other instruments onboard Solar Orbiter. The first one is PHI (Polarimetric and Helioseismic Imager) to derive the magnetic configuration of the observed feature. Apart from that, SPICE (Spectral Imaging of the Coronal Environment) observations of intensity maps in different channels including Ne VIII and C III lines. We also address the issues of the SPICE point spread function and its influence on the Doppler maps via performed forward modeling analysis.

O-16

Study of heating distribution and heating mechanism of coronal loops using Hinode/EIS

S. Ishigami (SOKENDAI/NAOJ), H. Hirohisa (SOKENDAI/NAOJ),
and T. Oba (NAOJ)

The purpose of this study is to investigate the heating mechanism in coronal loops. It allows us to distinguish the heating mechanism by using the scaling relation between the heating flux F_H and the parameters such as the magnetic field strength B and the loop half-length L. We determine the heating flux F_H by the heating scale s_H and the base heating rate E_0 which are the parameters of the heating distribution along a loop. We estimate the heating distribution by the temperature and the density distributions from spectroscopic data. This approach has no need to assume the filling factor of the loop for density diagnostics. Temperature and density distributions are measured using spectroscopic data for 18 loops with their half-lengths from 19−101 Mm obtained by the Hinode/EIS. As a result, s_H derived by spectroscopic data are similar to or shorter than that derived by imaging data from SDO/AIA for the same loops. It is found that the ratio of s_H to the loop half-length L is $s_H/L = 0.24 \pm 0.08$, implying that heating is concentrated at the footpoints of the loop. Analyzed loops locate on the solar disk to determine B by the SDO/HMI. To distinguish the heating mechanism, we obtain the B and L of each loop. The obtained scaling relation suggest that reconnection is important in the heating.

O-17

Even Small Events Involve the Entire Solar Atmosphere.

A. Kobelski ((NASA/MSFC), L. A. Tarr, and S. A. Jaeggli (NSO)

The connection between the photosphere, chromosphere, and corona is essential for understanding the energy flows throughout the solar atmosphere. Here we discuss and analyze observations centered on a bipolar region of enhanced-network magnetic flux near disk center on SOL2017-03-17T14:00-17:00. The comprehensive data set comprises observations from SDO: HMI, AIA; Hinode: SOT, XRT; DST: IBIS, FIRS; ALMA; and IRIS; thus providing a variety of plasma diagnostics spanning the photosphere to the corona. Numerous transient brightenings were observed across the data set, and here we highlight transient brightenings within a set of thin filamentary features. One interesting event shows initial heating in the cooler (ALMA, 7000 K) before showing in the hotter (XRT, 3 MK) data series. These brightenings showcase how even small events involve large ranges of the solar atmosphere.

O-18

Transition Region response to Quiet Sun Ellerman Bombs

A. Bhatnagar, and L. R. van der Voort (RoCS/UiO)

Quiet Sun Ellerman Bombs (QSEBs) serve as a key indicator of small-scale photospheric magnetic reconnection events and are distinctly identified by their pronounced enhancement in the wings of the hydrogen Balmer (Hβ) line and by the subsequent emission in the line core. Recent research has established their ubiquitous presence in the lower solar atmosphere. We analyse high-resolution Hβ observations from the Swedish Solar Telescope and utilise k-means clustering to detect QSEBs. We further use coordinated and co-aligned observations from the Interface Region Imaging Spectrograph (IRIS) to search for corresponding signatures in both slit-jaw images and spectra. For the spectral data, we focus on the Si IV, Mg h and k, and Mg triplet lines in relation to the detected QSEBs. Our investigation yields few cases where enhanced emission in the Si IV spectral data is both spatially and temporally coincident. Moreover, we identify numerous instances of QSEBs showing brightenings in the Si IV slit jaw data. These findings suggest the possibility that QSEBs, despite originating as reconnection events in the lower solar atmosphere, may attain temperatures comparable to the transition region.

O-19

Magnetic field structures at the X point of an Ellerman bomb

T. Anan, H. Uitenbroek (NSO), R. Casini (HAO), H. Socas-Navarro (IAC),
T. Schad (NSO), K. Ichimoto (Ritsumeikan U.), S. Jaeggli (NSO),
S. Tiwari (LMSAL), J. Reep (NRL), Y. Katsukawa (NAOJ), A. Asai (Kyoto U.),
K. Reardon (NSO), and J. Qiu (Montana State U.)

Magnetic reconnection in the solar atmosphere can release stored magnetic energy efficiently into the solar atmosphere and the heliosphere. In order to explain the high efficiency, various reconnection models have been proposed. Direct measurements of magnetic field structures at or around a reconnection X point where the magnetic fields reconnect would enable us to determine which reconnection models work. Using the newly commissioned National Science Foundation's Daniel K. Inouye Solar Telescope (DKIST), we observed NOAA active region 12995 on February 23rd, 2022, in the Ca II H 397 nm, Fe I 630.15 nm, Fe I 630.25 nm, and Ca II 854 nm lines using the Visible SpectroPolarimeter (ViSP) together with blue continuum imaging with the Visible Broadband Imager (VBI). We successfully obtained Stokes spectra of Ellerman bombs, which are brightenings in the lower chromosphere and are thought to be associated with magnetic reconnection. We applied Departure coefficient aided Stokes Inversion based on Response function (DeSIRe, Ruiz Cobo et al. 2022) to the Stokes spectra of the four lines at the Ellerman bomb. As a result, it is revealed that the inferred line-of-sight component of the magnetic field strongly varies along the line-of-sight, so that It has at least 3 or 4 peaks. The result supports turbulent or plasmid reconnection models. Moreover, at the Ellerman bomb, we discovered a broadband circular polarization in a Balmer line of the neutral hydrogen at 397 nm, H epsilon, that DeSIRe is not able to reproduce. In this talk, we will also discuss what additional information the circular polarization provides for understanding the reconnection.

O-20

Exploring solar jet dynamics using coordinated high-resolution observations

R. Joshi, L. R. van der Voort (RoCS/UiO),
and D. Nóbrega-Siverio (IAC, RoCS/UiO)

Solar coronal jets are observed as hot collimated plasma flows along magnetic field lines in a wide wavelength range, from X-rays to EUV. Usually, these jets are closely related to cool surges, which are chromospheric ejections that emerge in the form of unwrinkled threads. Though these phenomena have been studied over the past few decades with different instruments and models, their physical origin and evolution are still actively debated. To have a deeper understanding of the origin and driving of solar coronal jets, we analysed a solar jet event with very high-resolution observations from the Swedish 1-m Solar Telescope (SST), Interface Region Imaging Spectrograph (IRIS) and Solar Dynamics Observatory (SDO). Coordinated photospheric, chromospheric, and coronal observations provide a comprehensive view of the jet's origin and its relation to the upper solar atmosphere. This constrains existing numerical models as they provide details on different aspects of the origin and propagation of jets at different heights from the photosphere to the corona.

Day 3
September 27 (Wed)

I-9

The high helium abundance and charge states of the interplanetary CME and its material source on the Sun

H. Fu (Shandong U.), R. A. Harrison (Rutherford Appleton Laboratory),
J. A. Davies (Rutherford Appleton Laboratory), L. Xia (Shandong U.),
X. Zhu (MPS), B. Li (Shandong U.), Z. Huang (Shandong U.),
and D. Barnes (Rutherford Appleton Laboratory)

Identifying the source of the material within coronal mass ejections (CMEs) and understanding CME onset mechanisms are fundamental issues in solar and space physics. Parameters relating to plasma composition, such as charge states and He abundance (AHe), may be different for plasmas originating from differing processes or regions on the Sun. Thus, it is crucial to examine the relationship between in situ measurements of CME composition and activity on the Sun. We study the CME that erupted on 2014 September 10, in association with an X1.6 flare, by analyzing Atmospheric Imaging Assembly imaging and Interface Region Imaging Spectrograph (IRIS) spectroscopic observations and its in situ signatures detected by Wind and Advanced Composition Explorer. We find that during the slow expansion and intensity increase of the sigmoid, plasma temperatures of 9 MK, and higher, first appear at the footpoints of the sigmoid, associated with chromospheric brightening. Then the hightemperature region extends along the sigmoid. IRIS observations confirm that this extension is caused by transportation of hot plasma upflow. Our results show that chromospheric material can be heated to 9 MK, and above, by chromospheric evaporation at the sigmoid footpoints before flare onset. The heated chromospheric material can transport into the sigmoidal structure and supply mass to the CME. The aforementioned CME mass supply scenario provides a reasonable explanation for the detection of high charge states and elevated AHe in the associated interplanetary CME.

I-10

Introduction to the ASO-S mission and early observational results

L. Feng, W. Gan (PMO), and ASO-S team

The ASO-S mission was launched in October 2022. It has three payloads, a Full-disk vector MagnetoGraph (FMG) to measure photospheric magnetic Fields, a Hard X-ray Imager (HXI) to observe non-thermal signals from 30 to 200 keV, and Lyman-alpha Solar Telescope (LST) to take images of the Sun in Lyman-alpha and white light. Both flares and CMEs originate from the evolution of solar magnetic fields. The mission aims to simultaneously observe the magnetic fields, solar flares, and CMEs on a single platform, which constitute the main characteristics of ASO-S. For simplicity, we use "1M2B" to outline the scientific goals of ASO-S in which "1M" means magnetic field, "2B" means two bursts, i.e. flares and CMEs. In this talk, the characteristics and in-flight calibrations of the three payloads will be introduced. We will also show some early observational results of the mission.

O-21

NuSTAR, XRT, and AIA Differential Emission Measure Analysis of an Alternately Quiet and Flaring Active Region

J. Duncan, A. Shih (NASA GSFC),
L. Glesener, R. Masek, Y. Zhang (U. Minnesota),
W. Barnes (NASA GSFC/American U.), and I. G. Hannah (U. Glasgow)

Solar active regions contain plasma across a broad range of temperatures, with the thermal distribution often observed to peak in the few millions of kelvin (MK). Differential emission measure (DEM) analysis allows for multi-instrument observations of a single source to be combined to estimate the amount of material present as a function of temperature. By constructing DEMs, we can take advantage of the diverse temperature responses of solar-capable instruments observing across the electromagnetic spectrum. Hard x-ray (HXR) observations are uniquely sensitive to the high-temperature components of coronal plasma distributions, and are therefore essential for diagnosing hot (>5 MK) DEM components. The Nuclear Spectroscopic Telescope ARray (NuSTAR) is a powerful HXR observatory which makes periodic observations of the Sun. Combining NuSTAR's HXR coverage with soft x-ray (SXR) and extreme ultraviolet (EUV) observations from Hinode/XRT and SDO/AIA, we present a detailed DEM analysis of an active region (NOAA designation AR 12671) observed for ~5 hours on 2018 May 29. Over the course of the interval, we show how the plasma temperature distribution of the active region evolves as the region produces several small microflares, and also undergoes quiescent periods without obvious HXR transients. Additionally, we discuss the relative contributions of HXR, SXR, and EUV diagnostics in constraining the thermal plasma distribution over time.

O-22

SuperSynthIA: Bringing Hinode/SOT-SP Vector Magnetograms to the Full Disk at High Cadence

D. Fouhey (NYU/U. Michigan), R. Wang (NYU), R. Higgins (U. Michigan),
S. Antiochos (U. Michigan), G. Barnes (NorthWest Research Associates),
J. Todd Hoeksema (Stanford U.), K.D. Leka (NorthWest Research Associates),
Y. Liu (Stanford U.), P. W. Schuck (NASA GSFC),
and T. I Gombosi (U. Michigan)

The Solar Optical Telescope - Spectro-Polarimeter (SOT-SP) instrument onboard the Hinode mission and its associated analysis pipeline provide highly accurate information about the vector magnetic field of the Sun's photosphere. SOT-SP's accuracy, however, comes at the price of a limited field of view and long acquisition times. Accordingly, applications needing high-cadence and full-disk observations use instruments like the Helioseismic and Magnetic Imager on the Solar Dynamics Observatory (SDO/HMI), which offers fast full-disk acquisition at the cost of artifacts that can stymie progress in analysis and modeling.

We use deep learning to obtain vector magnetograms that extend the quality of Hinode/SOT-SP to the full disk with the fast cadence of SDO/HMI. As input, our SuperSynthIA model accepts SDO/HMI Stokes observations; as output, SuperSynthIA is trained to produce SOT-SP-like vector magnetograms, including the Level 2.1 disambiguated data that is in heliographic coordinates. We train and evaluate SuperSynthIA on a dataset of over 17,500 co-aligned scans spanning a decade of observation by Hinode and SDO and including all latitudes. The resulting SuperSynthIA data products are accurate across both the full disk, including the poles.

Thanks to the SOT-SP data and learning algorithm used, SuperSynthIA shows a substantial reduction in key artifacts. Compared to HMI, we find a strong reduction in a viewing-angle artifact that limits data assimilation to disk center, as well as large reductions in short-term magnetogram disambiguation inconsistency and 24-hour oscillations in field strength that hamper temporal modeling efforts. Compared to previous deep learning models for this task, SuperSynthIA produces disambiguated, heliographic magnetic fields and mitigates unphysical preferences in angles. As a final benefit, each data product can be obtained with a single forward pass of a deep network.

O-23

Solar coronal magnetic field measurements using spectral lines available in Hinode/EIS observations: strong and weak field techniques and temperature diagnostics

Y. Chen (MPS), X. Bai (NAOC), H. Tian (PKU), W. Li (NAOC), F. Chen (NJU), and Z. Yang (PKU), and Y. Yang (FDU)

Recently, it has been proposed that the magnetic-field-induced transition (MIT) in Fe X can be used to measure coronal magnetic field strengths. Several techniques, the direct line ratio technique and the weak and strong magnetic field techniques, are developed to apply the MIT theory to spectroscopic observations taken by EUV Imaging Spectrometer (EIS) onboard Hinode. However, the suitability of coronal magnetic field measurements based on the weak and strong magnetic field techniques has not been evaluated. Besides, temperature diagnostics is also important for measuring coronal magnetic field based on the MIT theory, but how to determine the accurate formation temperature of the Fe X lines from EIS observations still needs investigation. We synthesized emissions of several spectral lines from a 3D radiation magnetohydrodynamic model of a solar active region and then derived magnetic field strengths using different methods. We first compared the magnetic field strengths derived from the weak and strong magnetic field techniques to the values in the model. Our study suggests that both weak and strong magnetic field techniques underestimate the coronal magnetic field strength. We also developed two methods to calculate the formation temperature of the Fe X lines. One is based on differential emission measure analyses, and the other is deriving temperature from the Fe IX and Fe XI line pairs. However, neither of the two methods can provide temperature determination for accurate coronal magnetic field measurements as those derived from the Fe X 174/175 and 184/345 Å line ratios. More efforts are still needed for accurate coronal magnetic field measurements using EIS observations.

O-24

Coordinating Observations with Solar Orbiter

D. Williams (ESA/ESAC), M. Janvier (ESA/ESTEC), A. De Groof (ESA/ESAC),
A. Walsh (ESA/ESAC), C. Watson (ESA/ESAC), I. Zouganelis (ESA/ESAC),
D. Mueller (ESA/ESTEC), and L. S. Duarte (ESA/ESAC).

As Solar Orbiter enters its fourth science perihelion, we report on the evolution of the coordination process of joint observations between Solar Orbiter and other facilities in space and on the ground. We will describe what has worked well, what has needed improvement, and the lessons learned for the near-term future. This presentation may be considered timely, since Solar Orbiter will conclude its Nominal Mission Phase in late 2025, after which point the orbit and science focus will both evolve.

Day 4
September 28 (Thu)

Metcalf Travel Award Lecture

Dark Halos around Active Regions: emission properties of the Dark Halo around NOAA 12706

S. M. Lezzi (INAF/OACN), V. Andretta (INAF/OACN), M. Murabito (INAF/OACN), and G. Del Zanna (DAMTP)

Dark Halos (DHs) are areas surrounding active regions of reduced emission relative to the Quiet Sun (QS) that are visible only at certain wavelengths. They were observed for the first time in the chromosphere in the Ca II h&k lines (Hale & Ellerman 1903) and were later associated to the Hα fibril vortex around active regions. With the advent of UV/EUV instruments, it has been possible to observe DHs also in Transition Region, for instance in SOHO/SUMER S VI at 933 Å line, and corona, especially in the SDO/AIA 171 Å band. However, the counterparts of chromospheric DHs in these outer layers are poorly studied. Moreover, the origin, global structure, and evolution of DHs is still largely unknown. Furthermore, they are often mistaken for Coronal Holes (CHs), as to date there are no studies analyzing the differences between the properties of these two types of solar structures.

We present the first characterization of the emission properties of a DH, the one around AR NOAA 12706, that includes chromospheric, Transition Region and coronal observations, by using IRIS spectra from full-disk mosaics and SDO/AIA filtergrams. We also analyze SDO/HMI magnetograms to study its average magnetic field properties. We find that the DH has an emission lower than the QS in all IRIS lines and in the cooler AIA wavebands. Our work also reveals that the DH shape has undergone a morphological transformation passing from the chromosphere to the corona. In addition, we found evidence that DHs and CHs exhibit different behaviors, suggesting they are distinct types of structures on the Sun.

O-25

Can the solar p-modes contribute to the high-frequency transverse oscillations of spicules?

H. Kuniyoshi (U. Tokyo), M. Shoda (U. Tokyo), R. J. Morton (Northumbria U.), and T. Yokoyama (Kyoto U.)

Spicules serve as vital indicators of transverse waves in the solar atmosphere, and their study is crucial for understanding the wave heating process of the corona. Recent observations have focused on "high-frequency" transverse waves, with periods shorter than 100 s, which have the potential to transport sufficient energy for coronal heating. These high-frequency spicule oscillations are unlikely to originate from the granular motions that exhibit much longer periods of 5-10 min. Instead, it is proposed that they are generated through mode conversion from high-frequency longitudinal waves that arise from shock steepening process. Therefore, these oscillations may not solely be produced by the horizontal buffeting motions of granulation but also by the leakage of p-mode oscillations. To investigate the contribution of p-modes, our study employed two-dimensional magneto-convection simulations spanning from the upper convection zone to the corona. During the course of the simulation, we introduced a p-mode-like driver at the bottom boundary. The results revealed the mean velocity amplitudes and oscillation periods of 4.4±5.0 km/s and 49±48 s for the without p-mode stage, and 4.7±4.9 km/s and 56±59 s for the with p-mode stage, indicating that p-modes have a negligible impact on high-frequency spicule oscillations, with granulation being the primary driver.

O-26

EUV synthesis toward the measurement of transition-region temperature distribution with SOLAR-C

T. Oba (NAOJ), A. Tei (NAOJ), T. Yokoyama (Kyoto U.),
S. Toriumi (ISAS/JAXA), S. Imada (U. Tokyo),
and H. Hara (NAOJ)

The solar transition region (TR) is the thin interface connecting the chromosphere and the corona, increasing its temperature by two orders of magnitude. The spherical one-dimensional atmosphere of the TR has been reported to fail in modeling the observed temperature distribution, namely DEM, and accordingly several types of three-dimensional models have been proposed. One of the major candidates is a low-lying loop model, in which small magnetic bipoles within the supergranular network forms numerous loops at a spatial scale smaller than a few arcsec. However, it is still under debate. For properly modeling the TR structure, SOLAR-C is a key instrument because this spectrometer is to diagnose the plasma by covering all the temperatures of the TR, offering a spatial resolution of 0.4 arcsec. In this study, to see how SOLAR-C can proceed our understanding of the temperature distribution of the TR, we synthesize the EUV spectral lines in the numerically-simulated atmosphere reproduced with the coronal extension version of the MURaM code.

The calculated intensity map of the Ne VII 465.2 Å (its formation temperature peaks at logT~5.7) shows not only the large-scale loop but also small brightening features, and the latter would not have been resolved by the previous EUV spectrometers such as Hinode/EIS. The amount of the intensity of the brightening features accounts for a few 10% with respect to the total intensity, contributing to the DEM. We identify the mechanism to form this small brightening feature: because the geometrical height of the TR is severely corrugated, the thickness of the TR to the observer is made to be large in the line-of-sight direction, resulting in a highly-brightened structure under the optically thin regime. This mechanism can be tested by the density diagnostic technique using a line ratio, such as O V lines to be observed with SOLAR-C.

O-27

Spatially Resolved Plasma Composition Evolution in an X-class Flare

A. S.H. To (MSSL/UCL), S. Imada (U. Tokyo), D. H. Brooks (George Mason U.),
L. van Driel-Gesztelyi (MSSL/UCL/LESIA/Konkoly Observatory),
R. J. French (NSO), D. M. Long (QUB), and D. Baker (MSSL/UCL)

We analyse the coronal elemental abundances of the X8.2 flare on 2017 September 10 using spatially resolved measurements from Hinode/EIS. The loops in this flare exhibit a large variation of coronal abundances. The loop-tops show enhanced coronal abundances, as determined by the Ca XIV 193.87 Å/Ar XIV 194.40 Å and Fe XVI 262.98 Å/S XIII 256.69 Å composition diagnostic ratios, which gradually approach photospheric values along the loop towards its footpoints. We propose that this variation could be caused by two physical processes. The highly fractionated loop-top could potentially be linked to plasma downflow from the current sheet, which has coronal abundances, while the change in abundance values from coronal to photospheric levels from the looptop to its footpoints may be due to mixing between highly fractionated downflow plasma and chromospheric ablated plasma with photospheric or even inverse-FIP abundances. These findings provide a potential explanation for the composition discrepancy observed in Sun-as-a-star flare composition measurements, where the composition of flares are often observed to be close to photospheric. This study suggests the importance of spatially resolved measurements and calls for further studies to confirm these findings.

O-28

Evolution of Plasma Composition During an M-class Flare

T. Mihailescu (UCL/MSSL), P. Young (NASA GSFC),
L. Green, D. Baker (UCL/MSSL), D. Long (QUB),
and L. van Driel-Gesztelyi (UCL/MSSL/Observatoire de Paris/Konkoly Observatory)

One of the major open questions in solar physics is why the elemental abundance of some regions in the solar corona is different to that of the underlying photosphere. Addressing this question requires the bringing together of spectroscopic data with theories that address the plasma transport mechanisms. For example, models suggest that the abundance changes take place in the chromosphere, and, in non-flaring regions, the fractionated plasma is then transported from the top of the chromosphere upwards to the corona via diffusion. In flaring regions, however, the main mechanism of bringing mass into the corona is ablation of plasma from lower down in the chromosphere. Interestingly, this results in a different plasma composition behaviour in the corona. Thus, plasma composition observations can provide insights into how energy is transported from the flare reconnection region to the lower layers of the solar atmosphere. In this work, we investigate these scenarios using a Hinode EIS high cadence sit and stare dataset, including the Ca XIV 193.874 A and Ar XIV 194.396 A spectral lines, of the M-class flare and filament eruption at 13:00 on the 2nd April 2022. This dataset provides a rare opportunity to investigate the temporal evolution of the coronal plasma composition during the flare, and how it is linked to the complex suite of processes that take place during this event.

I-11

The SOLAR-C mission: Toward a new era of high-resolution solar physics research

T. Shimizu (ISAS/JAXA) and international SOLAR-C team

The SOLAR-C mission has made a great progress in the last year toward the current target date of the launch in July 2028. This presentation will report on the latest status of the mission to be shared with the meeting participants. The SOLAR-C mission will carry the EUV High-Throughput Spectroscopic Telescope (EUVST), which is a state-of-the-art EUV imaging spectrometer with slit-jaw imaging system, that will simultaneously observe the solar atmosphere from the photosphere/chromosphere up to the corona with seamless temperature coverage, high spatial resolution (0.4”), and high throughput for the first time. An EUV irradiance monitor, SoSpIM, will also be equipped to the EUVST as a complimentary instrument to monitor the EUV radiation at two wavelength bands from the entire Sun, contribute to the EUVST intensity calibration, and link solar knowledge into the influence to the Earth atmosphere. The mission is the 4th in the series of JAXA competitively chosen M-class science mission to be launched by Epsilon S rocket vehicle and installed into a sun-synchronous polar orbit. The international collaboration scheme has been established with NASA, ASI, CNES, DLR, SSO and ESA. The JAXA’s project is at the System Definition Review for moving to Phase B. Advances in EUV spectroscopy to be achieved with the SOLAR-C are expected to bring new observational findings and knowledges for answering important questions existing in the solar outer atmosphere. The coordinated observations with NASA’s MUSE mission and large-aperture ground-based telescopes will become a power tool in solar physics later in this decade.

I-12

The Multi-slit Solar Explorer (MUSE)

B. De Pontieu (LMSAL) and the MUSE team

In this talk I will provide a brief overview of the upcoming Multi-slit Solar Explorer (MUSE) mission, which is scheduled for launch in 2027. MUSE is a NASA MIDEX mission, composed of a multi-slit EUV spectrograph (in three narrow spectral bands centered around 171Å, 284Å, and 108Å) and an EUV context imager (in two narrow passbands around 195Å and 304Å). MUSE will provide spectral and imaging diagnostics of the solar corona at high spatial (~0.5 arcseconds), and temporal resolution (down to ~0.5 seconds) thanks to its innovative multi-slit design. By obtaining spectra in 4 bright EUV lines (Fe IX 171Å, Fe XV 284Å, Fe XIX-XXI 108Å) covering a wide range of transition region and coronal temperatures along 37 slits simultaneously, MUSE will be able to ``freeze" (at a cadence as short as 10 seconds) with a spectroscopic raster the evolution of the dynamic coronal plasma over a wide range of scales: from the spatial scales on which energy is released (<0.5 arcsec) to the large-scale often active-region size (~ 170 arcsec x 170 arcsec) atmospheric response. The MUSE science investigation is highly synergistic with that of Solar-C/EUVST and coordination with EUVST will be a key priority for MUSE. I will present some thoughts regarding how optimal coordination between these missions can help address some of the major outstanding unresolved issues in the physics of the low solar atmosphere, including heating of the corona and the mechanisms driving solar flares and coronal mass ejections.

I-13

Scientific Objectives of SOLAR-C and Strategies to Achieve

S. Imada (U. Tokyo), and International SOLAR-C Team

SOLAR-C is designed to comprehensively understand the energy and mass transfer from the solar surface to the solar corona and interplanetary space, and to investigate the elementary processes that take place universally in cosmic plasmas. The proposed mission is a fundamental step for answering how the plasma universe is created and evolves, and how the Sun influences the Earth and other planets in our solar system. The two primary science objectives for SOLAR-C are: I) Understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind, II) Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions. SOLAR-C will, A) seamlessly observe all the temperature regimes of the solar atmosphere from the chromosphere to the corona at the same time, B) resolve elemental structures of the solar atmosphere with high spatial resolution and cadence to track their evolution, and C) obtain spectroscopic information on the dynamics of elementary processes taking place in the solar atmosphere. In this talk, we will first discuss the science target of the SOLAR-C, and discuss the strategies for achieving these scientific objectives.

I-14

Addressing SOLAR-C/EUVST science: observations + models

I. Ugarte-Urra (NRL)

The main goal of the SOLAR-C/EUVST mission is to understand the origins of solar activity by observing fundamental processes in the solar atmosphere. EUVST will provide high spatial resolution, sensitivity and temporal cadence, combined with an unprecedented "seamless" temperature coverage from chromosphere to corona. In this presentation, we discuss how the synergy between the EUVST observations and the state-of-the-art numerical simulations of these processes is essential to the success of the mission in addressing the science objectives.

I-15

Aditya L1 mission updates and possible Synergies with Solar C

D. Banerjee (ARIES) and Aditya team

Aditya L1 mission is the first observatory class solar mission from the Indian Space Research organization, expected to be launched in 2023. With a combination of four remote sensing and 3 in situ instruments covering multi-wavelength it provides a unique opportunity to have joint observations with other co temporal missions. I will give a quick summary update of the status of the mission and possible coordinate observing camping we should plan ahead of time. The synergies of the transients studies of on disk observations from Solar C and Aditya Off-disk spectroscopic capabilities will be emphasized.

I-16

DKIST, the High-Resolution Solar Polarimeter, Early Results and Science Connections to EUVST and MUSE

S. Jaeggli, A. Tritschler, T. Schad, L. Tarr, and T. Rimmele (NSO)

The Daniel K. Inouye Solar Telescope (DKIST) is the U.S. National Science Foundation's new flagship facility for solar observations, offering diffraction-limited 20 km resolution at 500 nm enabled by the 4-meter main mirror of the telescope and high-order adaptive optics system. DKIST instruments provide access to a wide variety of wavelengths throughout the visible and infrared, targeting polarized diagnostics for characterizing the magnetized solar plasma, both in the lower solar atmosphere and above the solar limb in the corona. DKIST is currently conducting science observations and progressively ramping up observing modes offered to the community. The next generation of high resolution EUV spectrographs, including the Multi-Slit Solar Explorer (MUSE) and the EUV Solar Telescope (EUVST), will be launching in the next few years and provide an exciting opportunity for complimentary observations. Using the coronal temperature sensitivity of EUVST with the dynamic capabilities of MUSE and the magnetic characterization from DKIST, we will be able to gain knowledge of how mass, radiation, and magnetic field interact, from the lower solar atmosphere to the corona, and address many outstanding questions in solar physics.

O-29

How can IRIS and Solar-C improve our understanding of the campfires observed by Solar Orbiter/EUI?

M. Dominique, A.N. Zhukov (ROB/STCE), C. Nelson (ESA/ESTEC),
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Thanks to its high spatial resolution and specific orbit which brings it in the Sun's vicinity, the EUI/HRIEUV telescope onboard Solar Orbiter has provided coronal observations with an unprecedented level of details. One of its main discoveries is the presence of multiple small-scale brightenings, called campfires, all over the Sun surface and in particular in quiet-Sun regions, where they tend to track the chromospheric network. Those campfires, which last typically less than 100s, are thought to be associated with apex heating up to coronal temperatures of low-lying loops (a few Mm above the photosphere). Simulations demonstrate that magnetic reconnection could be at the origin of this heating process. Hence, campfires would not be different than small-scale flares. Because of their huge number, despite their small size, they could contribute significantly to coronal heating.

In EUI observations, evidence of those campfires was only found in the HRIEUV images at 17.4 nm, although associated fuzzier brightenings have been reported in the 17.1 nm, 19.3 nm, 21.1 nm, and 30.4 nm pass-bands of SDO/AIA. Co-located brightenings have also been reported in the slit-jaw images and spectra of IRIS. However, despite the presence of a Lyman-Alpha camera, no detection was confirmed so far at this wavelength of EUI. This lack of observation may be related to the poorer resolution of that channel or it may be an intrinsic property of these campfires being confined to the temperature of the EUV channel.

In this presentation, we review the status of the analysis of campfires and provide perspectives, emphasizing the role that can be played by IRIS and Solar-C/EUVST.

O-30

CMEx: The Chromospheric Magnetism Explorer

P. Bryans (HAO) and the CMEx Team

CMEx is a mission concept submitted to NASA's Heliophysics SMEX program that, if selected, will fly in 2028. CMEx uses ultraviolet spectropolarimetry to diagnose magnetism from the solar photosphere to the transition region, leveraging the heritage of both IRIS and Hinode. CMEx explores how the magnetic field evolves from the $\beta \gg 1$ photosphere to the $\beta \ll 1$ corona to form twisted non-potential flux ropes in the corona that are the energy storage devices for magnetic eruptions. This key β transition happens in the chromosphere where only UV spectropolarimetry gives access to the highly complex dynamics where plasma properties change rapidly. Recent advances in the understanding of the polarization of UV chromospheric lines, which are not observable from the ground, have primed a space-based mission like CMEx for success.

Day 5
September 29 (Fri)

I-17

Numerical Modeling for the MUSE Mission

M. Cheung (CSIRO), J. Martinez-Sykora (BAERI), P. Testa (SAO),
B. De Pontieu (LMSAL) and the MUSE team

The Multi-Slit Solar Explorer (MUSE) science team has embarked on the development of a numerical modeling framework connecting physical quantities in simulations with MUSE observables. The objectives of this framework are to: (1) demonstrate the capabilities of the MUSE mission, (2) maximise the scientific return from MUSE, (3) develop appropriate (co)observing modes for investigating diverse phenomena, and (4) push the limits of state-of-the-art models. The presentation will also discuss how this modeling framework may benefit other observatories, including EUVST and DKIST.

I-18

SoSpIM overview

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and S. Krucker (FHNW)

The JAXA SOLAR-C mission is designed to comprehensively understand how mass and energy are transferred throughout the solar atmosphere. The EUV High-Throughput Spectroscopic Telescope (EUVST) onboard does this by observing all the temperature regimes of the atmosphere from the chromosphere to the corona simultaneously. To enhance the EUVST scientific capabilities, there will be a Solar Spectral Irradiance Monitor (SoSpIM). SoSpIM will work hand-in-hand scientifically with EUVST, by providing the full Sun irradiance at sub-second time cadence combined with the spatially resolved spectroscopy from EUVST. The SoSpIM instrument will specifically address two aspects. These are:

- Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares - achieved through probing fast time cadence solar flare variations.
- Measuring solar irradiance that impacts the Earth's thermosphere and the mesosphere, linking to spatially resolved measurements of the solar atmosphere with EUVST.

SoSpIM will provide high time resolution measurements in 2 channels (a) in the corona through channel 1 (EUV: 170-215 Å) and (b) in the lower atmosphere through channel 2 (Lyman alpha: 1115-1275 Å). Each channel impacts different layers of the Earth's atmosphere.

I-19

Solar radiation wavelength that directly generates the Earth's ionospheric E-layer

A. Ieda (Nagoya U.), K. Watanabe, S. Kitajima (NDAJ), M. Nishioka, H. Jin (NICT), and T. Hori (Nagoya U.)

Solar radiation ionizes the Earth’s neutral atmosphere to generate the ionosphere. The ionospheric E-layer is characterized by the presence of horizontal electric currents, which cause geomagnetic variations. These quantities are often modeled using the maximum electron density of the E-layer. According to Chapman's ionospheric formation theory, this maximum electron density is proportional to the square root of the ionizing solar flux. The solar radio flux F10.7 (10.7 cm, 2.8 GHz) index has often been utilized as a proxy for the solar flux in models associated with the E-layer. However, such usage of F10.7 may be inappropriate because the E-layer is theoretically not generated by solar radio waves, but rather by Lyman β.

In this study, we compared the maximum electron density with solar fluxes, namely, the F10.7 index, Lyman β (103 nm), and Lyman α (122 nm). Data from 1991 to 2023 were used for least squares analyses. We used the Lyman α data (daily values) collected by the University of Colorado using multiple satellite observations. We calculated Lyman β flux using an empirical relationship with Lyman α. Hourly values of maximum electron density were obtained from ionosonde observations conducted at Yamagawa station in Kagoshima, Japan, operated by the National Institute of Information and Communications Technology.

Although the resultant correlation coefficients were similar among the three solar flux quantities, the fitted straight lines showed qualitative differences regarding the origin. The line fitted to the Lyman β data passed near the origin, suggesting that Lyman β directly generates the Earth's ionospheric E-layer. In contrast, the line fitted to the F10.7 index deviated from the origin, implying that the offset of F10.7 index should be subtracted in models associated with the E-layer. This correction presumably improves models of ionospheric electric conductivity, horizontal electric currents, geomagnetic variations, and Joule heating.

I-20

Center for Heliospheric Science: a core center to promote heliospheric system science

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T. Hori, S. Nakamura, C.-W. Jun, A. Shinbori, T. Sori, S. Masuda, K. Kusano , K. Iwai,
T. Matsumoto, H. Iijima, T. Segawa, K. Shiokawa (Nagoya U.),
K. Asamura, T. Shimizu, S. Toriumi (ISAS/JAXA),
S. Matsuda (Kanazawa U.), H. Hara, and Y. Katsukawa (NAOJ)

The Institute for Space-Earth Environmental Research, Nagoya University, JAXA, and NAOJ have established “Center for Heliospheic Science (CHS)”. In the 2020s, many spacecrafts are in operation in the inner heliosphere, and more will join them one after another. This is a unique opportunity to realize multi-point observations in the inner heliosphere in conjunction with remote observations on the solar atmosphere, and a system science approach is important to understand various phenomena in the heliospheric system. To promote the heliospheric system science, we need to carry out the integrated data analysis, which is a comprehensive analysis combining data from various observations and simulations. The CHS commits to the development and maintenance of standardized data files for Hinode, Arase, BepiColombo Mio, and the upcoming SOLAR-C missions, utilizing standardized data file formats such as CDF and FITS. Furthermore, the CHS is dedicated to the development and release of integrated analysis software as a plugin for SPEDAS/PySPEDAS and SolarSoftWare. Additionally, the CHS plays a crucial role in coordinating observation plans to maximize the scientific outputs from these missions. This presentation will provide an overview of the mission of the CHS, its current activities, and future perspectives.

I-21

Contribution of the BepiColombo mission to heliospheric system science: overview of interplanetary cruise observation

G. Murakami (ISAS/JAXA), and J. Benkhoff (ESA)

International Mercury exploration mission BepiColombo was launched in 2018 and will arrive at Mercury in 2025. During the interplanetary cruise phase, BepiColombo will range from 1.2 AU to 0.3 AU, and will stay in the inner heliosphere for long time. BepiColombo started its science observations during the interplanetary cruise phase in 2020. The initial results showed its enough performance to observe solar wind electrons, IMF, solar energetic particles (SEPs), and coronal mass ejections (CMEs) even in the composite spacecraft configuration. Especially in 2021 and 2022 two spacecraft of BepiColombo, Mercury Planetary Orbiter (MPO) and Mercury Magnetosphere Orbiter (Mio), successfully detected many solar events. BepiColombo can contribute to leading and expanding the heliospheric system science. In addition to BepiColombo, NASA's Parker Solar Probe and ESA's Solar Orbiter are also exploring the inner heliosphere. Coordinated observations between these multi spacecraft have been planned and performed. Ground based observations (interplanetary scintillation) and simulations (e.g., SUSANOO) can also be powerful tools to lead interdisciplinary studies. Here we present the overview and initial results of interplanetary cruise observations by BepiColombo.

Posters

P-1

What drives peacock jets?

S. Danilovic (Stockholm U.)

A combination of theoretical models with observations obtained by Yohkoh, Hinode, SDO, IRIS, and, since recently, Solar Orbiter space missions have revealed a wide range of jet-type features. They extend from a few to a few tens of megameters in height and seem to appear everywhere in the quiet Sun, coronal holes and active regions with varying prevalence. While there are several existing theories as to what drives anemone-type jets and surges, the field configuration necessary for the formation of peacock-type jets is more evident. The size and dynamics of peacock jets can vary, but the common property found in observations is a clear intrusion into a strong magnetic field region e.g. umbra or pore. In this study, we present an observation-inspired model of a peacock jet. By reproducing the overall direction of emerging with respect to the preexisting field, the simulations reproduce the morphology of the jet remarkably well. The jet is formed as the newly emerging flux rams into a cluster of pores and remains present during the next 20 min as long as it takes for the emerging field to push through and completely divide the strong unipolar field region. We compare both ground- and space-based observations with synthetic counterparts and discuss similarities and differences. We also discuss in detail the acceleration and collimation mechanisms at work and compare them to the standard jet theory. We show that the cool material visible in the Halpha line is ejected similarly to the cool jet in the standard jet model, but we found no indication of the so-called slingshot effect.

P-2

Properties of decayless oscillations in small-scale loops observed in quiet Sun and coronal holes

A. K. Shrivastav (ARIES), V. Pant (ARIES), D. Berghmans (ROB),
A. N. Zhukov (ROB), T. Van Doorsselaere (KU Leuven), E. Petrova (KU Leuven),
D. Banerjee (ARIES), D. Lim (KU Leuven, ROB), and C. Verbeeck (ROB)

Decayless oscillations are common in the solar atmosphere and a possible candidate for coronal heating. Decayless oscillations in coronal loops with a few hundred Mm lengths have been explored extensively, but the properties of these oscillations in small-scale loops are yet to be explored. We present the statistical analysis of decayless kink oscillations in small loops rooted in the quiet corona and coronal holes. We utilise high resolution observations from the Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter. We find 42 oscillation events in loops with an average loop length of ~10 Mm. The average displacement amplitude is computed to be ~136 km. The oscillations period has a range of ~27 to 276 s. The observed kink speeds are smaller than those observed in the active region loops. The coronal seismology showed an average magnetic field value of 2.1 G. We estimate the energy flux with a broad range of ~1-314 W/m-2. We obtain that high-frequency decayless oscillations, which carry enough energy to overcome the radiative losses in the quiet regions, are not prevalent. Therefore, our study indicates that the energy flux in decayless oscillations in small-scale coronal loops is not sufficient to maintain the radiative losses in the quiet Sun and accelerate the solar wind in coronal holes.

P-3

Investigating Wave Propagation above the Inter-Network Quiet Sun: A new insight from IRIS Observations

K. Sangal (IIT), A.K. Srivastava (IIT), P. Kayshap (VIT),
Ding Yuan (ISSAT/ Shenzhen Key Laboratory of Numerical Prediction for Space Storm/ Key Laboratory of Solar Activity and Space Weather, NSSC, CAS)
and E. Scullion (Northumbria U.)

We study a very complex physical scenario of wave propagation in the solar atmosphere by analyzing spectroscopic observations of the quiet sun recorded by the IRIS spectrograph. Our study aims to examine the behavior of various IRIS spectral lines, including Fe I 2799.972 A (put proper symbol) and Mn I 2801.907 Å in the photosphere, Mg II h 2802.704 Å in the chromosphere, and Si IV 1393.755 Å in the transition region. To determine the dominant oscillatory periods, we investigate the Doppler velocity time-series at different locations in the internetwork region. To carry out the analysis, we utilize wavelet tools such as power, cross-power, coherence, and phase difference, along with a generic noise model consisting of a power-law and constant components. Our findings indicate that oscillations in the photosphere exhibit a period of 5 minutes, while the chromosphere exhibits oscillations with a period of 3 minutes. In the transition region (TR), we observe a range of oscillation periods with dominant periods occurring at 3, 8, and 12 minutes. In order to explore the relationship between TR oscillations and photospheric oscillations, we perform the phase difference between velocity signals at two distinct heights. Our analysis reveals a significant correlation between the 3-minute periods in the TR and photospheric oscillations, suggesting that 3-minute oscillations in the TR might propagate from the photosphere. Additionally, we analyze the phase difference between chromospheric oscillations and photospheric oscillations, demonstrating that only the 3-minute oscillations propagate upwards. TR carries both its intrinsic long-period oscillations generated in situ, and some photospheric oscillations which are also able to reach to this layer from below. In conclusion, the quiet-Sun does exhibit a very complex behaviour of the wave propagation, which indicates that local magnetic field and plasma conditions are determining the physical characteristics of their propagation.

P-4

Investigating the role of diffusion effects in the fractionation of minor elements in solar loops, using a multi-specie high-order 1-D model

N. Poirier (RoCS/ITA), M. Lavarra (IRAP), A. Rouillard (IRAP), M. Indurain (IRAP), P.-L. Blelly (IRAP), V. Réville (IRAP)

We investigate several mechanisms that may produce abundance variations in solar loops, called as the First Ionization Potential (FIP) effect. We develop and exploit a multi-specie 1-D model of the solar atmosphere (called IRAP's Solar Atmospheric Model: ISAM) that solves, along a given magnetic field line, the transport of neutrals and charged particles from the chromosphere to the corona. We follow a high-order approach that allows to solve additional coupled transport equations for the heat flux, and that includes both friction and thermal diffusion effects. Thanks to a comprehensive treatment of collisions, we can analyze in detail the collisional coupling of minor species to protons. We found that depending of the nature of the interaction with protons, a fractionation between low and high FIP elements settles rapidly in the upper chromosphere up to the typical observed levels. However, under constant heating conditions we observed that this fractionation can take much longer (up to a few days) to propagate further into the corona, and hence also depends on the history of the loop. Seamless measurements of abundance variations from the chromosphere to the corona (to be later provided by e.g. SOLAR-C EUVST) become essential to better constrain such models, which in turn can prove to be valuable for the understanding of atmospheric heating. This work has been funded by the ERC SLOW_SOURCE and NRC ORCS projects.

P-5

Spectroscopic and time-dependent observational constraints on models of energy release in long-lived active region loops

W. T. Barnes (AU/NASA GSFC), H. P. Warren (NRL), and J. W. Reep (NRL)

Observations of coronal loops at the periphery of active regions have been found to be steady, lasting much longer than a radiative cooling time, and near-isothermal at approximately 1.5 MK. These relatively steady and high-density structures cannot be explained by either hydrostatic loop simulations or impulsive nanoflare heating and thus pose a challenge to existing heating models. In this presentation, we present Hinode EIS and SDO AIA observations of such loop structures from NOAA 11575 as observed on 29 September 2012. From these observations, we compute density diagnostics, emission measure distributions, filter ratios and time lags of the isolated loop structures. Additionally, we present model results from hydrodynamic simulations of these loop structures for several different heating scenarios, include steady uniform heating, stratified footpoint heating, and impulsive heating. From our model results, we derive density and temperature diagnostics in order to constrain the parameter space of feasible heating models using our observations. Comparing our observations and model results, we find that none of our proposed heating scenarios is able to fully reproduce the set of observed diagnostics and that in particular, the derived densities are most difficult to reproduce. We discuss these results in the context of current approaches to modeling energy release in loops in quiescent active regions.

P-6

Transverse Oscillations of Small Magnetic Loops in the Solar Transition Region and Corona

Y. Gao (PKU/KU Leuven), T. Van Doorsselaere (KU Leuven),
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J. Guo (KU Leuven/NJU), and S. Skirvin (KU Leuven)

Magnetic loops are widely observed structures in the solar transition region and corona. As closed magnetic flux tubes, they can act as important waveguides for MHD waves, particularly transverse waves/oscillations. In recent coronal observations, transverse oscillations in small magnetic loops have been frequently studied, uncovering two different types of decayless kink oscillations. The first type displays shorter periods that exhibit a linear correlation with loop lengths, indicating their nature as standing kink eigenmodes. The second type, first detected by us in 2022, is mainly observed in coronal bright points (CBPs). These oscillations have longer periods that show no linear scaling with loop lengths. Notably, a peak at approximately 5 minutes in the period distribution histogram suggests that these oscillations could be externally driven oscillations or propagating waves excited by photospheric p-modes. With 3D MHD simulations, we find that both types of oscillations can be excited by p-modes in short coronal loops. This implies that p-modes may contribute to coronal heating by exciting decayless transverse oscillations in small loops. On the other hand, the transition region also hosts many small-scale magnetic loop structures, especially in active regions. Our recent observation using the Interface Region Imaging Spectrograph (IRIS) reveal the existence of transverse kink oscillations in these structures for the first time. We also estimate the corresponding energy flux and conduct seismological diagnosis of magnetic field strength in these loops.

P-7

Quiet-Sun magnetism and its relation to radiative losses

A. Pastor Yabar (ISP/SU), and J. de la Cruz Rodriguez (ISP/SU)

The heating of the outer layers of the solar atmosphere is still far from being completely understood. In this sense, in the last few years we have witnessed a huge step forward in our understanding from both a theoretical and an observational perspective. This has been possible due to the inclusion of new physics in the former and the deployment of new observing facilities that has opened unprecedented technical capabilities required for the study of these highly dynamic layers. As a major result, it has been found that understanding the heating problem involves a coupled system (the solar atmosphere), thus requiring its study as a whole system.

One important missing piece in this context is the capability to observationally constrain the various physical mechanisms that heat the outer layers in the numerical simulations. In this contribution we present the application of a newly-developed inversion algorithm that expands the capabilities of the NLTE inversion code STiC to better handle inversions combining multi-resolution observations. This approach is optimum for ill-posed inferences such as chromospheric ones as it allows combining more information self-consistently. In particular, we combine observations of a quiet-Sun area co-observed in CaII K, CaII 854.2nm and FeI 617.3nm coming from the SST (CRISP and CHROMIS) together with data in MgII h&k from IRIS to infer the various physical properties of the photosphere and chromosphere, with special emphasis on chromospheric radiative losses. In order to identify specific intrinsic conditions, we make a comparative study between the various inferred parameters for a non-magnetic region, some long-standing magnetic features and a transient magnetic structure.

P-8

The Average Energy Deposition Rate in the Open Field Regions

Z. Huang (U. Michigan), G. Toth (U. Michigan), N. Sachdeva (U. Michigan),
L. Zhao (U. Michigan), B. van der Holst (U. Michigan), I. Sokolov (U. Michigan),
W. B. Manchester (U. Michigan), and T. I. Gombosi (U. Michigan)

The energy deposition rate into the solar atmosphere is critical in determining the solar wind acceleration and terminal velocity. However, this quantity is difficult to observe and has a large uncertainty. Sokolov et al. (2013) suggested that the ratio of the Alfven wave energy density to the magnetic field strength (at the surface of the Sun), which is called the Poynting flux parameter hereafter, can be approximated as 1.1 MWm^(-2)T^(-1) based on the Hinode observations by De Pontieu et al. (2007). Recently, Huang et al. (2023) used the Alfven Wave Solar atmosphere Model (AWSoM) to simulate different phases of the last solar cycle. They found that the required the Poynting flux parameter must be adjusted based on the area of the open field regions, so that the simulated solar wind can best match the OMNI solar wind observations. Moreover, the average Poynting flux parameter, which can be interpreted as the energy deposition rate for the model, is approximately constant in the open field regions in the last solar cycle. This new discovery needs to be validated with observations and can shed light on how Alfven wave turbulence accelerates the solar wind during different phases of the solar cycle.

P-9

Flux emergence thermodynamics in Coronal Holes and Quiet Sun

V. Upendran (LMSAL/BAERI/IUCAA), D. Tripathi (IUCAA), B. Vaidya (IIT Indore), M. Cheung (CSIRO), and T. Yokoyama (Kyoto U.)

The heating of solar corona and solar wind emergence are well known to be two sides of the same coin. The differences in the dynamics and thermodynamics of Coronal Holes (CHs) and Quiet Sun (QS) regions may hold the key to this differentiation. In this work, we study the differences in the dynamics of flux emergence in a funnel-topology representative of a CH and horizontal field representative of QS topology through 2.5D MHD simulations. We perform flux emergence from the convection zone to the solar atmosphere and study its interaction with the background topology by incorporating localized resistivity, thermal conduction, and optically thin radiative loss with background heating. We find plasmoids form due to interaction of the flux sheet with background field, resulting in hot outflows in the form of jets, and a local hot loop is formed due to the reconnection. We then calculate the mass flux and velocities as a result of these interaction. Finally, we perform forward modeling of spectral response in Si IV 1394 A, O IV 1401 A, O V 630 A, Ne VIII 770 A, Fe IX 171 A, Fe XV 285 A, and Fe XIX 108 A to understand the possible observational signatures in these spectral lines through future missions like MUSE and EUVST (Solar-C).

P-10

Statistical impulsive heating signatures in the solar corona

V. Upendran (LMSAL/BAERI/IUCAA), D. Tripathi (IUCAA), NPS Mithun (PRL),
S. Vadawale (PRL), and A. Bhardwaj (PRL)

The solar corona consists of a million-degree Kelvin plasma. Quiet Sun regions (QS), which form a background over which large, dynamic events occur, must be studied well to understand the presence of this million-degree plasma. In this work, we assume an impulsive heating forward model and develop an inversion code using a Convolutional neural network to infer these free parameters and their associated uncertainties for coronal light curves. We apply this inversion scheme on light curves from each pixel in the 171, 193, and 211 A passbands of Atmospheric Imaging Assembly (AIA) and disc-integrated data from X-ray Solar Monitor (XSM) from Chandrayaan - 2. We infer typical timescales, frequencies and power law slope for all data, while we are also able to provide event amplitudes for the flux-calibrated XSM data. We find the correlations between free parameters to be explained by the domination of conduction losses and the existence of an energy reservoir. The typical amplitudes of these events lie in an energy range of 1021-1024 erg, with a typical radiative loss of about ≈103 erg cm-2 s-1 in the energy range of 1-2.3 keV. These results provide further constraints on the properties of subpixel impulsive events in maintaining the quiet solar corona.

P-11

3D Radiative MHD Modeling of the Solar Transition Zone and Corona

I. N. Kitiashvili (NASA Ames Research Center), V. M. Sadykov (Georgia State U.),
A. G. Kosovichev (New Jersey Institute of Technology),
A. A. Wray (NASA Ames Research Center)

A variety of dynamical phenomena accompanied by strong thermodynamic and magnetic structural changes are of great interest in studying the solar atmosphere with high spatial and temporal resolutions. Using current computational capabilities, it is possible to model the magnetized solar plasma in different regimes with a high degree of realism. We use 3D radiative MHD models covering all layers from the upper convection zone to the corona to study the fine structure of the solar atmosphere and its dynamics. Realistic 3D radiative MHD modeling of solar magnetoconvection and the atmosphere allows us to generate synthetic observables that directly link the physical properties of the solar plasma to spectroscopic observables. We present 3D MHD simulations of quiet-Sun dynamics that cover the upper layers of the convection zone up to 25Mm above the photosphere. The simulations reveal the formation of self-organized funnel-like dynamical magnetic structures that extend through the chromosphere and corona, spontaneous heating events near the transition zone, and switch-back-like outflows. We calculate a series of synthetic spectropolarimetric imaging data that model observations from different space instruments: HMI and AIA (SDO), SOT (Hinode), and IRIS, and investigate how the observational data are linked to physical processes in the solar atmosphere. In the presentation, we discuss qualitative and quantitative changes in atmospheric structure and dynamics at different layers of the solar atmosphere, properties of acoustic and surface gravity waves, sources of local heating in the chromosphere-corona transition region, formation of shocks, and high-frequency oscillations in the corona, as well as manifestations of these phenomena in the modeled observables.

P-12

Acoustic Wave Excitation and Small-Scale Eruptive Activity in Quiet-Sun Regions

I. N. Kitiashvili (NASA Ames Research Center),
A. G. Kosovichev (New Jersey Institute of Technology),
and A. A. Wray (NASA Ames Research Center)

Realistic radiative modeling of solar dynamics is a powerful tool for understanding processes observed with high-resolution instruments in the solar atmosphere. To support the interpretation of high-resolution observations and understand the physics of observed processes, we use 3D realistic-type radiative MHD modeling from first physical principles. In this presentation, we discuss links between subsurface dynamics and the atmosphere due to vortex-tube dynamics in the intergranular lanes. In particular, we will discuss the mechanism of acoustic wave excitation in a quiet-Sun region in the presence of magnetic fields and small-scale eruptive activities, heating of the solar chromosphere, formation of spicule-like eruptions, and the manifestation of these phenomena in the Hinode observations.

P-13

3D Radiative Hydrodynamic Modeling of Multi-Scale Flows Driven by Subsurface Turbulent Convection

I. N. Kitiashvili, A. A. Wray (NASA Ames Research Center),
A G. Kosovichev (New Jersey Institute of Technology),
and V. M. Sadykov (Georgia State U.)

Spectropolarimetric observations of the solar surface and helioseismic inferences allow us to probe the dynamics, structure, and evolution of the Sun from the deep interior to the photosphere. However, modeling and explaining the observed global dynamical properties of the Sun, such as differential rotation, meridional circulation, and supergranulation, remains challenging. It has been suggested that a shallow, approximately 30-Mm deep, layer containing a strong radial gradient of the angular velocity (near-surface shear layer, or NSSL) may play a significant role in the global-Sun dynamics and dynamo. To shed light on the structure and dynamics of the NSSL, we perform 3D radiative hydrodynamics simulations in local cartesian domains located at various latitudes. In these simulations, we investigate the structure and dynamics of multi-scale turbulent flows in the presence of rotation from the photosphere to 20Mm below. The simulation results reveal the formation of the fine structure of the near-surface shear layer (so-called 'leptocline'), self-formation of meridional flows, and supergranulation. In this presentation, we will discuss the thermodynamic structure of the upper layers of the convection zone and center-to-limb effects and present a comparison with surface observations from Hinode/SOT and SDO/HMI, as well as helioseismic inferences.

P-14

Relationships between active regions and their associated solar wind

M. Chi (Shangdong U.), F. Hui (Shangdong U.), H. Zhenghua (Shangdong U.), X. Lidong (Shangdong U.)

The origin of active solar wind (plasma source) is an important problem in solar physics. A comparative analysis of the properties of the solar wind and its source region can improve the understanding of the above problems. In this study, we statistically analyze the properties of the outflow area and the magnetic condensation area (MCA) corresponding to it. Then, we study the correlation between the in-situ solar wind properties and the characteristics of the source region. Our statistical analysis revealed several key findings. The temperature in the outflow region was slightly lower than that in the MCA, while the density was significantly lower. The FIP (First Ionization Potential) bias showed variability between the two regions. There was no apparent correlation observed between the solar wind charge state O7+/O6+ and the temperature of outflow regions or MCAs. The FIP bias in the solar wind positively correlated with the remote sensing FIP bias in the outflow regions, indicating consistent with each other, statistically. These statistical results imply a close association between the active region solar wind and the outflow regions, indicating that the plasma in the active region solar wind primarily originates from the outflow region. However, it should be noted that it would be unreliable to directly speculate on the temperature of the source region based just on the abundance ratios of in-situ solar wind ions, using the assumption of ionization equilibrium. It is important to consider these findings in the context of understanding the complex relationship between active regions and the solar wind plasma they produce. Further research is needed to explore the underlying mechanisms and refine our understanding of the source properties of the active region solar wind.

P-15

Small EUV brightenings detected by HRI-EUV on board Solar Orbiter: estimation of their temperature with Solar Orbiter/SPICE and Hinode/EIS

A. Dolliou (IAS), S. Parenti (IAS), and K. Bocchialini (IAS)

The Solar corona is heated above the MK from the photosphere. One of the main theories explaining this heating (Parker, ApJ, 1988) suggests that the energy is deposited into the corona through a high number of impulsive, low energetic (1E24 ergs) heating events, called “nanoflares”. On May 30 2020, 1463 small (400 – 4000 km) and short lived (10-200 s) EUV brightenings were detected in the Quiet Sun (QS) by the high resolution UV imager HRI-EUV (174 Å), on board Solar Orbiter. These may be the signatures of the heating energy deposition.

As HRI-EUV is sensible to both coronal (i.e. Fe X) and TR (i.e. O VI) lines, our goal is to verify if these brightenings indeed do reach coronal temperatures. Dolliou at al. 2023, using the only data available on that date (6 EUV channels of the SDO/AIA imager) found no unique signature of a heating above the MK.

To confirm this result, here we use more recent UV-EUV spectroscopic (Solar Orbiter/SPICE and Hinode/EIS) data. Our work uses QS observations of Solar Orbiter HRI-EUV and SPICE coordinated with Hinode/EIS on the 8 and 17 March 2022.

Our results show that these EUV brightenings are visible in both HRIEUV and in the transition region lines of SPICE (i. e. O VI, log Te = 5.5 K), but rarely in the Ne VIII (log Te = 5.8 K) and never in the Mg IX (log Te = 6.0 K) lines. As Mg IX is an overall a weak line in the QS, we attempt a temporal and temperature analysis also using the Fe lines of EIS. We discuss here the possibility of detecting these small brightenings in the EIS data.

P-16

Spectroscopic Observations of the Solar Corona in the Visible, Extreme Ultraviolet, and Near-Infrared during the 2017 Total Solar Eclipse

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Total solar eclipses are one of the best opportunities to study the elemental composition and plasma properties of the solar corona within 2-3 Rsun (solar radii) above the solar surface. In this study, we present spectroscopic observations of the solar corona acquired during the 2017 August 21 total solar eclipse with a three-channel partially multiplexed imaging spectrometer operating at extremely high orders (> 50). The slit was 4 Rsun long and scanned from the central meridian to a heliocentric distance of approximately 1.5 Rsun off the east limb throughout totality. The line widths and Doppler shifts of the Fe X (637.4 nm) and Fe XIV (530.3 nm) emission lines, when present, yielded effective ion temperatures (Teff) and speeds along the line of sight in different coronal structures such as streamers and coronal holes (CHs). We found the Teff of Fe XIV in the streamer ranges from 4 to 5 MK, which is higher than the Teff in the active region (2.5-3 MK). We also confirmed an increase in the Fe X line width between 1.0 tP-1.3 Rsun in the polar CH. The plasma diagnostics inferred from the eclipse emission line profiles are consistent with the results obtained from the extreme ultraviolet (EUV) line profiles (e.g., Fe X 18.4 nm and Fe XIV 26.4 nm) and Fe XIII 1074 nm line in the near-infrared. This study underscores the importance of spectroscopic observations during the total solar eclipse to investigate the heating mechanism of heavy ions and variations of nonthermal motions in the solar corona.

P-17

High Resolution Observations of the Low Atmospheric Response to Small Coronal Heating Events in Active Regions

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High resolution spectral observations of the lower solar atmosphere (chromosphere and transition region) during coronal heating events, in combination with predictions from models of impulsively heated loops, provide powerful diagnostics of the properties of the heating in active region cores. Here we analyze the first coordinated observations of such events with the Interface Region Imaging Spectrograph (IRIS) and the CHROMospheric Imaging Spectrometer (CHROMIS), at the Swedish 1-m Solar Telescope (SST), which provided extremely high spatial resolution and revealed chromospheric brightenings with spatial dimensions down to ~150km. We use machine learning methods (k-means clustering) and find significant coherence in the spatial and temporal properties of the chromospheric spectra, suggesting, in turn, coherence in the spatial and temporal distribution of the coronal heating. The comparison of IRIS and CHROMIS spectra with simulations suggest that both non-thermal electrons with low energy (low-energy cutoff ~5keV) and direct heating in the corona transported by thermal conduction contribute to the heating of the low atmosphere. This is consistent with growing evidence that non-thermal electrons are not uncommon in small heating events (nano- to micro-flares), and that their properties can be constrained by chromospheric and transition region spectral observations.

P-18

Fine structure and multi-wavelength variability associated with coronal rain - Results from Solar Orbiter/EUI & SPICE and 2.5-D rMHD simulationS

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Coronal rain is the most dramatic cooling phenomenon of the solar corona. Recent observations in the visible and UV spectrum suggest that coronal rain is a pervasive phenomenon in active regions. Its strong link with the coronal heating properties through the Thermal Non-Equilibrium (TNE) - Thermal Instability (TI) scenario, makes it an essential diagnostic tool for coronal physics. Besides coronal heating, a puzzling feature of the solar corona is its filamentary structure and variability, particularly in the EUV. In this work we aim at identifying observable features of the TNE-TI scenario with current (IRIS, SDO, SolO) and future (MUSE, EUVST) missions to understand the role it plays in the solar corona. We use datasets from SDO/AIA and Solar Orbiter's EUI/HRIEUV & SPICE, which includes unprecedented spatial resolution of $\approx$ 240 km from the spring 2022 perihelion. Numerical modelling correspond to 2.5-D radiative MHD simulations with Bifrost that self-consistently form coronal rain. We report structure and variability associated with the TNE-TI scenario at a wide range of scales. At the smallest resolvable spatial scales (few hundred km on the Sun) and seconds timescale, we have coronal rain clumps and for the first time a phenomenon similar to a fireball produced by the large compression and heating underneath of falling clumps. At the large coronal loop scales and up to hours timescales, we observe rain showers that are composed of rain and coronal strands that are produced by the condensation-corona interface. The loop bundles then reheat due to the rebound shock and flow from rain impact, observed for the first time. SPICE observations show sequential cooling of loops, in agreement with TNE-TI, and strongly support the pervasiveness of coronal rain. This firmly establishes the major role that TNE-TI plays in the observed morphology and variability of the solar corona in the EUV.

P-19

Temperature-dependent plasma up- and down-flows along magnetic field lines driven by the Kelvin force

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Plasmas have a magnetic moment in a magnetic field. The Kelvin force acting on this magnetic moment works along the magnetic field in the direction of the weak magnetic field and is usually upward in the solar atmosphere. The plasma flows upward or downward depending on the magnitude of the upward Kelvin force and the downward gravity force. Since the magnetic moment is proportional to temperature, hot plasmas tend to flow upwards and cold plasmas tend to flow downwards. The Kelvin force is independent of the magnetic field strength and depends only on the spatial scale length of the magnetic field change. Applying this to the chromosphere, transition region, and corona, the behavior of the plasma in active regions can be discussed. In closed magnetic loops, the hot plasma concentrates at the top, forming an area of high pressure. It should be noted that the Bohr-van Leeuwen theorem states that thermal plasmas do not have a magnetic moment, but this is incorrect.

P-20

Scaling Relations for Sun-as-a-star XUV/FUV Spectrum and Magnetic Flux: Applications to Exoplanet-Hosting Sun-like Stars

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Recent observations unveiled that Sun-like stars frequently host exoplanets. They suggest that young exoplanets are subject to high X-ray and extreme-ultraviolet (EUV) radiation fluxes that may cause changes in their atmospheric dynamics and chemistry. While X-ray fluxes can be observed directly, EUV fluxes cannot be readily detected because of severe interstellar medium absorption. Here, we present a new solar empirical method to estimate the whole stellar XUV (X-ray plus EUV) and FUV spectral bands as a function of the stellar unsigned magnetic flux. We derive the power-law relations of the solar XUV and FUV spectrum (0.1-180 nm) to the total unsigned magnetic flux with a spectral resolution of 0.1-1 nm by using the long-term Sun-as-a-star dataset over 10 yrs (SDO/EVE, TIMED/SEE, and SORCE/XPS). We apply the scaling relations to active young Sun-like stars and find that the observed spectra (except for the longward EUV wavelength) are mostly consistent with the extension of the derived solar power-law relations within an order of magnitude. Our scaling relations consistently predict the flux around the missing EUV band. This suggests that our empirical model is a valuable method to derive the XUV/FUV fluxes of exoplanet-hosting Sun-like stars including the EUV band mostly absorbed at wavelengths longward of 36 nm. We also discuss differences between the solar extensions and stellar observations at the wavelength in the 2-30 nm band and conclude that simultaneous observations of magnetic and XUV/FUV fluxes of stars are required for further validations. With Hinode and IRIS and upcoming SOLAR-C and MUSE, we propose to enhance the focus on understanding and refining the dependence of EUV spectra on magnetic fluxes, locations, and/or coronal abundances. These data will further validate and improve our empirical method, thus advancing our characterization of solar/stellar atmospheres and their potential impact on exoplanets.

P-21

Spectroscopic Observations of Coronal Rain Formation and Evolution following an X2 Solar Flare

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A significant impediment to solving the coronal heating problem is that we currently only observe active region loops in their cooling phase. Previous studies showed that the evolution of cooling loop densities and apex temperatures are insensitive to the magnitude, duration, and location of energy deposition. Still, potential clues to how energy is released are encoded in the cooling phase properties. The appearance of coronal rain, one of the most spectacular phenomena of the cooling phase, occurs when plasma has cooled below 1MK, which sets constraints on the heating frequency, for example. Most observations of coronal rain have been made by imaging instruments. Here we report rare Hinode/EUV Imaging Spectrometer (EIS) observations of a loop arcade where coronal rain forms following an X2 limb flare. A bifurcation in plasma composition measurements between photospheric at 1.5MK and coronal at 3.5MK suggests that we are observing post-flare driven coronal rain. Increases in non-thermal velocities and densities with decreasing temperature (2.7MK to 0.6MK) suggest that we are observing the formation and subsequent evolution of the condensations. Doppler velocity measurements imply that a 10% correction of apparent flows in imaging data is reasonable. Emission measure analysis at 0.8MK shows narrow temperature distributions, indicating coherent behaviour reminiscent of that observed in coronal loops. The space-time resolution limitations of EIS suggest that we are observing the largest features or rain showers. These observations provide insights into the heating rate, source, turbulence, and collective behaviour of coronal rain from observations of the loop cooling phase. Future observations from Solar-C EUVST will resolve and measure properties in both individual rain features and loops, and track their formation and evolution all the way from the corona to the chromosphere.

P-22

Thermal Instability Near Magnetic Null Points Leading to the Formation of Coronal Rain and Prominences

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The solar corona is million-degrees hot and tenuous. Such hot plasma, under certain conditions, can enigmatically undergo a radiative cooling instability and condense into material of 100 times cooler in the form of coronal rain or prominences. Where, when, and how such cooling condensation takes place remain poorly understood. Magnetic fields in the magnetized corona undoubtedly play a crucial role (e.g., by trapping the plasma), but where and how? We report recent imaging and spectroscopic observations from SDO/AIA/HMI and IRIS that can shed light on this puzzle. Through a systematic survey, we found that a large fraction of quiet-Sun condensations preferentially occur at the dips of coronal loops or funnels. Such dips are located at/near magnetic topological features, such as null points and quasi-separatrix layers (QSLs), which are regions characterized by high values of the squashing factor. We also identified evidence of magnetic reconnection at such locations, which can produce favorable conditions, e.g., density enhancement by compression and/or mass trapping in plasmoids, that can trigger run-away radiative cooling. We present proof-of-concept MHD simulations that demonstrate the role of reconnection in transporting cooled mass from overlying, long loops to underlying, short loops where it slides down as coronal rain. We will discuss the significance of these results and their implications, e.g., for the fundamental question of coronal heating and the chromosphere-corona mass cycle.

P-23

Coronal EUV Waves and Their Implications for Global Coronal Seismology

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Large-scale extreme ultraviolet (EUV) waves associated with coronal mass ejections (CMEs) and solar flares can provide novel diagnostics of the solar corona on global scales, an area yet to be fully exploited. Some CME/flare events are also associated with quasi-periodic fast-mode propagating (QFP) wave trains that travel at typically ~1000 km/s. We performed detailed analysis of various behaviors, such as reflection and refraction of well-observed EUV wave events, including those associated with the SOL2017-09-10 X8.2 flare and the SOL2011-02-15 X2 flare. We also performed data-constrained simulations of these events, using state-of-the-art 3D MHD codes. By comparing the observations and simulations, we benchmark diagnostics of the magnetic field strengths and thermal properties of the solar corona. We will discuss the implications of these results for global coronal seismology.

P-24

Modeling In-Situ Measurements From Parker Solar Probe Encounter 12

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The launches of Parker Solar Probe (Parker) and Solar Orbiter (SolO) are enabling a new era of solar wind studies that track the solar wind from its origin at the photosphere, through the corona, to multiple vantage points in the inner heliosphere. We perform steady-state, data-driven magnetohydrodynamic simulations of the solar wind with the GAMERA model and compare the model results with various sources of in-situ measurements. Using the ADAPT and AFT flux transport models as inputs, we derive boundary conditions for the model using a self-contained implementation of a potential field source surface extrapolation, a Wang-Sheeley-Arge relationship between field line properties and solar wind speed, and a simplified Schatten current sheet model. We focus on Carrington rotation 2258, which overlapped with most of Parker Encounter 12 from 2022 May 27 to 2022 June 7. Despite the relative simplicity of the models, we find generally good agreement between the simulation results and the observed values of the solar wind magnetic field, density, and radial velocity at Parker, SolO, and Earth. Furthermore, we find that we can trace field lines from Parker to an outflow region observed by Hinode/EIS at the solar surface. Lastly, we compare EIS observations with in-situ solar wind parameters and composition measurements from Parker and SolO.

P-25

New model atmospheric stratifications for MHD simulations.

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Simplified 1D simulations of the solar atmosphere are important to understand specific processes in the corona, like for spectro-polarimetric inversions, coronal loops, and flares. Vertical 1D atmospheric-column models allow to study the plasma's response to heating and the subsequent evolution of the temperature. Most coronal MHD simulations require an atmospheric stratification to define the initial condition of the model. Previously available stratifications have several shortcomings, like not covering complete solar atmosphere or being derived from outdated observations.

We present a new 1D atmospheric model that spans from solar interior to corona of the Sun. We investigate the effect of diffusion terms and the grid resolution on numerical stability of the model, to get the simulation as realistic as possible. We investigate various heating/cooling terms & various heat transport mechanisms. We settle our initial stratification with 1D-MHD model with exactly those parameters of our future 3D models, like mass diffusion, Spitzer heat conduction, viscosity, coronal radiative losses, magnetic pressure. This is done to avoid shock waves released due to slight pressure imbalances in analytic solutions after being transferred into a numerical model. Also, we implement an artificial heating function for corona that resembles the expected coronal heat input of a self-consistent 3D model. Our 1D model is then able to maintain high coronal temperatures in the corona. Generally, one might think it is correct to use lower diffusion constants for finer grid resolutions, but we find this is not true for high-order derivatives in a high-resolution setup because too low diffusion undermines numerical stability. Our 1D stratification model result can be used as initial condition for 3D-MHD simulations – and is able to replace older stratifications like the VAL-C and FAL-C profiles, while we provide higher resolution, larger spatial extent, and more realistic temperature gradients at the transition region.

P-26

Investigating Heating in Active Region Coronal Loops in non-Eruptive Solar Active Regions

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Based on the results from Tiwari et al. 2017, we investigate the importance of magneto-convection in heating active region coronal loops. Tiwari et al. found via SDO/AIA observations and NLFFF extrapolations that loops connecting sunspot umbrae are invisible in EUV images and those with one footpoint in sunspot umbra or penumbra and the other in opposite-polarity sunspot penumbra or plage regions, are seen as bright and hot loops. They conclude that a combination of the magnetic field strength of the regions the loops are rooted in and the convective freedom of the regions play an important role in determining the amount of heating in these loops.

The aim of our present study is to understand the statistical significance of the above findings. We select a sample of active regions of three kinds – those containing a pair of sunspots, those with a sunspot in the leading polarity but not a fully developed sunspot in the trailing polarity, and those that have no sunspot in any polarity. Using SDO/AIA images, we obtain the time frames of the images where the active regions are somewhat steady over a 48-hour time period, without any eruptions or flare-like bursts beyond GOES B-class flares. We select the instances where bright loops are present and choose the nearest HMI/SHARP vector magnetograms in time to perform NLFFF extrapolations using the method of Weigelmann et al. 2004. We also perform differential emission measure calculations over these AIA timeframes to verify the temperature characteristics. We quantify the convective freedom in the general locations of the loop footpoints by studying the photospheric flows in the respective regions by applying local correlation tracking using Fisher and Welsch (2008). In addition, we plan to use IRIS observations for some of our active regions to obtain physical properties such as line-of-sight velocities, temperature and density in the chromosphere using inversions from IRIS2 (Sainz Dalda et al. 2019).

P-27

Two Diagnostic Study of Plasma Composition Evolution in a Solar Active Regions

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The plasma composition of the solar corona is different from that of the solar photosphere. Elements that have a low first ionisation potential (FIP) are preferentially transported to the corona and, therefore, show enhanced abundances relative to high FIP elements in the corona compared to the photosphere. Typically, the strongest enhancement (measured using the FIP bias parameter) is observed in active regions. In this work, we use data from the EUV Imaging Spectrometer (EIS) on Hinode to study the plasma composition in an active region following an episode of significant new flux emergence into the pre-existing active region. We use two FIP bias diagnostics: Si X 258.375 A/S X 264.233 A (temperature of approximately 1.5 MK) and Ca XIV 193.874 A/Ar XIV 194.396 A (temperature of approximately 4 MK). We observe slightly higher FIP bias values in the Ca/Ar diagnostic than Si/S in the newly emerging loops, and this pattern is much stronger in the preexisting loops (those that were formed before the flux emergence). This result can be interpreted in the context of the ponderomotive force model, which proposes that the plasma fractionation is generally driven by coronal Alfven waves. We propose that, in this case, the fractionation in the emerging loops is driven by resonant waves, while the fractionation in the preexisting loops is driven by nonresonant waves, which results in different fractionation patterns in these two sets of loops.

P-28

Damping of Coronal Oscillations in Self-Consistent 3D Radiative MHD Simulations of the Solar Atmosphere

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Oscillations are abundant in the solar corona. Coronal loop oscillations are typically studied using highly idealised models of magnetic flux tubes. In order to improve our understanding of coronal oscillations, it is necessary to consider the effect of a realistic magnetic field topology and the density structuring. We analyse the damping of coronal oscillations using a self-consistent 3D radiation-MHD simulation of the solar atmosphere spanning from the convection zone into the corona, the associated oscillation dissipation and heating, and finally, the physical processes responsible for the damping and dissipation. The simulated corona formed in such a model does not depend on any prior assumptions about the shape of the coronal loops. The coronal oscillations lead to the development of velocity shear in the simulated corona resulting in the formation of vortices seen in the velocity field caused by the Kelvin-Helmholtz instability, contributing to the damping and dissipation of the transverse oscillations. The oscillation parameters and evolution detected are in line with the values that are typically seen in observations of coronal loop oscillations.

P-29

About the source of sustained kink oscillations in coronal loops: what do we know and what do we need from future observation campaigns?

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We investigate sustained quasi-periodic kink oscillations in coronal loops, by looking at their properties and potential drivers in multiple observational datasets, including both EUV imagers and spectrographs. Kink oscillations have been observed for years, where a majority of them has been seen to dissipate quickly and to be associated with impulsive heating events (as during e.g. magnetic reconnection events). That until recently, when long-lived (decayless) kink oscillations have started to be observed more frequently with the advent of the high-resolution EUV imager on board Solar Orbiter (SolO-EUI). Their nature remains puzzling as it indicates the presence of a sustained source of energy, that is still to be identified. Several potential sources have been suggested, but there is no established consensus yet. We apply Fourier and wavelet analyses to intensity maps and doppler velocity measurements to check for dominant frequencies and potential phase shifts. To this end, we exploit in addition to SolO-EUI, spectral information given by IRIS and the imaging spectrograph on board Solar Orbiter (SolO-SPICE). We also look at photospheric and chromospheric diagnostics given by the Swedish 1-m Solar Telescope (SST), to check for potential drivers for the coronal oscillations. Connecting low atmospheric and coronal diagnostics together has always been challenging, that now should be more accessible with dedicated co-observations between Solar Orbiter and the near-Earth observatories. In this contribution we will show preliminary results and future perspectives to this work, which has been funded by the NRC ORCS project.

P-30

The effect of non-Equilibrium Hydrogen ionization in the formation of ALMA mm-intensities

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ALMA mm-observation in the continuum sample the solar chromosphere. While the continuum source function at mm-wavelengths follows the Planck function (LTE), the opacity depends on the electron density and the Hydrogen ionzation degree, which are far from following an LTE description. Moreover, the ionization of Hydrogen in the chromosphere must be modelled including time-dependent non-equilibrium effects.

In this study we use a Bifrost rMHD simulation to analyze the formation of ALMA mm observations when the Hydrogen populations and the electron densities are computed under non-LTE/non-equilibrium conditions. We compare our results with the pure LTE case for the 1.2 mm and 3.0 mm bands.

P-31

Automatic computation of linear magneto-hydro-static equilibria and application to chromospheric, transition region, and coronal loops

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We present the development of a new computational algorithm based on a magneto-hydro-static model that computes the magnetic field in the solar atmosphere and automatically matches individual magnetic-field lines with observed structures. Obtaining the physical parameters of observed phenomena in the solar atmosphere has fundamental importance, as these parameters are then employed to constrain and validate models. Presently, for the quiet-Sun regions, we can only measure the vertical photospheric magnetic field Bz, as accurate horizontal magnetic field measurements are not available. Thus, vertical photospheric magnetic-field measurements are extrapolated into the upper atmosphere, from the photosphere to the corona, with a magneto-hydro-static model. Free model parameters are then optimized with a downhill-simplex method by comparing quantitatively magnetic-field lines with the enhanced emission of loop structures recorded in transition-region and coronal images. The algorithm will be applicable to any solar image data where individual structures can be resolved. Most importantly, the algorithm can be employed to obtain the magnetic properties of these structures above the photosphere. We discuss the application of the algorithm to chromospheric data and features observed in absorption.

P-32

Unraveling the role of acoustic waves in chromospheric heating through inversion analysis

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The heating of the solar chromosphere has long been partly attributed to wave dissipation, primarily driven by convective motions in the photosphere. Acoustic waves are an obvious candidate, however, their exact contribution to the energy balance remains controversial. While some studies indicate sufficient acoustic flux to sustain the canonical radiative losses, others fall short by up to an order of magnitude. Discrepancies may arise from spatial resolution limitations, different spectral diagnostics, and inherent assumptions in current models.

To address these issues, we present self-consistent heating rates and wave fluxes obtained from joint observations using the Interferometric BIdimensional Spectrograph (IBIS) and Interface Region Imaging Spectrograph (IRIS). The data from a network/internetwork region were analyzed using non-local thermodynamic equilibrium (NLTE) inversions. Our results provide new insights into the heating and wave characteristics of the solar chromosphere.

P-33

Magnetic fields in plage regions: insights from DKIST/ViSP spectropolarimetry

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Previous studies have provided insights into the properties of magnetic fields in solar plage regions, but accurately measuring chromospheric magnetic fields remains a challenging yet crucial task for understanding chromospheric heating and dynamics. In this study, we utilized high-sensitivity spectropolarimetric data obtained from the 4m-Daniel K. Inouye Solar Telescope (DKIST) to investigate the dynamic environment and distribution of magnetic fields in an extended plage region. We find strong polarization signals in both plages and neighboring fibrils, with the linear polarization signals clearly distinguishing between plage patches and the fibril canopy. Inversions show fibril-like structures in the chromospheric magnetic field, with typical field strength values ranging from approximately 200 G to 300 G. These results help us understand the magnetic field properties and dynamic processes within plages, underscoring the need for further research to explore magnetic field expansion with height and how that affects the heating rates.

P-34

An optically thin view of the solar chromosphere. IRIS observations of the O I 1355 spectral line

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The O I 1355 A spectral line is one of the only optically thin lines that are both routinely observed and thought to be formed in the chromosphere. We present analysis of a variety of observations of this line with the Interface Region Imaging Spectrograph (IRIS) and compare it with other IRIS diagnostics as well as diagnostics of the photospheric magnetic field. We utilize special deep exposure modes on IRIS and provide an overview of the statistical properties of this spectral line for several different regions on the Sun. We analyze the spatio-temporal variations of the line intensity and find that it is often significantly enhanced when and where magnetic flux of opposite polarities cancel. Significant emission occurs in association with chromospheric spicules. Because of the optically thin nature of the O I line, the non-thermal broadening can provide insight into unresolved small-scale motions. We find that the non-thermal broadening is modest, with typical values of 5-10 km/s, and shows some center-to-limb variation, with a modest increase towards the limb. The dependence with height of the intensity and line broadening off-limb is compatible with the line broadening being dominated by the superposition of Alfven waves on different structures. The non-thermal broadening shows a modest but significant enhancement above locations that are in between photospheric magnetic flux concentrations in plage, i.e., where the magnetic field is likely to be more inclined with respect to the line-of-sight.
Our measurements provide strict constraints on future theoretical models of the chromosphere.

P-35

In Search of the "Smoking Gun" with MOXSI: Constraining Very Hot Active Region Plasma with Slitless Spectroscopy

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Models of impulsive heating in non-flaring active region loops have long predicted the presence of faint, very hot (>4 MK) plasma, the so-called "smoking gun" of nanoflare heating. Unambiguous observations of such plasma have remained elusive, due in part to the sparsity of observations of high-temperature spectral lines, particularly in the soft X-ray range. The Multi-Order X-ray Spectral Imager (MOXSI) aboard the CubeSat Imaging X-Ray Solar Spectrometer (CubIXSS), to be launched in 2025, is a soft x-ray pinhole imager that includes four filtergrams with passbands similar to the Al-poly and Be filters on Hinode XRT as well as a slitless imaging spectrograph that will observe the entire solar disk over the spectral range 1--60 Å. Because this range contains a number of key high-temperature diagnostic lines, MOXSI is well-positioned to place unprecedented constraints on this faint, hot plasma. In this poster, we present a series of full active region simulations composed of many hundreds of impulsively heated loops with varying amounts of very hot plasma as produced by low-frequency impulsive heating. From these simulations, we forward model a series of MOXSI images, including the effect of the dispersive grating, the point spread function, and other instrumental effects. Additionally, we perform inversions of the resulting simulated slitless spectrograph data and compare the resulting inverted emission measure distribution to the true emission measure distribution. We demonstrate that MOXSI will be able to place tighter constraints on this faint hot plasma than current observations allow, due primarily to its novel spectral range and slitless design.

P-36

Are There Any Differences in the Chromosphere of Coronal Holes and Quiet-Sun?

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In the solar atmosphere, quiet regions are broadly divided into two categories: quiet-Sun regions (QS) and coronal hole regions (CH). The global magnetic field is closed in QS while it is open and extends into space in CH. The chromospheric and coronal energy losses are estimated for both regions and they are different. To understand chromospheric and coronal heating problem, it is interesting to compare these different regions. Although some previous studies made such comparisons, it's only since the IRIS (Interface Region Imaging Spectrograph) satellite was launched that we have obtained high-resolution, stable, and spectroscopic data of the solar chromosphere.

In order to reveal the difference between QS and CH in the chromospheric layer, we analyzed, for each of CH and QS, multiple off-limb datasets obtained at polar regions by IRIS. We also used 193A images obtained by Atmospheric Imaging Assembly (AIA) onboard Solar Dynamics Observatory (SDO) to determine if the IRIS data region is CH or not (QS).

We found that the integrated intensities in the Mg II k line show rapid decrease with the height in QS while they remain bright at higher altitude in CH. This is qualitatively consistent with the results of high-resolution imaging observations of the chromosphere by Hinode/SOT Ca II H filtergram (Zhang et al. 2012; Pereira et al. 2012), and also consistent with the IRIS C II SJI observations of on-disk network jets (Narang et al 2016). Moreover, we also found that the widths of the Mg II k line first increase and then decrease with height in both CH and QS, but they are overall larger for CH than for QS."

In this poster presentation, we will show the results and discussions for those findings.

P-37

Role of Poynting flux injection by magneto-convection on the chromospheric energy balance

Q. Noraz, and M. Carlsson (RoCS/ITA)

The solar atmosphere exhibits a diverse range of dynamical processes that contribute to the heating of the outer atmosphere. Recent observations and simulations have highlighted the importance of waves and magnetic reconnection in the chromosphere, providing energy to balance the radiative cooling. However, the precise amount of energy and the relative roles of these processes in different solar regions (e.g., coronal hole, quiet sun) are still under debate.

The community agrees that magnetic fields play a major role for the atmospheric heating. Numerical simulations have especially demonstrated that the braiding of magnetic field lines by photospheric convection can sustain a million-degree corona by injecting energy through Poynting flux (Gudiksen and Nordlund 2005, Finley et al. 2022). However, the initial magnetic field in such models remains a free parameter, and limited resolution may dampen velocity dispersions, impacting the accuracy of the simulations. In that context, how is the energy injected by magneto-convection into the chromosphere impacting its dynamics and the subsequent heating?

We present a parametric study using the Bifrost code, focusing on high-resolution simulations of coronal holes. By varying the amount of upwardly advected magnetic field at the bottom boundary, we simulate different configurations of flux emergence. Analysis of the internal energy balance confirms an increase in Ohmic atmospheric heating related to the amplitude of the injected Poynting flux, with a specific emphasis on understanding the dynamics of these magnetic heating events.

Comparisons of these models with future observations of the IRIS mission and the out-of-the-ecliptic exploration of polar caps by Solar Orbiter, make us envision the possibility for better constrains on the turbulent dynamics of coronal holes, and the injection of energy into the solar wind.

P-38

EUV observation of small-scale dynamics in solar plumes

Z. Huang, L. P. Chitta, L. Teriaca, R. Aznar Cuadrado, H. Peter, and S.K. Solanki (MPS)

Coronal plumes, largely radial ray-like structures located in coronal holes, are interesting targets to investigate aspects of magnetohydrodynamic wave and solar wind origins. Due to the observing geometry and generally large sizes of polar coronal holes where they are embedded, polar plumes can be observed projecting well beyond the limb of the Sun. However, plumes in low-latitude holes are more difficult to observe because of the much higher background from the nearby quiet Sun and, often, active regions. These plumes are best observed against the disk. In all cases, plume bases seem to be very active with many small-scale transients (so-called jetlets) observed, which are likely important to the formation and evolution of plumes and could contribute to the solar wind. The High Resolution EUV telescope, part of the Extreme Ultraviolet Imager on board Solar Orbiter provided on 2022 October 13 a 30-minute long observation of three plumes within an equatorial coronal hole, at a high spatial resolution of about 200 km. The plume bases are very dynamic with numerous jetlets being observed. In this study, we selected 50 jetlets within three plumes and investigated their properties (intensity, lifetime, area, velocity, length, width) statistically. Among all the jetlets studied here, we find that (1) most of them are small-scaled (with an area from 0.2 to 2 Mm^2), transient (with a lifetime less than 5 minutes) and substantially round; (2) their mean intensity doesn't change dramatically within the same plume, but varies from plume to plume; (3) most of the jetlets appear to move with a velocity component in the plane of sky of less than 20 km/s; (4) their areas and length/width ratios might be related to their velocities. The investigation of jetlets in plume bases may help understanding whether and how plumes contribute to the solar wind.

P-39

Spectroscopic study of Alfvén waves in the upper chromosphere as a source of solar wind acceleration in coronal holes

Y. Naito, J. Okamoto, and H. Hara (NAOJ/SOKENDAI)

Alfvén waves are thought to play a crucial role in solar wind acceleration in coronal holes. However, it is still unknown what processes Alfvén waves undergo in terms of energy transport as they propagate from the chromosphere to the lower corona. To clarify this, it is important to investigate a height variation of the property of Alfvén waves from the chromosphere to the lower corona. In our study, we used IRIS data in the sit-and-stare mode. The slit is perpendicular to the solar limb in coronal holes. From the height-time plots of the line-of-sight (LOS) velocity derived from the Si IV spectra, we detected 3 examples of ascending periodic features, and the upward propagation speed of one of the ascending features is 94 km/s, which corresponds to the typical Alfvén speed in the upper chromosphere. These LOS velocity variations do not correlate with the intensity at the corresponding heights and times, thus we can assume the observed features are kink mode waves (i.e., Alfvén waves) propagating along spicules. We estimated the energy flux of these waves with the electron density derived from the emission measure of the Si IV spectra under the assumption of a single cylindrical structure of the spicule, and we found complex height variations of the energy flux: increasing in two cases and decreasing in one case. In this poster, we would like to show the results and discuss the contribution of the waves to solar wind acceleration.

P-40

Revisiting the relationship between solar X-ray irradiance and magnetic flux using Hinode/XRT, SDO/HMI, and SOHO/MDI

K. Yoshimura, A. Takeda, and D.W. Longcope (MSU)

The relationship between total unsigned magnetic flux and X-ray spectral irradiance was notably studied by Petvsov et al. (2003). Their analysis used over 12 orders of magnitude in flux, ranging from quiet region of the Sun through TTauri stars. From this data they concluded that a single power-law (index=1.15) could well express the relationship for the whole range. The solar portion of their study was based on the X-ray data from Yohkoh/SXT and magnetic flux data from NSO/KP and they reported that the power-law index for the full, disk-integrated flux changes from the low magnetic flux end (index~2) to high end (index~1), which forms a "knee" in the plot of X-ray irradiance vs magnetic flux. We used more recent data set, Hinode/XRT, magnetograms of SDO/HMI and SOHO/MDI, to make the same plot for the full Sun data.

There are several parameters whose choice is critical to the calculation of the X-ray irradiance and the total unsigned magnetic flux. We studied how the selections of the parameters impact on the results. The parameters we checked are (1) selection of XRT filter pairs, (2)area of integration, (3)energy band of irradiance calculation, and (4)cutoff magnetic field strength. We also tried some different coronal models for the X-ray irradiance calculation, i.e., different versions of CHIANTI and different abundance models.

All the results show single or broken power law distribution. We found the cutoff magnetic field strength was the key parameter of the "knee" structure. The "knee" can be seen with the low cutoff values, but not with the higher values. The critical value appears to be higher than the noise level of the HMI magnetograph. This may suggest there are weak magnetic field which do not contribute to the X-ray irradiance. We will also discuss the other parameters which affect the results to some extent.

P-41

Non-thermal Observations of EUV Loop-top Knots: Implications for Evaporation, Turbulence, and Energy Release

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A common element of solar flares are localized regions of enhanced extreme ultraviolet (EUV) emission along the loop-tops of the post-flare arcade, referred to as knots. While these knots are generally thought to be the result of colliding evaporation flows at the apex of a flare loop, discrepancies between previous observations and models suggest their diagnostic potential for the temporal and spatial extent of flare energy release. Using the Interface Region Imaging Spectrometer (IRIS), this work presents spectroscopic observations of a loop-top knot via hot (~10MK) Fe xxi 1354Å coronal line emission during the 2022 March 30 X1.4 flare (SOL2022-03-30T17:23:06). We find the peak emission of the knot is preceded by non-thermal line broadenings that decrease linearly with time — an evolution characteristic of MHD turbulent decay. Moreover, an initial increase in Fe xxi emission occurs prior to the onset of the knot, with non-thermal motions reaching upwards of 70 km/s. The non-thermal nature of this initial emission is further corroborated by coronal microwave emission in the vicinity of the IRIS slit as measured with the Expanded Owens Valley Solar Array (EOVSA). When combined with DEM images calculated using SDO/AIA, these observations support a scenario of loop-top heating followed by evaporation, which ultimately forms the knots. Following this interpretation, the turbulent, non-thermal behavior of the initial emission becomes indicative of the stochastic acceleration of electrons along the loop.

P-42

Examining FIP Bias Turnovers in Flares Using XSM and EIS

S. Chhabra (NRL/GMU), J. Reep (NRL), and H. Warren (NRL)

Flares have often been observed to exhibit variations in the FIP effect during their evolution. Meaning that the pre-flare coronal abundances quickly deplete to photospheric values during the impulsive phase of the flare, which are then slowly replenished as the flare decays. The Solar X-ray Monitor (XSM) onboard Chandrayaan-2 allows measurements of absolute abundances of trace elements. The instrument observes the integrated solar-disk X-ray spectra between 1-15 keV at a spectral resolution of 0.18 keV (at 5.9 keV) with a cadence of 1 s and provides excellent diagnostics of high-temperature flare plasma. The Extreme Ultraviolet Imaging Spectrometer (EIS) onboard Hinode provides abundance diagnostics at lower temperatures from Ar/Ca and S/Si ratios. In this study we combine XSM and EIS observations of several events to analyze the evolution of elemental abundances at both high (~10 MK) and intermediate (~4 MK) temperatures. 2-Temperature (2-T) spectral fits are also performed to investigate the variations in temperature and emission measure (EM) during the flare. The combination of XSM and EIS data allows us to validate the abundance measurements for different trace elements and provides a wider range of temperatures to constrain the EM.

P-43

Lyman-alpha Variability During Solar Flares

R. Milligan, H. Greatorex, E. Butler (QUB), P. Chamberlin (LASP),
and L. Majury (QUB)

The chromospheric Lyman-alpha (Lya) line of hydrogen at 1216A is the brightest emission line in the solar spectrum and yet studies of solar flares at this wavelength have been scarce until relatively recently. Changes in the Sun's Lya output can drive changes in the dynamics and composition of planetary atmospheres and Lya can be a significant radiator of solar flare energy. Milligan et al. (2020) published a statistical study of ~500 M- and X-class flares using GOES/EUVS data, showing that while Lya irradiance increases by only a few percent during large events, it can radiate up tP-100 times more energy than the corresponding X-rays. It was also shown that impulsive Lya emission, not X-rays, can induce currents in the E-layer of Earth's ionosphere. The contribution of B- and C-class flares to the solar irradiance was also investigated in a follow-up study using a superposed epoch analysis (Milligan 2021). Both studies found that flares close to the solar limb exhibited a smaller Lya enhancement relative to those on the disk due to opacity and/or foreshortening effects. A proxy for irradiance measurements in Lya can be obtained from the Flare Irradiance Spectral Model (FISM). In a recent study of three M3 flares that had appreciably different Lya responses, it was found that FISM significantly under-predicts the level of Lya emission. It was also found that flares with a harder nonthermal electron spectral index tended to have larger Lya enhancements above the pre-flare level (Greatorex et al. 2023). The recently released archive of spectral scans from SORCE/SOLSTICE also allows for the characterisation of the Lya line profile during flares for the first time. These findings should serve as a baseline for the advent of new Lya flare observations from Solar-C and the SNIFS sounding rocket in Solar Cycle 25.

P-44

Improving Flare Models by Initializing Simulations with Retraction Signatures.

J. Unverferth (NRL), and J. Reep (NRL)

Typical 1D flare loop models consider a static loop length to study the dynamics of the loop. This is in contrast to the standard model of flares where the loops retract out of the reconnection region before coming to a stop at the flare arcade. Using a retraction model, we derive a set of initial conditions that can be used in static loop models to mimic the effects of that retraction. We determine which elements of the retracted loop contribute to an accurate reproduction of the hydrodynamic evolution, finding that the best outcome results from considering thermal and kinetic energy distributed along the loop in addition to adjusting the mass in the loop. Based on the expected conditions from retraction explored here, initializing simulations with a non-static (i.e. with developed flows along the flare loop) loop is a more appropriate initial condition. We use these revised initial conditions to forward model evaporation flows for several IRIS and EIS lines, to compare against the initial retraction model and observations.

P-45

3D rMHD Simulation of a small C-class flare; from convection zone to corona

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and S. Bose (BAERI/LMSAL)

Our ability to predict the occurrence and impact of flares is hampered by an incomplete picture of underlying physical drivers, triggers, and instabilities. This situation is being ameliorated by recent advances in the gathering of both high cadence, high resolution data as well as long term evolutionary data, spanning the solar atmosphere from the photosphere to corona with ground based and space borne instruments such as DKIST and the SST, IRIS, SDO/AIA, Hinode/EIS and SOT, SOLO/EUI and PHI, and SDO/HMI. The situation should become even better with the launches of MUSE and Solar C/EUVST. However, flares are complicated phenomena, and making sense of them can be greatly helped with the assistance given by 3D rMHD simulations spanning a similar range of the solar atmosphere. We present a Bifrost simulation featuring magnetic flux emergence with amplitude approximately that found in a mid sized active region. After several hours solar time the simulation produces a C-class flare. We synthesise several observables relevant to IRIS, Hinode, AIA, and future MUSE observations, such as Fe I 617.3 nm, Ca II K, 854.2 nm, Mg II k and triplet, Si IV 139.2 nm, Fe IX 17.1 nm, Fe XII 19.5 nm, Fe XV 28.4 nm and Fe XIX 10.8 nm, and compare these to and observed flare of the same class. Similarities and differences between the observed and synthesised data and their physical interpretation and consequences are discussed.

P-46

X-ray Investigation of non-thermal plasma in "X10,000,000-class" flare of the RS CVn binary star

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and Y. Tsuboi (Chuo U.)

In solar and stellar flares, magnetic energies are thermalized into heat energies in a short time. It takes a finite time for the plasma to reach a collisional ionization equilibrium (CIE). Diagnosis of the relaxation process is critical to understand the physics of energy input and dissipation. However, such observations are limited. In solar flares, the relaxation time is too short of O (10 s) to accumulate photons for X-ray line spectroscopy. In stellar flares, the time scale is expected to be longer, but no X-ray spectrometers are available to monitor a particular source all the time to catch flares. We overcame the difficulty in stellar flare observations by a combination of two X-ray instruments onboard the International Space Station: MAXI and NICER. MAXI enables a frequent update of all-sky X-ray image every 92 minutes, which has led tP-167 detections of stellar flares from 30 objects since 2009. NICER is the best instrument to follow-up because of its ability to conduct fast maneuvers and collect a large number of photons with better spectral resolution than MAXI.

In this study, we focus on an observation of a giant stellar flare equivalent of GOES X10000000-class occurred on August 17, 2020, in the RS CVn-type binary star UX Arietis (UX Ari). We successfully started NICER observation approximately 90 minutes after the MAXI detection, capturing the flare's peak flux (2 × 10^33 erg/s in 0.5 – 8 keV), and continued observations for approximately 5 days until the flare decayed. We investigated the variation of the intensity ratio of the Fe XXV Heα and Fe XXVI Lyα lines, which turned out to be a deviation from the expectation of a CIE plasma at a single temperature. We examine the validity of the off-CIE plasma by considering the differential emission measures of the CIE plasma.

P-47

Plasma Diagnostics of Solar Flares from the Miniature X-ray Solar Spectrometer (MinXSS)-1 CubeSat and the Hinode/X-ray Telescope (XRT)

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J. Velasquez (SAO), C. S. Moore (SAO), and K. K. Reeves (SAO)

Solar flares emit all types of electromagnetic radiation, and accelerate particles on timescales of minutes, converting magnetic energy to thermal, radiative, and kinetic energy through magnetic reconnections. As a result, local plasma can be heated to temperatures in excess of 20 MK. During the soft X-ray (SXR) solar flare peak, the elemental abundance of low first-ionization potential (FIP) elements are typically observed to be depleted from coronal values. We explore the abundance variations using disk-integrated solar spectra from the Miniature X-ray Solar Spectrometer CubeSat-1 (MinXSS-1). MinXSS-1 is sensitive to the 1-12 keV energy range with an effective 0.25 keV full-width at half-maximum (FWHM) resolution at 5.9 keV. During the year-long mission of MinXSS-1, between May 2016 - May 2017, 21 flares were observed ranging from C to M class. We examine the time evolution of temperature, volume emission measure, and elemental abundances of Fe, Ca, Si, and S with CHIANTI spectral models near the peak SXR emission times observed in the MinXSS-1 data. We determine the average absolute abundance of A(Fe) = 7.81, A(Ca) = 6.84, A(S) = 7.28, and A(Si) = 7.90. These abundances are depleted from coronal values during the SXR peak compared to non-flaring times. The elemental abundance values that are depleted from their coronal values are consistent with the process of chromospheric evaporation, in which the lower atmospheric plasma fills the coronal loops. Furthermore, we explore the temperature diagnostics of the July 21, 2016 M1.0 flare using the Hinode/X-ray Telescope (XRT) and the derived elemental abundances from MinXSS-1.

P-48

Non-Thermal Velocity and Magnetic Energy in X-Class Solar Flares: A High Temporal Resolution Study

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In this study, we present a novel approach to understanding the dynamics of energy release in solar active regions during flaring by investigating the relationship between non-thermal velocities and free magnetic energy at a high temporal resolution.

Using data from the Extreme Ultraviolet Imaging Spectrometer (EIS) onboard the Hinode spacecraft, we calculated the coronal non-thermal velocities of Active Region 12673 at a 3-minute cadence for various emission lines over an approximately 9-hour period. This period includes the occurrence of two X-class flares, of interest to our study. We then also computed the free magnetic energy of this active region using non-linear force-free extrapolations of magnetograms taken by the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory over the same period. The method for this makes use of a physics-informed neural network (PINN), allowing massively accelerated extrapolations and therefore a free magnetic energy estimation at the full magnetogram 12-minute cadence for the entire 9-hour duration of EIS observations.

Our analysis of these time series reveals a compelling inverse relationship: an increase in non-thermal velocities is associated with a clear and proportional decrease in free magnetic energy for the two flares. This finding provides new insights into the complex interplay of forces in active regions and demonstrates the conversion of magnetic energy to kinetic energy in the corona at a high temporal resolution. Furthermore, we spatially resolve these regions of non-thermal velocity increase and free magnetic energy decrease and observe clear co-spatial structures during flaring.

P-49

Spectral and imaging observations of a C2.3 white-light flare observed by ASO-S and CHASE

Q. Li (PMO), Y. Li (PMO), and Y. Su (PMO)

Solar white-light flares are characterized by enhancements in the optical continuum, which are usually large flares (say, X- and M-class flares). Here we report a small C2.3 white-light flare (SOL2022-12-20T04:10) observed by the Advanced Space-based Solar Observatory (ASO-S) and the Chinese Hα Solar Explorer (CHASE). This flare exhibits an increase of ∼6.4% in the Fe I line at 6569.2 Å and ∼3.0% at the nearby continuum. The continuum at 3600 Å also shows an enhancement of ∼4.6%. At the white-light brightening kernels, the Fe I line displays an absorption profile that has a good Gaussian shape, while the Hα line shows an emission profile though having a central reversal. The Hα line profile also shows a red or blue asymmetry caused by plasma flows. The white-light brightening kernels are mainly located at the flare ribbons and are co-spatial with nonthermal HXR sources as revealed by high-resolution HXR observations. This implies that the enhanced white-light emissions are closely related to the nonthermal eletron beam heating.

P-51

Sun-as-a-star spectroscopy of CME: observations and modeling

Z. Yang, H. Tian, Y. Xu, and H. Lu (Peking U.)

Coronal mass ejections (CMEs) are the largest-scale eruptive phenomena in the solar system. Associated with enormous plasma ejections and energy release, CMEs have an important impact on the solar-terrestrial environment. CMEs can also occur on other stars and will greatly impact the habitability of the orbiting exoplanets around the hosting stars. Therefore, the detection of stellar CMEs and how stellar CMEs affect the space environments are indispensable when evaluating the habitability of exoplanets. Observationally, solar CMEs could result in the asymmetries of spectral line profiles. However, few studies have concentrated on whether we can detect solar and stellar CME signals and accurately diagnose CME properties through line profile asymmetries. Using the Sun-as-a-star spectral observations from SDO/EVE, we found several evidences of solar CMEs through the asymmetry of EUV spectral line profiles. Meanwhile, we constructed a geometric CME model and derived the analytical expressions for full-disk integrated extreme ultraviolet (EUV) line profiles during CMEs. For different CME properties and instrumental conditions, full disk-integrated line profiles were synthesized. We further evaluated the detectability and diagnostic potential of CMEs from the synthetic line profiles. Our investigations prove that CME velocity can be determined through Sun-as-a-star spectral observations, and our modeling work provides important constraints on the future design of spectrographs for solar and stellar CME detections through EUV line asymmetries.

P-52

A statistical study of solar white-light flares observed by ASO-S/LST/WST

Z. Jing, Y. Li, LST Team, Y. Su, W. Chen, and D. Song (PMO)

Solar white-light flares (WLFs) are those accompanied by brightenings in the optical continuum. The White-light Solar Telescope (WST), as an instrument of the Lyman-alpha Solar Telescope (LST) on the Advanced Space-based Solar Observatory (ASO-S), provides continuous solar full-disk images at 360 nm, which can be used to study the WLFs. We analyze 205 flares above M1.0 observed by WST from October 2022 to May 2023 and identify 49 WLFs, i.e., with an occurrence rate of 23.9%. The percentages of WLFs for M1–M4 (31 out of 180), M5–M9 (11 out of 18), and above X1 (7 for all) flares are 17.2%, 61.1%, and 100%, respectively, namely the larger the flares, the more likely they are WLFs at 360 nm. We further study 38 WLFs with good data and investigate their properties such as white-light enhancement, duration, and brightening area. It is found that the relative enhancement of the white-light emission at 360 nm is mostly less than 30% and the mean enhancement is 17.3%. The WLFs' duration at 360 nm is mostly less than 20 minutes and its mean is 10.4. The brightening area at 360 nm is mostly less than 200 square arcseconds and its median is 95.9. In addition, we find that there exist good correlations between the enhancement/duration/area of white-light emission and the peak SXR flux of the flare, with correlation coefficients of 0.56, 0.58, and 0.86, respectively. The enhancement and duration of the white-light emission also have a positive correlation with the brightening area, with correlation coefficients of 0.46, 0.43, respectively. The peak times of white-light and HXR in many WLFs (20 out of 24) are also found to be very close.

P-53

Energetics of the November 29th, 2020 limb event

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We study an M-class (Nov 29th, 2020) flare to understand the energy budget of the event. We determine the thermal energy content and its evolution throughout the flare and how the contribution of thermal energy to the global energy budget changes during the flare. The bulk thermal energy of the flare is obtained from images from the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO), the Hinode X-ray Telescope. We calculate the Differential Emission Measure to infer the thermal energy as a function of time. We also use spectra obtained from the Fermi satellite for the flare to understand the non-thermal energy evolution. The flare also exhibits fan structure and SADs. A portion of the flare arcade appears hotter than the rest and is accompanied by spatial differences in the cooling of the fan. The CME emerging from this event hit PSP and grazed Stereo-A. The CME was observed by both Stereo-A and LASCO C2 and C3 coronographs. We plan to use these observations to quantify the energy budget associated with the CME eruption.

P-54

Thermal Evolution of a post-CME Current Sheet observed by the Metis on-board SolO

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The evolution of the coronal reconfiguration after a Coronal Mass Ejection (CME) was observed on February 12-13, 2021 by the Metis on-board the ESA - Solar Orbiter (SolO) mission. Combining multi-channel observations, temporal evolution of the 2D multiple plasma physical parameters of the post-CME CS is obtained for the first time. In particular, the electron temperature reaching peak values higher than 1 MK, more than 2 times larger than the surrounding corona in the covered altitude range (3.0 - 5.4 Rs). An elongated vertical diffusion region, characterized as a region of much higher thermal pressure and lower magnetic pressure, is slowly propagating outward during 13 hours of observations. Inside this region the plasma β is close to unit, and the level of turbulence is higher than the surrounding corona but decreases slowly with time. Measurements of inflow and outflow speeds also provided an estimate for the Alfvén Mach number on the order of 0.02 - 0.1. All these results, in good agreement with recent MHD simulations, support the picture of a magnetic reconnection coupled with turbulence and occurring in multiple smaller scale CSs resulting in the much broader macroscopic feature from observations.

P-55

Turbulent convection injects significant amount of magnetic helicity for solar flares

S. Toriumi (ISAS/JAXA), H. Hotta (Nagoya, U.), and K. Kusano (Nagoya, U.)

Solar flares are a sudden releasing of free magnetic energy accumulated in the corona in the form of magnetic helicity, a quantity to measure magnetic twists, kinks, and linkages. Therefore, the emergence of magnetic flux from the deep convection zone is a key to understanding how magnetic helicity is injected into the active region corona. To this end, we performed a series of realistic flux emergence simulations, in which magnetic flux tubes rise through the turbulent convection zone and appear to the photosphere to create bipolar sunspots. It was found that even a flux tube with no initial magnetic twist can reach the photosphere, build up rotational sunspots, and eventually inject non-zero magnetic helicity into the upper atmosphere. Detailed analysis revealed that vortices of turbulent convection spin the magnetic flux beneath the photosphere, which leads to the sunspot rotation in the photosphere and helicity injection into the atmosphere. The amount of injected helicity was about 20% to 50% of those in the flux emergence simulations with stronger initial twists, and even explains the lower-level solar flares. Our results indicate the possibility that the turbulent convection in the solar interior plays a crucial role in the helicity injection and, therefore, the flare eruptions.

P-56

Plasma properties of the loop top region of a solar flare

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Magnetic reconnection is the key mechanism for energy release in solar eruptions, where the high-temperature emission is the primary diagnostic for investigating the plasma properties during the reconnection process. We report observations of a flare in the loop top region with XRT, IRIS and AIA that include high-temperature emission and non-thermal broadening of high-temperature spectroscopic lines. In this work, we use a recently developed three-dimensional magnetohydrodynamic (MHD) simulation to model magnetic reconnection in the standard solar flare geometry and reveal highly dynamic plasma flows in the reconnection regions. We calculate the synthetic profiles of the Fe XXI 1354 A line observed by the Interface Region Imaging Spectrograph (IRIS) spacecraft by using parameters of the MHD model, including velocity and the plasma density and temperature as determined by XRT. The model shows that the turbulent bulk plasma flows in the CS and flare loop-top regions are responsible for the non-thermal broadening of the Fe XXI emission line.

P-57

Spectroscopic features on active phenomena in multiple chromospheric lines observed with Domeless Solar Telescope at Hida Observatory

J. Natsume, A. Asai, S. Ueno, and K. Ichimoto (Kyoto U.)

Solar active phenomena such as flares are important not only for understanding solar physics itself but also for understanding space weather and stellar activity. Chromospheric lines have different sensitivity to physical quantities such as temperature, density in the chromosphere and show different line-profiles during active phenomena. In the chromospheric lines of the Sun, features such as eruptions in Hα (e.g., Sakaue et al., 2018) and He I 10830 Å (e.g., Penn 2000) and red-asymmetry in flare kernel in Hα, Ca II K, and Ca II 8542 Å (Tei et al., 2018) have been observed. However, simultaneous spectroscopic observations of active phenomena in He line and other chromospheric lines have been rarely reported, and their comparisons have been lacking. In order to investigate differences in spectroscopic data of active phenomena among multiple chromospheric lines, we obtained spectroscopic data of four chromospheric lines (Hα, Ca II K, Ca II 8542 Å and He I 10830 Å) during flare brightenings and filament activations with Domeless Solar Telescope at Hida Obs. of Kyoto Univ. We compared the line profiles of these lines during the phenomena. In the wings of Hα and He I, it was found that the absorption components had similar line widths and sensitivity. In line center of these lines, on the other hand, the absorption component was detected in He I even when it was not detected in Hα. We considered that both the two lines have similar sensitivity to filament but the sensitivity of He I to flare brightening is weaker than that of Hα. The Ca II K brightening profile was detected with red-asymmetry even when Hα profile had filament absorption component. We thought this is because the Ca II K line has relatively higher sensitivity to emission of the flare than the Hα line.

P-58

Hot magnetic flux ropes preceding solar flares from active regions far from the limb

N. Nitta (LMSAL), V. Polito (BAERI), and P. Testa (SAO)

In some flares on or near the limb, images in SDO/AIA 131 A channel show a distinct feature below a closed structure in 171 A images that appears to become the front of a coronal mass ejection (CME). As presented by several authors, this feature in 131 A channel may signal a magnetic flux rope that is as hot as the formation temperature of the Fe XXI line. It may correspond in disk view to an S-shaped loop that arguably foretell an impending major eruption. But AIA (or GOES/SUVI) 131 A images alone may not serve as evidence for the presence of a hot flux rope because they are also contributed by cooler plasma in, e.g., Fe VIII lines. In order to further evaluate the importance of a hot flux rope in major eruptions that lead to full-blown CMEs, we compare IRIS spectra that contain the Fe XXI line with AIA 131 A images for intervals that precede several intense flares from regions on disk with varying eruptivity. As a forbidden line, the Fe XXI line at 1354.08 A is intrinsically weak, and has almost always been dealt with during the thermal phase of flares, but we find some signals prior to a few major eruptions.

P-59

Sounding rocket experiment FOXSI-4 for the focusing X-ray imaging spectroscopic observation of a solar flares

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FOXSI-4 is the fourth flight of the US-Japan joint sounding rocket experiment "Focusing Optics X-ray Solar Imager”. It will perform the world's first focusing X-ray imaging spectroscopic observation (0.5 keV to 30 keV) of a solar flare. The purpose is to demonstrate the research methodologies and observational techniques necessary to study the release of magnetic energy caused by magnetic reconnection and the resulting energy conversion mechanism. This project is scheduled for launch in Alaska, USA, in the spring of 2024 using a NASA sounding rocket. Currently, preparations for the launch are ongoing.

In order to observe solar flares, which are difficult to predict when they occur, using a sounding rocket whose observation time is limited to approximately 5 minutes, the following launch procedures will be conducted. (1) Standby under immediate launch-ready conditions. (2) Monitor solar X-ray intensity (GOES X-ray flux) in real time. (3) Launch immediately after a flare occurs. These are the first attempts even by NASA.

The observation technique and equipment are X-ray focusing imaging spectroscopy using a combination of a high-precision mirror and a high-speed camera as in the previous three FOXSI flights, but each component of FOXSI-4 has been updated for solar flare observations.

In this presentation, the science targeted by the FOXSI-4 and the preparation status of the instruments will be reported.

P-60

Observation and energy analysis of non-thermal precursor of an M5.4 flare

Z. Tian, L. Feng, and Y. Su (PMO)

The analysis of the activity and energy during the precursor phase plays an important role in understanding the mechanism of flare eruption. Here we investigate an M5.4 flare on March 29, 2023, which was accompanied by a failed filament erupt.

Interestingly, combining imaging and spectral data from the HXI (on board ASO-S) and STIX (on board Solar Orbiter), we found that the precursor phase of the event showed higher energy radiation than the main phase. This is the first time that we have verified the non-thermal source of the precursor phase of the flare from the same perspective, but at different distances, and the energy of particles in the precursor phase may exceed that of the main phase. Through the energy spectrum analysis, we find that the high-energy particle count in the precursor phase is significantly higher than that in the main phase, while the opposite is observed in the low-energy range. The energy spectrum during the precursor phase is flatter compared to the main phase.

A series of observations also support these phenomena. The LST on board the ASO-S observed this non-thermal precursor brightening at the Lyα waveband firstly, and STEREO A WAVES captured a Type III radio burst during the precursor phase, indicating the generation of high-speed electron beams during this period.

In this study, by integrating the above observations and energy analysis, we have explored the reasons behind the failed eruption of the flare event and the high-energy response during the precursor phase.

P-61

Lyα Emission Enhancement Associated with Soft X-Ray Microflares

Z. Tian, L. Feng, L. Lu, F. Xia, Y. Su, W. Gan, H. Li, and Y. Zhou (PMO)

Lyα (Lyα, 1216 Å) is the strongest emission line in the solar ultraviolet spectrum. In the present work, we obtained a Lyα enhancement catalog covering flares larger than B1 class from the GOES/EUVS data during 2010–2016. We focused on the 242 B-class events which are less investigated, however, show non-negligible Lyα emission enhancement. We found that on average the Lyα peak of B-class flares is 0.85% stronger than the background.

For the flare energetics, it is found that the weaker the soft X-ray (SXR) flare, the larger the ratio of the radiated energy in Lyα to SXR. Using the RHESSI data and multi-wavelength observations taken by SDO-AIA, we diagnose the thermal and non-thermal properties of several flares. Three case studies show that the coincidence of the Lyα peak with the SXR time-derivative peak is not a sufficient condition of the nonthermal property of a Lyα microflare. The Lyα enhancement in the microflares may be caused by the nonthermal electron beams or/and thermal conduction.

However, for type III events, we found that the delay of the Lyα peak with respect to the SXR peak can be attributed to either the Lyα emission from a filament erupted or the cooling of the thermal plasma in flare loops. Furthermore, interestingly the Lyα emission from filaments can not only occur in the decay phase of the flare, but also in the pre-flare phase. In this case, the Lyα emission was originated from an erupted filament which probably initiated the flare.

P-62

Prospects of Detecting Non-thermal Protons in Solar Flares via Lyman Line Spectroscopy: Revisiting the Orrall-Zirker Effect

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and J.W. Brosius (CUA/NASA GSFC)

Solar flares are efficient particle accelerators, with a substantial fraction of the energy released manifesting as non-thermal particles. While the role that non-thermal electrons play in transporting flare energy is well studied, the properties and importance of non-thermal protons is rather less well understood. This is in large part due to the paucity of diagnostics, particularly at the lower-energy (deka-keV) range of non-thermal proton distributions in flares. One means to identify the presence of deka-keV protons is by an effect originally described by Orrall & Zirker 1976. In the Orrall-Zirker effect, non-thermal protons interact with ambient neutral hydrogen, and via charge exchange produce a population of energetic neutral atoms (ENAs) in the chromosphere. These ENAs subsequently produce an extremely redshifted photon in the red wings of hydrogen spectral lines. We revisit predictions of the strength of this effect using modern interaction cross-sections, and numerical models capable of self-consistently simulating the flaring non-equilibrium ionization stratification, and the non-thermal proton distribution (and, crucially, their feedback on each other). We synthesize both the thermal and non-thermal emission from Ly-alpha and Ly-beta, the most promising lines that may exhibit a detectable signal. These new predictions are are weaker and more transient than prior estimates, but the effects should be detectable in fortuitous circumstances. We degrade the Ly-beta emission to the resolution of the Spectral Imaging of the Coronal Environment (SPICE) instrument on board Solar Orbiter, demonstrating that though likely difficult, it should be possible to detect the presence of non-thermal protons in flares observed by SPICE.

P-63

Towards Realistic Solar Flare Models

M. Haahr, B. Vilhelm Gudiksen (RoCS), and Å. Nordlund (NBI)

Solar flares are complex events that challenge our understanding of energy distribution in the Sun's atmosphere and the coronal heating problem. Accurate modeling of small and large-scale phenomena is crucial to capture the underlying physics. We here present a new particle-in-cell (PIC) solver within the Dispatch framework for simulating energetic particle acceleration and transport in the solar atmosphere.

Our approach combines global and kinetic simulations to investigate dynamics involving plasma instabilities, magnetic reconnection, and particle acceleration. Leveraging Dispatch, the PIC code integrates different solvers, utilizing magnetohydrodynamic (MHD) solvers for larger scales and resolving phenomena at smaller scales that exceed the MHD approximation.

Unresolved small-scale structures within the solar atmosphere pose a challenge for current satellite observations. These structures are believed to play a crucial role in the dynamics of solar flares. Our PIC solver, with its ability to capture processes at small scales, provides a promising avenue for investigating these elusive structures.

Our primary focus is on implementing and validating the PIC code within the DISPATCH framework. Rigorous validation tests ensure the fidelity, accuracy, and reliability of our simulation results. This poster outlines our methodology, provides an update on the validation process, and highlights our future code development roadmap. Our approach has the potential to revolutionize solar flare research by bridging the gap between large-scale and small-scale phenomena, deepening our understanding of particle acceleration during solar flares.

In summary, our study introduces a new PIC solver within Dispatch for simulating energetic particle acceleration in the solar atmosphere. We address the challenge of unresolved small-scale structures and highlight the potential of our approach to advance solar flare research.

P-64

Delays between transition region and chromospheric flare emission observed by the Interface Region Imaging Spectrograph

J. Lorincik (BAERI/LMSAL), V. Polito (BAERI/LMSAL/Oregon State U.),
G. Kerr (NASA GSFC/Catholic U. America), and L. Hayes (ESTEC)

Spectral observations of flare ribbons provide a wealth of information about the response of the lower atmosphere of the Sun to the energy injected during solar flares. The Interface Region Imaging Spectrograph (IRIS) has recently begun a series of campaigns that observe spectra at sub-second cadence, opening a new window on rapid processes occurring during the release and transport of energy during flares. Our study details one of the first analyses of flare spectra using those observations. We focus on transition region and chromospheric spectra observed during a C4-class flare from 2022 September 25. The intensities of the Si IV 1403Å, C II 1336Å, and Mg II k 2796Å lines observed in a flare ribbon exhibited enhancements with periods close tP-10 seconds. Interestingly, the times of the peak intensities differed across the three ions. The delays were most pronounced between Si IV (formed in the transition region) and Mg II (formed in the upper chromosphere), and were typically of the order of a few seconds. Throughout the observation and particularly towards the end of the impulsive phase of the flare, the Si IV intensity enhancements preceded those of Mg II. We attempted to reproduce these delays using RADYN radiation hydrodynamic simulations of flares driven by (1) electron beams, (2) thermal conduction following in-situ energy release, and (3) Alfvenic waves. The parameters of the electron beam simulations were constrained using non-thermal hard X-ray data from the Gamma-ray Burst Monitor (GBM) onboard the Fermi spacecraft. Reproducing the scenario in which peaks in the Si IV preceded the peaks in the Mg II lightcurves was generally difficult. Nevertheless, we present several simulations that did result in synthetic lightcurves consistent with the observations. Our observations thus pose tight constraints on the properties of the energy transport acting in this flare.

P-65

EIS Observations of the Transition Region During Solar Flares

H. Warren, and J. Reep (NRL)

Solar flares result from the release of magnetic energy in the corona, but a detailed understanding of this energy release process has remained elusive. In this poster we investigate the structure of the solar transition region during a flare using observations from the Extreme Ultraviolet Imaging Spectrometer (EIS) on Hinode. The strongest emission lines observed by EIS are typically formed at or above a million Kelvin. During a flare, however, emission lines from the transition region also become easily observable, making it possible to measure plasma over much of the solar upper atmosphere simultaneously. Furthermore, EIS observes density sensitive line pairs, which provide strong constraints on energy deposition. In this paper we compare EIS observations of flare footpoints from five events with simple hydrodynamic models. We find that these models overestimate the intensity of transition region emission by about a factor of 20. We conjecture that this discrepancy is a signature of the geometrical structure of the transition region, something that has been ignored in most previous simulations of solar flares. We also consider alternative explanations, such as non-Maxwellian distributions of energetic particles.

P-66

High-resolution observations of recurrent solar flares using SST and IRIS

J. Thoen Faber, R. Joshi, S. Wedemeyer, and L. Rouppe van der Voort (RoCS/UiO)

We investigate two flares (C1.9 and C2.4) that were captured by the Swedish 1-m Solar telescope (SST) in the photosphere and chromosphere at high resolution. The two flares were possibly connected and were co-observed with IRIS which provides flaring dynamics also in the transition region (TR). The IRIS observed the flares with slit-jaw images and spectral information using a medium dense 16-step raster. Spatial and temporal alignment between ground based (SST) and space-borne (SDO and IRIS) observations was performed to connect the different data-sets. This allows us to analyse the flares in different wavelengths that form at different atmospheric heights. In this contribution we will show some preliminary results.

Chromospheric H-alpha and Ca II 8542 Å profiles obtained from SST have been used for inversions of the C-class flares to get temperature, electron density and plasma bulk velocity stratification. This method is used with the application of RADYNVERSION code (Osborne et al., 2019). The code is much faster than traditional inversion methods as it utilises a machine learning approach to avoid heavy computations. Inversions on multiple pixels from a single time step and within the same flare ribbon consistently show that the TR was displaced approximately 1 Mm further down in the atmosphere. The main difference between the pixels is that they showed different velocity gradients below the TR.

P-67

Characteristics of accelerated particles in the solar corona

E. S. Øyre, and B. Gudiksen (RoCS/UiO)

Solar flares cannot be explained or simulated without considering the effects of non-thermal particles. The particles are observed through X-ray emissions in the flare loop-top and footpoints, and through ultraviolet radiation produced in flare ribbons. Magnetic reconnection releases the energy required to reach non-thermal velocities, but the processes dominating the acceleration is heavily debated. In addition, the observed signatures point towards an energy distribution which varies significantly from flare to flare. We are studying particle acceleration mechanisms by embedding trace particles in solar magnetic reconnection environments. In this contribution, we show preliminary results from simulations in a magnetic null-point configuration. The reconnection environment is produced by an MHD simulation, and the particles follow the guiding centre approximation.

P-68

Breaking all the rules: NOAA AR 12665

D.P. Cabezas (Nagoya U.), KD Leka (NWRA/Nagoya U.), and K. Kusano (Nagoya U.)

Solar active regions that behave in unexpected ways force us to re-consider our understandings. They should not be ignored. NOAA Active Region 12665, which transited mid-July 2017, is such a region; at first glance it is an isolated, not-very-complex, not-very-active sunspot group. However, the evolution of the photospheric magnetic field in the context of the chromosphere, corona, and energetic events, presents interesting contradictions: M-class flares without a strong Polarity Inversion Line (PIL), gradually disappearing bald-patch separatrix surfaces without (immediate) evidence of a Magnetic Flux Rope, a (later) Magnetic Flux Rope without a photospheric bald-patch area (which is involved in a large CME). Using data from the Hinode/Spectropolarimeter, Hinode/XRT, imaging spectroscopy from Hida Observatory SDDI (H-alpha) and IRIS, plus SDO/AIA images in the EUV for context, we examine the evolution and fate of the bald-patch separatrix surfaces in light of the formation of chromospheric filaments and coronal sigmoids.

P-69

Data-driven modeling of an inclined solar eruption in NOAA active region 11283

Y. Kang (ISEE/Nagoya U.), T. Kaneko (Niigata U.),
KD Leka (NWRA, ISEE/Nagoya U.), and K. Kusano (ISEE/Nagoya U.)

In this study, we conduct a long-term data-driven MHD simulation of the M5.3 eruptive flare produced in AR 11283 and reveal the initiation of eruption mechanism from the viewpoint of the torus instability theory using a new method to analyze the decay index. The initiation mechanism of solar eruption is not understood completely because currently, coronal magnetic fields are hard to be measured directly. To overcome this observational limitation, numerical simulations can be good approaches to explore the dynamics of coronal magnetic fields in flaring phases. AR 11283 is a typical AR which produced several large flares after a new magnetic flux is emerging. The objective of this study is to understand the whole process from the accumulation of free magnetic energy to the occurrence of the M5.3 flare, the first large flare produced in the AR on September 6 01:59 UT, 2011. We use a data-driven method introduced in Kaneko et al. (2021). In this method, a time-series of the photospheric vector magnetic field data (SHARP) is used as the input. The simulation covers a long-term period of September 4, 19:48 UT, 2011 to September 6, 06:48 UT, 2011. Our modeling has reproduced both a formation of magnetic flux ropes (MFRs) and a following solar eruption corresponding to the M5.3 in the AR, with a good agreement with the SDO/AIA observation. In particular, the reproduced eruption exhibited an inclination with respect to the local normal direction. To understand the mechanism of this deflected eruption, we introduce a new method to calculate the decay index, which considers all eruptive directions of the MFRs. This approach enables both the evaluation of the torus instability growth and the determination of the potential eruptive direction of the MFRs.

P-70

Magnetic field solar dark filaments obtained from He I 1083 nm spectropolarimetric observation

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D. Cabezas (Nagoya U.), S. Ueno (Kyoto U.), T. Kawate (NIFS),
and K. Ichimoto (Ritsumeikan U.)

Solar filaments are dense cool plasma in the solar corona. They are supported in a dip of coronal magnetic field. However, the models still disagree between two types of field configuration; one is the normal polarity model proposed by Kippenhahn & Schlueter (1957), and the other is the reverse polarity model proposed by Kuperus & Raadu (1974). To understand the mechanism that the filaments become unstable before eruption, it is critical to confirm the magnetic field configuration of solar filaments. In this study, we performed the spectro-polarimetric observation with the He I 1083 nm line to investigate the magnetic field strength and structure of dark filaments. The observation was carried out with the Domeless Solar Telescope at Hida Observatory which achieves a polarization sensitivity of 3.0×10^-4. We obtained 8 samples of quiet sun (QS) filaments. As a result of our analysis of full Stokes profiles, we found that the field strengths were estimated as 8 - 35 G. By comparing the direction of the magnetic field in filaments and the global distribution of the photospheric magnetic field, we determined the magnetic field configuration of the filaments, and we concluded that 1 out of the 8 samples has normal polarity configuration, and 7 out of the 8 have reverse polarity configuration. In our presentation, we will also discuss the disambiguation method in Stokes inversion and validation of field configuration by comparing to the X-ray observation by Hinode XRT.

P-71

Time-Series Prediction of SDO Ultraviolet Full-disk Images using a Video Prediction Method with Deep Learning

A. Sasaki, and Y. Iida (Niigata U.)

The importance of space weather forecasting is increasing in recent years. Solar full-disk ultraviolet images are often used in predicting solar activities that influence space weather. In this study, we conduct prediction and generation of full-disk solar ultraviolet images for earlier space weather forecasting using a method known as video prediction.

Video Prediction is a deep learning model that takes a part of a video as input and generates and outputs frames that are predicted to follow that input. Video prediction has made remarkable progress in recent years with the advent of ConvLSTM (Shi, Xingjian, et al 2015). In this study, we used Motion-Aware Unit (MAU) based on Pred-RNN proposed in Chang, Zheng, et al. (2021).

As a dataset, we used full-disk images of SDO/AIA211, where large structures such as coronal holes and active regions can be clearly seen. Data from 2010 to 2022 were sampled at 4-hour intervals. We built a model that takes 48 hours of data, or 12 full-disk images, as input and estimates the following 48 hours at 4-hour intervals.

The model we built generally reproduced large-scale structures that were visible on the disk at the time of the most recent input, along the differential rotation. We compared the UV intensity of the same pixel in the predicted image and the correct image for ten such active regions and calculated the correlation coefficient, which was 0.86 after 4 hours, 0.76 after 24 hours, and 0.63 after 48 hours. In addition, the model also roughly reproduced the distribution of UV intensity for active regions that existed on the eastern limb at the time of the latest input and appeared on the disk after time passed.

These results demonstrate the usefulness of deep learning-based video prediction technology in space weather forecasting.

P-72

Understanding the origin of the 30 THz emission in active regions and during solar flares

K. Lopez, C. Giménez de Castro, J.-P. Raulin (CRAAM), D. Cabezas (Nagoya U.), and Carlos Francile (OAFA)

Mid-Infrared (MIR) solar observations (e.g. 30 THz; 10um) have been poorly explored and recent studies of flares using 30 THz observations are scarce, remaining elusive a definitive interpretation of its origin as well as the emission mechanism at work. Moreover, only few studies of the quiet-sun and active regions at 30THz have been conducted so far. In this work, we aim at understanding where the 30 THz emission originates during solar flares as well as in quiescent active regions. Our data sample includes observations taken on May 20, 22, and 23, 2022 by the AR30T telescope located at OAFA, Argentina.

We compare active regions images at 30 THz with multiwavelength observations including: G band (4305 Å) and Ca II K (3933.67 Å) provided by the Solar Observatory of NAOJ, Hα line center (6562.8A) and wings (Hα ± 1.25Å, Hα ± 2Å, Hα + 3Å) from the SMART telescope at Hida Observatory, HMI continuum (6173Å), 1700Å and 1600Å recorded by SDO/AIA, and line-of-sight magnetograms. At first glance/impression it is likely that active regions 30 THz emission originate close to the photosphere because we found similarities with Hα wings observations, that is, the morphology of sunspots and also the bright regions called plages that surround the sunspots exhibit similar characteristics. In case of solar flares, it is expected that 30 THz emission is due to the thermal radiation from the chromosphere. Our data sample will also allow us to gain better clues on the emission mechanism of 30THz during solar flares.

P-73

MHD simulations of the CME near the Sun

K. Hayashi (GMU), C-.C. Wu (NRL), and K. Liou (APL/JHU)

We will present results from the MHD simulation of the coronal mass ejections (CMEs) with various setting choices, such as the initial configuration of magnetic field and plasma within the initiated CME body and the background quiet solar corona and solar wind. We will particularly discuss the differences in the simulated propagation of the compression wave front and the nonpotential magnetic field.

The CME propagation, in particular, the variation of the shock front shape, is determined by several factors, such as the magnetic and plasma properties of the CME body and the surrounding quiet solar wind. The gradient of the solar wind properties near the Sun is very steep, in comparison with that in the so-called solar wind regime (i.e. $r > 20$ Rs). The MHD simulation study for the region near the Sun is critically important for understanding the CME propagation in the background solar wind that quickly varies in the radial direction.

The simulation will be done mainly for the region from 2.5 Rs and beyond using a modified version of our existing solar wind model (H3DMHD) with a characteristics-based boundary treatment for the inner boundary surface (at 2.5Rs) in the middle of the solar corona. The boundary treatment is named CharM. With the CharM boundary treatment, we can simulate the CME propagation at their earliest phase near the Sun. In this study, we model a CME event with various parameters, and examine which parameters, such as the plasma density and temperature, field strength, the orientation of the torus-structure magnetic rope, and velocity of the initial propagation, are relevant to the dynamics of the CME propagation and the interactions with the ambient solar wind.

P-74

High resolution imaging and spectroscopy of an Active region Filament

M. Murabito, V. Andretta (INAF/OACN), S. Parenti (IAS),
C. Kuckein (IAC), and S. J. Gonzales Manrique (KIS)

Solar filaments are cool, dense plasma structures suspended in the extremely hot solar corona. They always lie above magnetic polarity inversion lines (PILs) on the photosphere and are supported by the local magnetic fields against gravity.

We present a unique study of an active region filament, where we had the possibility to study the evolution of the filament itself using all the data available so far. Indeed, the filament was observed using the 1.5-meter ground-based GREGOR telescope giving us the chance to have the highest spatial and temporal resolution Halpha imaging, capturing the formation phase and stable phase of the filament. The IRIS satellite performed very large spectroscopic raster scans allowing us to have plasma properties from the higher chromosphere to the transition region revealing a downflow velocity pattern at the edge of the filament. Lastly, we complement the study using chromospheric and coronal SDO/AIA filtergrams (304, 193 and 94 A).

P-75

Modeling of the Si IV emission as a response of the flare energy transport to the transition region

E. Dzifcakova (Astronomical Institute of the Czech Academy of Sciences)

First results of the modeling of the Si IV emission at the foot points of flaring loops are presented. The radiation-hydrodynamical simulations were performed using the FLARIX code. We modelled transition region response to an electron beam transporting an energy from reconnection site down to the chromosphere using a wide range of the beam parameters. Consequently, non-equilibrium ionization states of silicon and Si IV emission were calculated in high temporal resolution. The results are then compared with Si IV emission observed by IRIS in the impulsive phase of solar flares.

P-76

Searching for Photospheric Responses of Solar Eruptions with Near-UV Absorption Lines

I. Berry, X. Sun (IfA), S. Jaeggli (NSO), and W. Liu (LMSAL)

Solar active region (AR) photospheric magnetic fields undergo rapid evolution during major eruptions. Specifically, the horizontal magnetic field component near the main polarity inversion line of the AR sees permanent increases of order hundreds of Gauss over several minutes. The resulting Lorentz force acts on the dense, lower atmosphere, capable of drawing material upwards from the photosphere. This "gentle photospheric upwelling" is expected to occur in the AR core situated between flare ribbons with mean velocity estimates on the order of tens of meters per second. To investigate this phenomenon, we use near-ultraviolet (NUV) observations of photospheric absorption lines (in the Mg II h&k line wings) taken by the Interface Region Imaging Spectrometer (IRIS), as well as vector magnetic field observations taken by the Helioseismic and Magnetic Imager (HMI) to search for such Doppler signal. X1.0 and X1.1 class solar flares observed by IRIS occurring respectively on 2014 March 29 and 2023 February 11 are analyzed. We extract the Doppler velocities for a number of lines at various formation heights. Our initial results show that Doppler velocities of the AR core during the flare are statistically different from the pre-flare state: the overall distribution is slightly more blueshifted; both more extreme blueshifts and redshifts are present. There is no obvious trend as a function of height. We discuss the implication of our findings on the "gentle photospheric upwelling" hypothesis.

P-77

History Matters: NOAA AR 12665 and Testing for the Presence of a Magnetic Flux Rope

KD Leka, K. Kusano, and D. Cabezas (ISEE/Nagoya U.)

The "flux rope" is a proposed magnetic topological structure that may (or may not) present with some observable characteristics. Searching for evidence of a magnetic flux rope generally involves magnetic extrapolations and concurring evidence from the photosphere, chromosphere, and corona. We present the interesting case of NOAA AR 12665, which crossed the solar disk in July 2017. As discussed in the poster by Cabezas et al, this region presented some serious challenges to model expectations, which we explore more, here. In particular, we investigate the ability (or not) of extrapolations to confirm the existence of a magnetic flux rope, in light of NOAA AR 12665's contradictory photospheric indications of the presence of a flux rope, namely the bald-patch separatrix surface, during different periods of its evolution.

P-78

Evaluation of electron acceleration efficiency during solar flares using MHD+GCA test particle simulation

Y. Sato (SOKENDAI/NAOJ), T. Kaneko (Niigata U.), N. Narukage (NAOJ), and S. Takasao (Osaka U.)

Previous hard X-ray and radio observations reveal that solar flares produce high-energy electrons ranging from tens of keV to the MeV band. However, the mechanism of electron acceleration is still unresolved.

In MHD simulations with high spatial resolution, various plasma structures such as plasmoids and termination shocks have been found. They are possible candidates for particle acceleration ([Takasao & Shibata 2016], etc.). However, we cannot evaluate the acceleration of each particle in the framework of MHD where the fluid approximation is applied. Therefore, previous studies such as [Birn et al. 2017] have evaluated the acceleration efficiency of MHD flare structures by performing test particle calculations based on the relativistic Guiding Center Approximation (GCA), using the results of MHD calculations as background electric and magnetic fields.

In this study, we applied this method to MHD backgrounds covering the entire flare region to quantitatively evaluate the particle acceleration efficiency for various plasma structures that are reproduced self-consistently in the same flare model. We investigated the several time frames that correspond to different stages in the evolution of reconnection. As a result, it was found that electrons moving periodically around plasmoids with large curvature can be efficiently accelerated. In this presentation, we will discuss electron acceleration in flares, including the results of acceleration efficiency in other plasma structures.

P-79

Impact of subsurface convective flows on the formation of sunspot magnetic field and energy build-up

T. Kaneko (Niigata U.), H. Hotta (Nagoya U.), S. Toriumi (ISAS/JAXA), and K. Kusano (Nagoya U.)

Strong solar flares occur in δ-spots characterized by the opposite-polarity magnetic fluxes in a single penumbra. Sunspot formation via flux emergence from the convection zone to the photosphere can be strongly affected by convective turbulent flows. It has not yet been shown how crucial convective flows are for the formation of δ-spots. The aim of this study is to reveal the impact of convective flows in the convection zone on the formation and evolution of sunspot magnetic fields. We simulated the emergence and transport of magnetic flux tubes in the convection zone using radiative magnetohydrodynamics code R2D2. We carried out 93 simulations by allocating the twisted flux tubes to different positions in the convection zone. As a result, both δ-type and β-type magnetic distributions were reproduced only by the differences in the convective flows surrounding the flux tubes. The δ-spots were formed by the collision of positive and negative magnetic fluxes on the photosphere. The unipolar and bipolar rotations of the δ-spots were driven by magnetic twist and writhe, transporting magnetic helicity from the convection zone to the corona. We detected a strong correlation between the distribution of the non-potential magnetic field in the photosphere and the position of the downflow plume in the convection zone. The correlation could be detected 20-30 h before the flux emergence. The results suggest that high free energy regions in the photosphere can be predicted even before the magnetic flux appears in the photosphere by detecting the downflow profile in the convection zone.

P-80

The mechanism of the formation and eruption of flux rope associated with the M2.8 flare that occurred in the active region 12871 on September 21, 2021

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Eruptive solar flares are associated with the eruption of magnetic flux rope such as H-alpha filament or Soft-Xray/EUV sigmoid.It is widely accepted that eruption of magnetic flux rope is driven by the MHD instability,e.g. torus instability(Kliem and Török 2006), kink instability(Kruskal 1954,Shafranov 1957), double arc instability(Ishiguro and Kusano 2017) and so on. In recent years, the decay index of the torus instability is widely used to investigate the cause of the eruption. Many previous studies assume the direction of the eruption is normal to the solar surface, however some of the flares show non-radially directed CMEs (McCauley+ 2015).

In this study, we carefully analyze the non-radially directed flux rope eruption observed in NOAA12871 on 21-Sep-2021 associated with M2.8 flare and CME. A small brightening is observed along the magnetic neutral line at 04:09, and then the flux rope appears as hot channel in high temperature band of SDO/AIA images. The flux rope shows slow rise for about 10 minuets, and eruption and flare observed at 04:38. We examine if the appearance of the hot channel and the slow rise of the flux rope can be explained by the tether-cutting reconnection and the subsequent torus instability.

The eruption of the flux rope formed along the magnetic neutral line followed by the slow rise phase is successfully explained using the numerical solution of the equation of motion for torus instability by Kliem and Török 2006.We found that the observation can be explained by a theoretical model of flux rope with inclination angle of 51 deg from the horizontal direction. We also found that the flux rope is free from torus stability when the flux rope is formed, and the initial velocity is required to develop eruption.

P-81

IRIS Fe XXI line profiles as diagnostics for flare heating models

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Recent observations with IRIS show that the Fe XXI line completely blueshifted profiles at the flare footpoints are significantly and symmetrically broadened around the line center for several minutes, with non-thermal velocities of up to ~100 km/s. Different interpretations for the excess broadening include: superposition of unresolved flows along the line-of-sight, Alfvén waves turbulence, and Isotropic broadening with the absence of a preferential direction with respect to the magnetic field. By comparing IRIS Fe XXI observations and hydrodynamic simulations of multithread flare loops, Polito et al. 2019, ApJL, found that the superposition of flows alone cannot easily reproduce the observations. In this work we will expand on these preliminary results by analyzing the Fe XXI line profile in a larger your sample of flares observed by IRIS as a function of different longitudes along the solar disk, and compare the observations with predictions from different flare models. We will discuss whether the IRIS observations can be explained by Alfvén waves turbulence or whether some other physical process needs to be invoked.

P-83

Comparison of 3D coronal magnetic field structure between eruptive and confined flares observed in AR 12673 on September 6, 2017

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Solar flares and CMEs are considered to be similar eruptive events that release coronal magnetic energy, but the relationship between them is not clear. It is also important to understand CME-triggering 3D coronal magnetic field configurations for space weather prediction. To investigate the difference of 3D coronal magnetic field configurations between the eruptive and confined flares, we analyzed the time series of AIA 1600 Å images and performed a nonlinear force-free field (NLFFF) extrapolation of the active region (AR) 12673, in which the confined and eruptive flares were observed on 2017 September 6. We analyzed flare ribbons to find the flare onset region. On the confined flare, a pair of flare ribbons appeared around the main polarity inversion line (PIL) at the center of the AR. On the eruptive flare, flare ribbons appeared around the main PIL and extended to the southwest in 6 minutes, and the other flare ribbons appeared at the northwest of the AR. Moreover, the distance of flare ribbons around the main PIL was 20 and 40 arcseconds on the confined and eruptive flares respectively, the distance is thought to be proportional to the reconnection height. In addition, we checked the NLFFF to compare the flare-related magnetic field configuration and magnetic twist as a proxy of magnetic energy around flare ribbons. Before the confined flare, the twisted magnetic field lines existed around the main PIL and at the northwest and southwest of the AR. Before the eruptive flare, the number of the northwest and southwest twisted magnetic field lines with magnetic twist of more than 0.5 increased about twice. These results suggest that only the eruptive flare had CME because magnetic reconnection took place in the northwest and southwest of the AR at the higher corona, and then a larger-scale magnetic field configuration changed.

P-84

Generation of EIT waves by coronal mass ejections: Global magnetohydrodynamic simulation

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Moreton waves are a semi-circular brightening arc propagating across the solar disk at speeds ranging from a few hundred to over a thousand km/s. They are first observed in 1960, long before the discovery of EIT waves and coronal mass ejections (CMEs). Propagation of these waves were generally explained as the "skirt" of an expanding coronal wave (presumably flare-related) intersecting with the chromosphere (Uchida, 1968). Such a scenario has been demonstrated in a study of the May 12, 1997 CME event using a three-dimensional global magnetohydrodynamic simulation model (Wu et al., 2013). This particular CME event, which has been studied by many workers, was a halo CME. It was observed by SOHO/EIT and its associated magnetic cloud and driven shock were observed three days later by the Wind spacecraft. In our previous study, a pressure pulse (e.g., cloudless) was used as the CME proxy. This simplified CME model may compromise our simulation result. Here, we re-study the same CME event by employing a magnetic flux rope in our MHD simulation. This new simulation with a flux rope also supports the scenario proposed by Uchida. We conclude that in addition to its possible flare source, an EIT wave can be a part of CME-induced coronal wave/shock. We will present the detailed result.

P-85

Spectro-Polarimetric Analysis and Modeling of Sunquake Sources

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We perform a detailed spectro-polarimetric analysis of the sunquake photospheric sources of a X1.5 flare, using the Stokes profiles of the Fe I 6173 A line, reconstructed from the HMI linear and circular polarized filtergrams. The results show fast variations of the continuum (white-light) emission with rapid growth and slower decay lasting 3-4 min, coinciding in time with the hard X-ray impulses observed by the Konus instrument onboard the Wind spacecraft. The variations in the line core appeared slightly ahead of the variations in the line wings, showing that the heating started in the higher atmospheric layers and propagated downward. The most significant feature of the line profile variations is the transient emission in the line core. In addition, the observed variations of the Stokes profiles reflect transient and permanent changes in the magnetic field strength and geometry in the sunquake sources. The analysis results and comparison with radiative hydrodynamics models suggest that the flare energy release, which occurred in low-lying magnetic loops, produced high-energy electrons and protons. The electrons, precipitating into the high chromosphere, produced hard X-ray emission at the loop footpoints, but the protons penetrated deeper into the photospheric layers and delivered the momentum sufficient for the generation of sunquakes. The line core emission indicates strong impulsive heating of the lower chromosphere and photosphere, to which high-energy protons ($E \gtrsim 5$ MeV) and electrons ($E \gtrsim 200$ keV) could contribute.

P-86

Predicted appearance of Magnetic Flux Rope and Sheared Magnetic Arcade Structures before a Coronal Mass Ejection via three-dimensional radiative Magnetohydrodynamic Modeling

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Magnetic Flux Ropes (MFRs) are free-energy-carrying, three-dimensional magnetized plasma structures characterized by twisted magnetic field lines and are widely considered the core structure of Coronal Mass Ejections (CMEs) propagating in the interplanetary space. The way MFRs form remains unclear as different theories predict that either MFRs form during the initiation of the CME or pre-exist the onset of the CME. The term "pre-existing structure" is synonymous with "filament channels." On the one hand, the theories predicting on-the-fly MFR formation require Sheared Magnetic Arcades (SMAs; low twist but stressed magnetic structures) for the filament channel/pre-existing magnetic structure of CMEs. On the other hand, a growing number of works using SDO/AIA observations (combined with non-linear force-free extrapolations; NLFFF) suggest that MFRs may be the form of filament channels, therefore pre-existing the CME eruption. However, due to the inability to routinely measure the 3D magnetic field in the solar atmosphere, we cannot unambiguously interpret optical and EUV imaging observations as projected on the plane of the sky. Therefore, a raging debate on the nature of the pre-eruptive structure continues. It is also possible that the filament channel/pre-eruptive structure evolves from SMA to MFR slowly, further complicating the distinction between these two types of structures in the solar observations. This work presents realistic simulated EUV observations synthesized on a time-evolving radiative MURaM MHD model along the slow evolution of an SMA converting to an MFR. We discuss the implications of our results in the context of filament channel formation and CME initiation theory.

P-87

A multi-observatory view of chromospheric oscillations

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We present an overview of chromospheric oscillations observed during a coordinated campaign that collected data from X-ray to radio wavelengths using Hinode, IRIS, SDO, DST, and ALMA on 2017-03-17. The target was a bipolar region of enhanced network near disk center. We found spatial patterns of oscillatory power that display a clear relationship with the underlying magnetic field, but the exact pattern of correlation, anticorrelation, or no correlation depends on the specific diagnostic. Of particular note, we found a strong spatial correspondence between the oscillatory power in the millimeter wavelength ALMA brightness temperature and the width of the hydrogen alpha line observed by DST/IBIS. These diagnostics are related to, but do not directly match, the photospheric magnetic field concentrations observed with Hinode/SOT and SDO/HMI, nor the density of bright points in the IRIS Si IV slit-jaw images. By comparing spatially averaged power spectra of the IBIS and ALMA data, we argue that the lack of clearly observed p-modes in the ALMA data is due to the timing and duration of the ALMA calibration windows, at least for this data set.

P-88

Data-Driven Boundary Conditions for 3D Magnetohydrodynamic Photosphere to Corona Simulations of the Sun

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We present a new method for data driven boundary conditions, based on the method of characteristics, that is valid for magnetohydrodynamic (MHD) simulations of the solar atmosphere driven at a photospheric boundary. The boundary condition incorporates observationally derived estimates for the full MHD state vector at every spatial point. We combine an optimization method with the characteristics to find a time evolution of the boundary between sparsely observed instances that is also strictly consistent with the MHD equations. We discuss why such boundary conditions are necessary in the field of solar physics, and then validate our method by replicating the results of a ``ground truth" simulation of an expanding spheromak. The expanding spheromak mimics the emergence of a magnetic active region on the Sun, and the data-driving algorithm uses a time series of data extracted from just a single layer of the ground truth simulation.

P-89

Investigation of Moving Magnetic Features using Coordinated Hinode/SOT-SP and IRIS Scans

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Moving magnetic features (MMFs) are small unipolar and/or bipolar concentrations of magnetic field surrounding sunspots. Most MMFs are $<$ 2¥arcsec¥ in size and last for 10 minutes tP-10 hours. They move laterally outward (with a speed of $<$ 2 ¥kms) across the sunspot's ``moat'' until they reach the network field, and carry a significant amount of magnetic flux -- thus, MMFs are proposed to be responsible for sunspot decay. Although many researchers have explored the photospheric properties of MMFs, only a few have studied how the chromosphere and transition region respond to the evolution of MMFs. We compare ¥MgII, ¥SiIV, and ¥CII¥ spectra and slit-jaw (SJ) images from the Interface Region Imaging Spectrograph (IRIS), and line-of-sight (LOS) magnetograms, inferred from a Milne-Eddington inversion of the spectral data obtained by Spectropolarimeter (SP) on the Hinode spacecraft, to study the structure and dynamics of MMFs in the photosphere and their response to the chromosphere and transition region. Hinode/SOT-SP and IRIS have simultaneously scanned a part of sunspot penumbra, covering the sunspot peripheral region, for about four hours. Each MMF, either unipolar or bipolar, identified in SP LOS magnetograms, shows enhanced dynamic brightenings in IRIS SJ images. These brightenings accompany multiple jet-like events, particularly when the underlying MMF is bipolar and an obvious magnetic flux cancellation is going on. Nonetheless, a few MMFs that are outstandingly bright in ¥MgII, ¥SiIV, and ¥CII¥ SJIs, and are long-lived, are visibly unipolar in SOT-SP LOS magnetograms. A majority of MMFs show redshifted IRIS ¥MgII¥ spectra but some that most clearly correspond to flux cancellation sites show both blueshift and redshift. We compare IRIS spectra of unipolar and bipolar MMFs. Finally, we will discuss how some of our MMFs relate with Ellerman Bombs and/or EUV bursts.

P-90

Ultra-high resolution observations of plasmoid-mediated magnetic reconnection in the deep solar atmosphere

L. Rouppe van der Voort (RoCS/UiO)

Magnetic reconnection in the deep solar atmosphere can give rise to enhanced emission in the Balmer hydrogen lines, a phenomenon referred to as Ellerman bombs.
To effectively trace magnetic reconnection below the canopy of chromospheric fibrils, we analyzed unique spectroscopic observations of Ellerman bombs in the H-alpha line.
We analyzed a 10min dataset of a young emerging active region observed with the prototype of the Microlensed Hyperspectral Imager (MiHI) at the Swedish 1-m Solar Telescope (SST). The MiHI instrument is an integral field spectrograph that is capable of achieving simultaneous ultra-high resolution in the spatial, temporal and spectral domains. With the combination of the SST adaptive optics system and image restoration techniques, MiHI can deliver diffraction limited observations if the atmospheric seeing conditions allow. The dataset samples the H-alpha line over 4.5 A with 10 mA/pix, with 0.065"/pix over a field of view of 8.6" x 7.7", and at a temporal cadence of 1.33s. This constitutes a hyperspectral data cube that measures 132x118 spatial pixels, 456 spectral pixels, and 455 time steps.
There were multiple sites with Ellerman bomb activity associated with strong magnetic flux emergence. The Ellerman bomb activity is very dynamic, showing rapid variability and small-scale substructure. We found a number of plasmoid-like blobs with full-width-half-maximum sizes between 0.1" - 0.4" and moving with apparent velocities between 14 and 77km/s. Some of these blobs have Ellerman bomb spectral profiles with a single peak at a Doppler offset between 47 and 57km/s.
Our observations support the idea that fast magnetic reconnection in Ellerman bombs is mediated by the formation of plasmoids. Earlier, we found evidence of the presence of plasmoids in coordinated SST and IRIS observations of UV Bursts.

P-91

Does Big Heating Come in Small Sizes? Chromospheric Turbulence and Heating Due to the Thermal Farley-Buneman Instability

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Models fail to reproduce observations of the coldest regions in the Sun's atmosphere, where interactions between multiple ionized and neutral species prevent an accurate MHD representation. We present evidence that a meter-scale electrostatic plasma instability develops in these regions, causing turbulence and heating. We refer to this instability as the Thermal Farley–Buneman Instability (TFBI). We simulate the TFBI and characterize the wave-driven heating, plasma transport, and turbulent motions. These results all contend that the TFBI contributes to the discrepancies between observations and radiative MHD models of the solar chromosphere.

P-92

IRIS Spectral Observations of a Jet-generating Minifilament Eruption

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and B. De Pontieu (LMSAL)

Solar jets of all sizes are magnetically channeled narrow eruptive events. They are often observed in UV, EUV, and coronal X-ray images. Here we present the detailed analysis of a coronal jet and the minifilament eruption that made it, fully captured and well-resolved in high-resolution IRIS Mg II spectra. The Mg II spectroheliograms show that the minifilament plasma temperature is chromospheric. The Mg II spectra show that the erupting minifilament's plasma has blueshifted upflow in the onset of the jet spire and simultaneous redshifted downflow at the location of the compact jet bright point (JBP). From co-aligned IRIS Mg II spectroheliograms, HMI magnetograms, and AIA coronal EUV images, we find that (i) in a coronal hole, a minifilament forms above a flux-cancelation neutral line at the edge of a negative-polarity network flux clump; (ii) during the onset of the minifilament's eruption, the JBP appears over the flux cancelation neutral line. From IRIS2 inversion of the Mg II spectra, the JBP's Mg II bright plasma has electron density, temperature, and downward (redshift) Doppler speed of 1012 cm−3, 6000 K, and 10 km s−1, respectively. We conclude that magnetic flux cancelation builds a minifilament-carrying twisted flux rope and triggers the jet-generating eruption of the flux rope.

P-93

MultiFluid simulations of magnetic reconnection in the lower solar atmosphere with a helium-hydrogen-carbon mixture

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and V. H. Hansteen (LMSAL/BAERI)

Magnetic reconnection (MR) is a fundamental process that occurs frequently in the chromosphere at various scales. This study investigates the influence of multi-fluid multi-species (MFMS) effects on MR in conditions representative of the upper solar chromosphere, incorporating a mixture of helium, hydrogen, and carbon. MRs play a significant role in the dynamics of chromospheric jets, as observed by the Interface Region Imaging Spectrograph (IRIS) (Rouppe et al., 2017). Recent observations employing IRIS and the Swedish Solar Telescope (SST) (Rouppe van der Voort et al., 2018) provide evidence for the formation of plasmoids during MR events. The focus of this work is to comprehend MR events occurring during ultraviolet (UV) bursts or flares through 2.5D numerical simulations.

To accomplish this, we employ the Ebysus code (Martinez-Sykora et al., 2019), which extends the state-of-the-art radiative magnetohydrodynamic (MHD) code Bifrost (Gudiksen et al., 2011). We develop an efficient numerical strategy (Abdulle & Vilmart (2013)) that employs a partitioned implicit-explicit orthogonal Runge-Kutta method for integrating the MFMS model.

In a classical 2.5D perturbed Harris current sheet under solar chromospheric conditions, our findings demonstrate that MFMS effects and particle decoupling lead to efficient heating mechanisms. The distinct dynamics exhibited by helium, hydrogen, and carbon species could also result in chemical fractionation and the enrichment of helium or carbon species. These results have significant implications for recent observations of helium enrichment in switchbacks or coronal mass ejections.

P-94

Evolution of an Ephemeral Active Region

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Active regions on the Sun, characterized by intense magnetic fields and enhanced activity, play an important role in understanding solar dynamics. In this study, we present a comprehensive analysis of a small bipolar ephemeral active region observed through a synergistic combination of ground-based and space-based observatories. The investigation was conducted as part of an observing campaign supporting NASA's Parker Solar Probe during its 8th perihelion passage in late April and early May 2021. Our focus centered on a highly dynamic and rapidly evolving ephemeral active region positioned close to a coronal hole. The analysis combines data from Hinode, IRIS, SDO, GREGOR, GST, and DST to form a holistic understanding of this ephemeral active region. Early in our small region's life its poles first spread apart from each other; but later in its life the two poles appeared to converge back toward each other, and perhaps undergo mutual flux cancellation. By examining multiple physical quantities, including lightcurves, temperature, emission measure, magnetic field, and Doppler velocities, we aim to shed light on the dynamic processes within this region.

P-95

Magnetic structure analysis by applying persistent homology to Hinode and SDO magnetograms

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The ability to encode and simplify all information about the shape and distribution of data has turned Topological Data Analysis (TDA) into one of the most relevant fields in state-of-the-art data analysis. Among all the tools of TDA, persistent homology has proven to be one of the most relevant techniques, and has been applied in numerous fields of study, such as biomedicine, chemistry, atomic physics, or image classification.

In this work, we study what persistent homology can offer in the analysis of solar magnetograms, with the purpose of providing a new tool that will serve as foundation for further studies of magnetic structures on the solar surface. We propose an approach based on the use of persistence diagrams belonging to various filtrations in order to be able to capture the whole magnetic scene involving a mixture of positive and negative polarities.

We have applied the analysis to quiet sun and active regions observations, taken with both Hinode/SOT and SDO/HMI, respectively. Persistent diagrams have proven to be able to encode the spatial structure complexity of the magnetic flux of active regions by identifying the isolated and connected (interacting) structures. Holes or pores are also displayed in persistent diagrams, allowing as well for the identification of interacting structures of opposite polarities in the form of ring-like structures. The overall temporal evolution of active regions, as well as small scale events in quiet sun such as magnetic flux cancellation and emergence are also displayed in persistent diagrams and can be studied by observing the evolution of the diagrams and tracking the relevant features.

P-96

Investigation of small-scale brightening events in the solar atmosphere

H. Eklund (ESA)

An algorithm was developed that enables automatic detection of brightening events in solar ALMA data, providing valuable information about their lifetimes, sizes, and velocities. The intensity of millimeter-wavelength radiation is closely linked to the local plasma temperature, which allows for the investigation of potential heating processes in the upper layers of the solar atmosphere in connection to these events.
However, the brightening events are comparable in scale to the angular resolution of the ALMA observations, resulting in significant degradation of their magnitudes. Earlier this year, we conducted the highest-resolution measurements of the Sun at 3.0 mm with ALMA to date, enabling us to better resolve and study these events with significantly increased accuracy.
In addition to our highly resolved ALMA measurements, we conducted coordinated observations with both Hinode and IRIS, which resulted in a rich dataset that enables comprehensive modelling, characterisation and analysis of the detected brightening events.

By performing radiative transfer calculations through state-of-the-art Bifrost simulations of the solar atmosphere, we show that the radiation at 3.0 mm is particularly suitable for tracking the propagation of shock waves all the way throughout the lower to upper chromosphere. This seamless tracking capability allows us to study the energy deposition of shock waves at different atmospheric heights and determine their potential contribution to the heating of the solar chromosphere and corona.

P-97

Spatio-temporal deconvolution method for enhanced analysis of solar images

H. Eklund (ESA)

Deconvolution of solar data plays a crucial role in ensuring the reliability of scientific analysis performed on the resulting images. We introduce a novel spatio-temporal deconvolution method designed specifically for this purpose. The solar atmosphere is highly dynamic with rapid fluctuations occurring at short time scales which can be used to improve the analysis of solar observations. Leveraging this connection, we employ an artificial deep neural network to learn and identify dynamic patterns of features in both the spatial and temporal domains. Consequently, we can estimate the degradation of intensity contrast.

This deconvolution technique yields a significant improvement in accuracy and contrast within the observations. Moreover, it enables us to determine the extent to which small-scale dynamic events or features are properly resolved, as well as to assess the degree to which their intensities are either overestimated or underestimated. The analysis of such small-scale events occurring in the solar atmosphere is crucial for comprehending the intricate dynamic behavior of the solar atmosphere, for instance in understanding phenomena such as the heating of the solar corona and the production of solar wind.

The presented technique incorporates the temporal domain and outperforms conventional 2D-deconvolution methods. Although initially developed for analysis of solar ALMA images, this technique can be adapted to observations from instruments operating at any wavelength regime. As a result, it holds a great scientific potential and presents exciting prospects for future observations and research.

P-98

Early Science with SO/PHI

S. Solanki and the SO/PHI team (MPS)

The Polarimetric and Helioseismic Imager on Solar Orbiter (SO/PHI) is the first magnetograph and helioseismology instrument to study the Sun from a direction other than along the Sun-Earth line. It has also observed the Sun from much closer than any other magnetograph. Later in the mission, SO/PHI will become the first magnetograph to leave the ecliptic plane and study the solar poles in detail. Below is an incomplete list of some of the early science highlights:
a) First direct test of far side helioseismology and its calibration in terms of magnetic flux by providing magnetograms of the Sun's far side;
b) First fast synoptic maps of the magnetic field, taking only 16 days, compared with the 27 days usually required, thus obtaining more up-to date maps of the field;
c) Most of the campfires, small-scale coronal brightenings, discovered by SO/EUI have been identified to be associated with cancelling magnetic flux;
d) Dark coronal regions, termed coronal voids, discovered in SO/EUI data have been shown to be the result of reduced magnetic flux in the underlying photosphere and are not due to an excess of one magnetic polarity (as is the case for the larger coronal holes);
e) Changes in solar irradiance on timescales of days to weeks are mostly due to the evolution of magnetic features, rather than their passage over the visible disk of the rotating Sun;
f) By combining data from SO/PHI with SDO/HMI, far more reliable facular brightenings near the solar limb are determined;
g) A purely geometric resolution of the 180 degrees ambiguity in the magnetic field's azimuthal direction, plaguing all Zeeman effect measurements, is provided by combining SO/PHI and HMI data;
h) A possible reason for the factor of approximately 2 mismatch between open magnetic flux on the Sun and in the heliosphere has been identified.
Joint observations of SO/PHI with Hinode/SOT/SP are providing new opportunities to make maximum use of data from both instruments.

P-99

On the million-degree signature of spicules

S. Bose (LMSAL/RoCS/UiO), B. De Pontieu (LMSAL/RoCS/UiO) and J. Joshi (IIA)

Spicules have often been proposed as substantial contributors toward the mass and energy balance of the solar corona. While their transition region (TR) counterpart has unequivocally been established over the past decade or so, especially after the launch of the Interface Region Imaging Spectrograph (IRIS), the observations concerning the coronal contribution of spicules have often been contested. This is mainly attributed to the lack of adequate coordinated observations, their small spatial scales, their highly dynamic nature, and complex multi-thermal evolution, which are often observed at the limit of our current observational facilities. Therefore, it remains unclear how much spicular plasma is heated to coronal temperatures. In this study, we use coordinated high-resolution observations of the solar chromosphere, TR, and corona of a quiet-Sun network region with IRIS and the Atmospheric Imaging Assembly (AIA) onboard SDO to investigate the (lower) coronal (~1MK) emission associated with spicules. We perform differential emission measure (DEM) analysis on the AIA passbands using basis pursuit (Cheung et al. 2015) and a newly developed technique based on Tikhonov regularization (Plowman et al. 2020) to probe the thermal structure of the spicular corona for the first time. We find that the EM maps at ~1 MK reveal the presence of ubiquitous, small-scale jets that have a clear spatio-temporal coherence with the spicules observed in the IRIS/TR passband. Detailed space-time analysis of the chromospheric, TR, and EM maps show unambiguous evidence of rapidly outward propagating spicules with strong emission (2—3 times higher than the background) at 1MK. Our findings are consistent with existing MHD simulation that shows heating to coronal temperatures in spicules.

P-100

How well can we estimate the open magnetic flux with Hinode/SP observation?

B. Yamashiro (U. Hawaii), and X. Sun (U. Hawaii)

The solar open magnetic flux estimated from spectropolarimetric observations lacks absolute calibration. The values are well below the in situ measurements, and can vary significantly from one observatory to another. Here we use Hinode/SP observations of a polar coronal hole to explore their dependence on selective analysis techniques. We derive the magnetic vectors using the SIR inversion algorithm for patches with strong polarization signals. The area of these patches increases with decreasing optical depth ($-2 < \log \tau < 0$), which indicates an expansion of the magnetic flux tube with height. The magnetic fluxes, on the other hand, decrease with height by a few tens of a percent. The fluxes change drastically when the filling factor is introduced as a free parameter. They also show scatter when different initial guesses of filling factor are used. Our preliminary analysis suggests many of these solutions possess similar chi-squares from the inversion. The apparent degeneracy may pose serious limits on how well we can estimate the open magnetic flux from remote-sensing observations.

P-101

MgII h&k Fine Structure Prominence Modelling and the Consequences for Observations

A. Peat, N. Labrosse (U. Glasgow), and P. Gouttebroze (IAS/Retired)

Using 2D MgII h&k solar prominence modelling we aim to understand the formation of complex line profiles and how these are seen by the Interface Region Imaging Spectrograph (IRIS). Additionally, we see how the properties of these simulated observations are interpreted through the use of traditional 1D prominence modelling.

We use a cylindrical non-local thermodynamic equilibrium (NLTE) 2D complete redistribution code to generate a set of cylindrical prominence strands which we stack behind each other to produce complex line profiles. Then, with the use of the point-spread functions (PSFs) of IRIS, we can predict how IRIS would observe these line profiles. We then use the 1D NLTE code PROM in combination with the Cross Root Mean Squared method (xRMS) to find the properties recovered by traditional 1D prominence modelling. Velocities of magnitude lower than 10 km/s are sufficient to produce asymmetries in the MgII h&k lines. However, convolution of these with the point-spread functions (PSFs) of IRIS obscures this detail and returns standard looking single peaks. By increasing the velocities by a factor of three, we recover asymmetric profiles even after this convolution. The properties recovered by xRMS appear adequate at first, but the line profiles chosen to fit these profiles do not satisfactorily represent the line profiles. This is likely due to the large line width of the simulated profiles.

Asymmetries can be introduced by multithread models with independent Doppler velocities. The large line width created by these make it difficult for traditional 1D forward modelling to find good matches. This may also suggest there are degeneracies in the solution recovered by 1D modelling.

P-102

Initiation of Quasi-Periodic Pulsation at the Base of Kink Unstable Jet via Periodic Magnetic Reconnection.

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P. Jelinek (U. South Bohemia),
A.K. Srivastava (IIT (BHU)), and S.P. Rajaguru (IIA, Bangalore)

The solar corona shows small- to large-scale magnetized solar eruptions, e.g., prominence/filament, jets, solar flares, spicules, etc., that may significantly contribute to maintaining the mass and energy flow in the overlying solar atmosphere. Magnetic reconnection and MHD instabilities may be the two possible mechanisms to trigger the blowout coronal jets, which show marvelous dynamics such as rotation, blobs, waves, plasmoids, etc. In this talk, I will discuss the initiation and triggering mechanism of quasi-periodic pulsation (QPP) in a kink unstable blowout jet using imaging AIA and spectroscopic IRIS data. An inverse γ-shape flux-rope appears before the eruption of the jet, a morphological indication of the onset of kink instability. The internal reconnection between the lifting flux rope and the overlying pre-existing coronal magnetic field is responsible for triggering and forming the blowout jet's spire. During its eruption, one leg of the jet erupts completely, while another leg remains connected to the solar disk. Most of the plasma dynamics (e.g., bright spikes, upflow and downflow, etc.) appear along this connected leg. The time-distance diagrams show multiple spikes or bright dots resulting from periodic fluctuations, i.e., quasi-periodic fluctuations (QPPs). The wavelet analysis confirms that QPPs have a dominant period of $\approx$ 3 minutes. IRIS spectra obtained from the same region show the existence of broad and complex profiles and bi-directional flows in the jet, which confirm the onset of magnetic reconnection. Further, this periodic line-broadening and Emission Measure (EM) also show the same period of $\approx$ 03 minutes, which strongly supports that multiple magnetic reconnections to trigger the QPPs in the blowout jet.

P-103

Formation of Hε in the Solar Atmosphere

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and L. H. M. Rouppe van der Voort (RoCS/ITA/UiO)

In the solar spectrum, Hε one of the shorter wavelength Balmer series lines is a weak blend on the wing of Ca II H. Recently we gathered high-resolution Hε observations that reveal a reversed granulation pattern and in some cases unique structures. We investigate the formation of Hε using a 3D radiative MHD Bifrost simulation and non-LTE radiative transfer. We detail how Hε is formed in the quiet Sun and its diagnostic potential for different solar structures. The most interesting features we observe in Hε are bright dots connected to magnetic elements, dark fibrilar structures, and Hε emission profiles. We find that Hε emission profiles are particularly interesting. They can be a powerful tool to detect small-scale heating events in the lower atmosphere, such as Ellerman bombs at higher spatial resolution than achieved before and augment the diagnostic potential of Ca II H when observed simultaneously.

P-104

Multiline Stokes Synthesis of Ellerman bombs: Diagnostic capability of SUNRISE III/SCIP

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In the lower solar atmosphere, there are phenomena such as Ellerman bombs and UV bursts, which are thought to originate from magnetic reconnection. For revealing energy conversion process, theoretical studies predict that the magnetic reconnection rate depends on the altitude of the reconnection site have been made because ionization degree and plasma β have the large variations from the photosphere to the chromosphere. To verify these theoretical predictions, it is necessary to obtain physical quantities around the magnetic reconnection region occurring at various altitudes. The Sunrise Chromospheric Infrared spectropolarimeter (SCIP) for the SUNRISE III balloon borne telescope aims to seamlessly acquire physical quantities in the photosphere and chromosphere by multiline spectropolarimetry in the near-infrared region.

The purpose of this study is to validate the diagnostic capabilities and usefulness of near-infrared multiline spectropolarimetric observations with SCIP for understanding magnetic reconnection phenomena by synthesizing the Stokes profiles from a realistic magnetohydrodynamic simulation. The analysis considers two magnetic reconnection regions occurring at different heights. In the case of magnetic reconnection at low altitude, both red- and blueshifted components originating from reconnection bidirectional flow are identified in the photospheric lines. In the case of magnetic reconnection at high altitudes, chromospheric lines show emission due to the heating that occurs at the upper part of the formation layer. In both cases, the detected velocity corresponds to the local Alfvén speed. Magnetic field maps derived by weak field approximation show good consistency with reference field from the photosphere to the chromosphere although some discrepancies exist where the large velocity gradient exists. These results suggest that multiline spectropolarimetric observations with SCIP can provide the information of the location of reconnection site and magnetic reconnection rate through the outflow velocity and magnetic field around the reconnection site.

P-105

Non-LTE Simulations of the Chromosphere with MURaM

D. Przybylski, R. Cameron, and S. K. Solanki (MPS)

Advances in computational power have allowed increased resolution, box sizes, and physical realism in radiative magnetohydrodynamics simulations. However, discrepancies remain between synthesized and observed chromospheric spectral lines. The MURaM radiation-magnetohydrodynamics code has long been applied to simulations of near-surface magnetoconvection, ranging from quiet sun conditions to active regions and sunspots. The code includes the physics required to treat the convection zone, and the solar atmosphere, previously limited to local thermodynamic equilibrium. The MURaM code has now been extended to include NLTE effects, including a non-equilibrium treatment of hydrogen, scattering radiative transfer and chromospheric line losses, following the prescriptions used in the Bifrost code. In this work, we investigate the structure of the modelled chromosphere. We show some initial models, including an inter-network and a network region. Comparing synthetic spectral lines, including Calcium II 8542 and Magnesium II h&k spectra, we discuss the implications of the new models towards understanding the chromosphere.

P-106

Spectropolarimetric observations of an atmospheric vortex flow: Study of a collapsed magnetic bright point interacting with intergranular vortex associated with a chromospheric swirl and on-disk spicule release

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O. Steiner (KIS/IRSOL), and S. Berdyugina (KIS/IRSOL)

High-resolution solar observations revealed the existence of small-scale swirling vortices in chromospheric intensity maps and velocity diagnostics. Frequently, vortices have been observed near magnetic flux concentrations, indicating a link between swirls and the evolution of the small-scale magnetic fields. Vortices were also studied with MHD numerical simulations of the solar atmosphere, revealing their complexity, dynamics, and magnetic nature. In particular, it has been suggested that the chromospheric swirling plasma motion is due to a rotating magnetic field structure, which is driven by a photospheric vortex flow at its footprint. We present a complete and comprehensive description of a bright magnetic flux concentration affected by convective instability which interacts with an intergranular vortex flow. This magnetic flux concentration is associated with a persistent and dynamic chromospheric swirl. It undergoes a sudden further intensification and deformation, coinciding with the observation of an impulsive rapid blue excursion (RBE) as an on-disk spicule. We study observations taken with the CRISP and CHROMIS instruments at the 1m Swedish Solar Telescope (SST) in April 2019. The data were taken at the quiet-Sun disk center, recording full Stokes photospheric maps in the Fe I line at 617 nm, full Stokes data in the Ca II infrared triplet line at 854 nm, and spectroscopic maps in the Hα 656 nm and Ca II K 393 nm lines. Utilizing the multi-wavelength data and applying height-dependent Stokes inversion, local correlation tracking methods and wavelet analysis, we are able to study several atmospheric properties during the event lifetime, which allowed us to interpret the spatial and temporal connectivity between the photosphere and the chromosphere. We identified signatures of a rebound upflow in the magnetic flux concentration that eventually steepened, producing an acoustic shock wave. This shock wave propagated through the chromospheric swirl and subsequently triggered the emergence of an on-disk spicule.

P-107

Variation of the photospheric line shift toward the north and south limbs observed with Hinode SOT/SP

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and R.T. Ishikawa (NIFS)

There is a center-to-limb variation of the spectral line shifts in the solar photosphere. In the disk center, blueshifts are observed due to bright granules with upflows. These blueshifts decrease toward the limb and turn into redshifts. This variation is thought to be caused by the corrugated convection on the solar surface although it is poorly known how granules and intergranules separately contribute to the Doppler shifts especially near the limb. In this study, we aim to resolve the trend of the Doppler shifts caused by granules and intergranules.

We selected the north and south limb data observed with Hinode SOT/SP. The high spatial resolution of SOT enables us to separate granules and intergranules. In addition, the photospheric lines observed as absorption on the disk can be observed as emission within 1 arcsec above the limb. We analyzed the Doppler shifts of the Fe I 630.15 nm line with distinguishing granules and intergranules and derived their trends as a function of heliocentric angles.

The spatially-averaged spectrum profiles of granules show blueshifts of about 240 m/s at a heliocentric angle of 60 degrees. These blueshifts decrease toward the limb and become redshifts of about 150 m/s at an angle of 80 degrees. These redshifts decrease closer to the limb above 80 degrees. Intergranules show redshifts of about 140 m/s in angles from 60 to 80 degrees. These redshifts decrease above 80 degrees and show 30 m/s very close to the limb. The emission profiles of the line show 190 m/s blueshifts above the limb. We do not find a significant difference between the north and south limbs. Based on the observed trend of the Doppler shifts, we argue how the Doppler shifts are created by the corrugated structure of surface convection.

P-108

IRIS observations of flux emergence in a decaying active region

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The emergence, growth, and decay of magnetic flux and the corresponding magnetic loops in an active region has long been the focus of much research in the solar photosphere and corona. However, chromospheric and transition region studies of the long term evolution of solar active regions are comparatively rarer. We present a series of large field-of-view spectroscopic rasters of a decaying active region taken from 2-7 April 2020 by the IRIS spacecraft. AR12759 was the only observed active region on disk during this particularly quiet period of solar activity, and was the focus of a series of IRIS observing campaigns. In addition to the observed long term decay of the active region, there was a small flux emergence within the active region, providing an insight into plasma signatures of both decaying and newly emerging magnetic flux. We discuss plasma diagnostics derived using the Si IV, Mg II, and C II lines and examine how they evolve across the whole observing period.

P-109

The effects of 3D radiative transfer on the Ca II 854.2 nm line

T. M. D. Pereira (RoCS/UiO)

The Ca II infrared line at 854.2 nm is widely used to study the chromosphere, in particular in coordination with space observatories. Earlier work found that it does not suffer from significant effects from 3D NLTE radiative transfer, making it easier to model and a preferential target for inversions. Many of DKIST's current and upcoming instruments cover the 854.2 nm line. With increased spatial resolution, the smallest observable sizes become closer to the photon mean free path, thereby increasing the potential of 3D effects in the radiative transfer. In this work, we make use of a 3D rMHD simulation with high spatial resolution (6 km grid size) to synthesise Ca II 854.2 spectra in both 3D NLTE and 1.5D NLTE. We compare the differences in emergent line profiles, and quantify the effects of 3D NLTE radiative transfer by performing inversions in both types of spectra.

P-110

Solar Prominence Bubbles and Associated Plasma Instabilities: Hinode, IRIS, and SDO/AIA Observations

T. Berger (U. Colorado), and W. Liu (LMSAL/BAERI)

Solar prominences or filaments are cool and dense plasma situated in the hot and tenuous corona. The so-called prominence bubbles are mysterious, dome-shaped, apparently void structures residing in the lower portions of prominences. Such bubbles are associated with various plasma instabilities, such as the Rayleigh-Taylor (RT) and Kelvin-Helmholtz (KH) instabilities. The former is manifested in plumes that are often produced at the top boundary of a bubble and intrude upward into the dense prominence material. The latter is found to be triggered by shear flows at the bubble boundaries. We present recent observations of prominence bubbles by Hinode, IRIS, and SDO/AIA, focusing on the diagnostic potential of RT and KH instabilities on the physical conditions of the prominence and its supporting magnetic field. We searched for evidence of magnetic flux emergence as the origin of prominence bubbles. We discuss their role in mass and magnetic flux transport in the solar atmosphere.

P-111

Large Photospheric Doppler Shift in Solar Active Region 12673

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S. Jaeggli (NSO), B. T. Welsch (U. Wisconsin), and C. Quintero Noda (IAC)

Delta sunspots sometimes host fast photospheric flows along the central magnetic polarity inversion line (PIL). Here we study the strong Doppler shift signature in the central penumbral light bridge of solar active region NOAA 12673. Observations from the Helioseismic and Magnetic Imager (HMI) indicate highly sheared, strong magnetic fields. Large Doppler shifts up to 3.2 km/s appeared during the formation of the light bridge and persisted for about 16 hours. A new velocity estimator, called DAVE4VMwDV, reveals fast converging and shearing motion along the PIL from HMI vector magnetograms, and recovers the observed Doppler signal much better than an old version of the algorithm. The inferred velocity vectors are largely (anti-)parallel to the inclined magnetic fields, suggesting that the observed Doppler shift contains significant contribution from the projected, field-aligned flows. High-resolution observations from the Hinode/Spectro-Polarimeter (SP) further exhibit a clear correlation between the Doppler velocity and the cosine of the magnetic inclination, which is in agreement with HMI results and consistent with a field-aligned flow of about 9.6 km/s. The complex Stokes profiles suggest significant gradients of physical variables along the line of sight. We discuss the implications on the delta-spot magnetic structure and the flow-driving mechanism.

P-112

Penumbral Fine-Scale Bright Dots as a Precursor to Coronal Plumes? Solar Orbiter/EUI, IRIS, and SDO Observations

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and B. De Pontieu (LMSAL/Oslo U.)

This work presents coordinated Solar Orbiter/EUI and IRIS observations of a high density of fine-scale bright dots at the base of a plume in sunspot penumbra during the plume formation. To our knowledge, this is the first detailed analysis of plume formation in a sunspot penumbra. We find significantly more bright dots in EUI 174 Å at the plume base than in other similar regions around the sunspot, and we characterize these dots by their size, lifetime, intensity and velocity in EUI 174 Å, and IRIS 1400 Å and 2796 Å. Time-distance maps along the plume show some parabolic patterns. We find a small systematic spatial offset of dot locations along the plume in IRIS 2796 Å, 1400 Å, and EUI 174 Å, respectively. We discuss the possible ways these brightenings are formed — chromospheric shocks and magnetic reconnection — as well as how these brightenings may contribute to plume heating.

P-113

Statistics of Coronal Bright Points and Preparation of a CBP simulation with Hinode and SDO data

I. Kraus, and Ph.-A. Bourdin (U. Graz)

The exact coronal heating mechanism remains a riddle, but magnetically active regions are known to trigger extreme-UV emission along coronal loops. Also at much smaller scales, there are small bipolar regions that can be associated with evenly sized coronal bright points (CBPs). We study the statistical properties of CBPs with continuous data from the SDO spacecraft to track the lifetime of CBPs. We aim to verify if the lower corona co-rotates with the photosphere. From 346 CBPs we extract information on their lifetime, size, shape, polarity, etc. We then compare the CBP lifetime with its shape and EUV visibility. From the CBP tracking algorithm we confirm a strict co-rotation of the CBPs with the photospheric differential rotation. Furthermore, we like to reproduce one CBP in a 3D magneto-hydrodynamic simulation. A vertical Poynting flux is created from horizontal advection motions in the photosphere that perturb the magnetic field. We verify if the coronal heating is from Ohmic dissipation of direct currents. The observational data for the CBP simulation is obtained from the Hinode/SOT instrument and is complemented with SDO/HMI data. This allows us to enlarge the field-of-view, so that the simulation is driven fully by observed photospheric magnetic fields. The bottom and top model boundaries are fully closed for mass and heat flows. The hottest and brightest CBPs seem to exist for significantly longer time, up to 24 hours, than compared to fainter CBPs. The merging of two CBPs has no influence on the overall size of the persisting CBP. We also find that the merging of two CBPs is a relatively rare phenomenon. Loop-like CBPs are usually bipolar and their merging probability is low. Weaker magnetic polarities produce fainter and cooler CBPs. This supports that the CBP heating is mainly based on magnetic energy dissipation.

P-114

Analysis and comparison of the magnetic field properties in a decaying sunspot using Hinode/SOT and SDO/HMI data

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and N. Bello González (Leibniz Institute for Solar Physics (KIS)

Several studies in the last few years have focused on the analysis of the magnetic properties on umbra-penumbra (UP) boundaries of sunspots (e.g. Jurčák et al. 2018, Schmassmann et al. 2018, Benko et al. 2018). Jurčák et al. 2018, using Hinode data, and Schmassmann et al. 2018, using HMI data, found a critical vertical magnetic field on UP boundaries of stable sunspots, with a different absolute value. In order to find shared characteristics between magnetic structures, solar pore boundaries have recently been included in the sample (e.g. García-Rivas et al. 2021). Since solar pores are more heavily affected by light contamination from quiet Sun regions than umbrae, a new dataset was employed: SDO/HMI maps corrected for scattered light (HMI_dcon). With the aim of running a comparison between the datasets above-mentioned (Hinode, HMI and HMI_dcon), we study the continuum intensity and magnetic temporal evolution of a decaying sunspot that eventually loses its penumbra and transforms into naked spots. Spot boundaries have historically been defined by a continuum intensity threshold even though intensity maps from different instruments exhibit different intensity contrasts that affect the boundary position. The studied spot allows us to look for general dissimilarities in the selected datasets, and the influence of the nature of the spot (umbra surrounded by a penumbra / umbra without penumbra) on the derived UP boundary properties. We now better understand the origin of the discrepancies on boundary properties between these datasets.

P-116

Predicting Spectro-polarimetric Observations of Chromospheric Jets using Radiative Magnetohydrodynamics Simulation

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H. Iiijima (ISEE), and C. Quintero Noda (IAC)

Chromospheric jets, which play a significant role in energy and mass transport within the solar chromosphere, still lack a comprehensive understanding of their driving mechanisms. To investigate and distinguish these driving mechanisms, magnetic field measurements are of utmost importance. In this study, we employed a realistic radiative magnetohydrodynamics simulation and performed a full Stokes synthesis in the infrared range. The simulation successfully generated a chromospheric jet, allowing us to make predictions about spectro-polarimetric observations using the Sunrise Chromospheric Infrared spectro-Polarimeter (SCIP), which is equipped on the SUNRISE III balloon telescope. The chromospheric jet originated from the collision between the transition region and an upflow driven by the ascending motion of the twisted magnetic field at the flux tube's envelope. Notably, this upward motion exhibited characteristics consistent with the propagation of nonlinear Alfvenic waves. Our analysis revealed that the upflow could be detected through continuous Doppler signals in the Ca II 849.8 nm line at the envelope region, where both dark line core intensity and strong linear polarization are present. Furthermore, the flux tube's axis appeared bright in both the Fe I 846.8 nm and Ca II 849.8 nm lines, indicating the presence of down-flowing plasma within it. The comprehensive insights gained from our study, including the structure, temporal evolution, and predicted Stokes signals, will significantly enhance the interpretation of future spectro-polarimetric observations carried out with SUNRISE III, SST, EST and DKIST.

P-117

Understanding the stability of a highly dynamic dome-like feature as observed by Solar Orbiter

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On October 2022 Solar Orbiter run an active region tracking program that lasted several days. During one of the high cadence observations, a dome-like feature was observed with EUI/HRIEUV, the high spatial and temporal resolutions' imager of EUI. This structure resulted to be highly dynamic and lasted for several hours.

Here we present the preliminary results of its temporal evolution. We make in relation the photospheric magnetic field changes, measured by PHI, with the dynamics observed higher in the atmosphere. We provide the changes of plasma parameters using the UV spectrometer SPICE. Petrova et al. 2023 demonstrate the presence of torsional waves. Here we investigate the relation between the internal dynamics and the hours' stability.

P-118

Solar Prominence Bubble and Plumes Caused by an Eruptive Magnetic Flux Rope

C. Chen, Y. Su (PMO/USTC), J. Xue, W. Gan, and Y. Huang (PMO)

Prominence bubbles and plumes often form near the lower prominence–corona boundary. They are believed to play an important role in mass supply and evolution of solar prominences. However, how they form is still an open question. Here we present a unique high-resolution Hα observation of a quiescent prominence by the New Vacuum Solar Telescope. Analysis of the Hα and extreme-ultraviolet data indicates that the rising magnetic flux rope (MFR) is the cause of bubble expansion and that the interaction between the prominence and MFR results in plume formation. These observations provided clear evidence that emerging MFR may be a common trigger of bubbles and suggested a new mechanism of plumes in addition to Rayleigh–Taylor instability and reconnection.

P-119

The Impact of Cross-Sectional Area Expansion on Flows through the Solar Atmosphere

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Flows between the chromosphere and corona dictate the mass in the corona, and thus the intensity of the spectral lines forming there. In the vast majority of prior work, coronal loops have been assumed to have a uniform cross-sectional area. While measurements of loops are generally consistent with this assumption, it seems likely that this Is an artifact of the relatively modest resolution of current observations. In the presence of a cross-sectional area expansion, importantly, simulations show that there is a major impact on flows into and through the loop, notably that draining is significantly slowed, so that the corona remains dense for significantly longer periods of time. In this work, we examine directly how area expansion affects the flows across the solar atmosphere to better understand the cooling and draining timescales, as well as the effect on chromospheric evaporation. We use forward modeling of spectral lines from Hinode/EIS and IRIS to compare model predictions with observable quantities.

P-120

SUNRISE III SCIP: a balloon-borne instrument for multi-line spectropolarimetry in the photo- and chromosphere

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S. Solanki, A. Lagg, A. Gandorfer, and A. Feller (MPS)

SUNRISE III is the third flight of the international balloon project Sunrise. The team led by NAOJ provided the near-infrared spectro-polarimeter SCIP through international collaboration with the Spanish and German teams. By combining the 1-meter aperture telescope, SCIP will simultaneously observe many spectral lines including two of the chromospheric Ca II infrared triplet lines, upper photospheric K I D1 and D2 lines, and multiple photospheric Fe I lines with a resolution of 0.2" which is higher than that of the HINODE Solar Optical Telescope. The observation provides three-dimensional magnetic field structures and their time evolution from the photosphere to the chromosphere and clarifies the transport and dissipation processes of magnetic energies. One of the science cases is a chromospheric jet driven by twisted magnetic fields, in which we aim to detect linear polarizations for directly measuring transverse magnetic fields together with Doppler shifts. The other case is Ellerman bombs driven by magnetic reconnection in the lower atmosphere, in which we aim to detect reconnection jets and their quantitative relation with surrounding magnetic fields. SUNRISE III was launched in July 2022, but was terminated because of a hardware problem. The telescope and instruments were successfully recovered and confirmed to be in good condition. Thus, we are proposing a reflight in 2024.

P-121

XRTpy: A Hinode/X-Ray Telescope Python Package

J. Velasquez, N. Murphy, K. Reeves, M. Weber, and J. Slavin (CFA)

XRTpy is a Python package developed for analyzing observations from the X-Ray Telescope (XRT) on the Hinode spacecraft. It enables comprehensive analysis of Hinode-XRT data, offering functionalities such as object-oriented representation of instrument configuration, effective area calculation, temperature response computation, light leak subtraction, image sharpening, electron temperature and emission measure derivation, and various abundance model options. With XRTpy, Python users can efficiently analyze and process Hinode-XRT data, bridging the gap between traditional IDL routines and the increasing adoption of Python within the scientific community.

P-122

A unified model of solar prominence formation

C. J. Huang (KYU), J. H. Guo (NJU), Y. W. Ni (NJU), A. A. Xu (XMU), and P. F. Chen (NJU)

Several mechanisms have been proposed to account for the formation of solar prominences or filaments, among which direct injection and evaporation-condensation models are the two most popular ones. In the direct injection model, cold plasma is ejected from the chromosphere into the corona along magnetic field lines; in the evaporation-condensation model, the cold chromospheric plasma is heated to over a million degrees and is evaporated into the corona, where the accumulated plasma finally reaches thermal instability or nonequilibrium so as to condensate to cold prominences. In this paper, we try to unify the two mechanisms: The essence of filament formation is the localized heating in the chromosphere. If the heating happens in the lower chromosphere, the enhanced gas pressure pushes the cold plasma in the upper chromosphere to move up to the corona, such a process is manifested as the direct injection model. If the heating happens in the upper chromosphere, the local plasma is heated tP-1-2 million degrees, and is evaporated into the corona. Later, the plasma condensates to form a prominence. Such a process is manifested as the evaporation-condensation model. With radiative hydrodynamic simulations we confirmed that the two widely accepted formation mechanisms of solar prominences can really be unified in such a single framework. A particular case is also found where both injection and evaporation-condensation processes occur together.

P-123

Spectroflat - a novel calibration approach for spectro-polarimetric data

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Flat fielding spectro-polarimetric data with one spatial and one spectral dimension is inherently difficult as the imprint of the spectral lines needs to be separated from other wavelength dependent effects, such as fringes or prefilter profiles, and wavelength independent effects, such as dust and sensor response. Current approaches are often based on moving the grating, depend on optical models and/or on (non-timely) lab calibration data.

The approach we present here allows to obtain timely flat field calibration data for diffraction-grating-based, long-slit spectrographs and temporally-modulated polarimeters, during nominal flat fielding procedures in the observational configuration of the instrument.

From the raw modulated flats we derive separated flat fields for sensor and slit dust features. Then, we remove the spectrographic curvature effect (smile) to ensure orthogonality of the spectral and spatial dimensions. We identify distortions by tracking the position of multiple spectral lines on each individual modulation state. From the de-smiled flat frames, we derive an instrument gain table free of spectral line imprints. Optionally, wavelength calibration and continuum correction can be included in this process.

We have created a generic python library that can be plugged in into existing pipelines or used as a standalone calibration tool. First results show a significant performance correcting for sensor artifacts and suppressing fixed-pattern noise in demodulated data.

Finally, we discuss the applicability to different wavelength regimes for ground- (SST/TSP, GST/FISS-SP), stratosphere- (SUNRISE-III/SUSI) and potential next-generation space-based (SOLAR-C) instruments with a spectral range spanning multiple solar lines.

P-124

Estimation of the structure of thermal convection inside the sun by machine learning using wide-domain radiative magnetohydrodynamic simulations as training data

H. Masaki, and H. Hotta (Nagoya U.)

We make a neural network to estimate the structure of thermal convection inside the Sun, using large domain simulations as training data. This thermal convection inside the Sun is critical to understanding fundamental processes in the Sun, such as magnetic field generation. Due to the large optical depth of the solar interior, direct observation of the region is unforeseeable. To know the inside of the Sun, we use helioseismology, which uses the propagation of sound waves, and this provides a number of results on large-scale flows and thermal convection structures. However, helioseismology requires long time averages for its evaluation. In this study, we develop a new method by performing a radiative magnetohydrodynamic simulation of the solar convection zone and using the data to train neural networks. We perform numerical simulations at scales that include supergranulation. Using one hourly three sets of inputs - intensity, line-of-sight velocity field, and line-of-sight magnetic field - the up flow field at a depth of about 10 Mm from the solar surface match simulation somewhat at a few Mm spatial scales. It can be estimated with a correlation coefficient of about 0.6 at scales of about 20 Mm.

P-125

Sub-Grid Scale Model with Small-Scale Dynamo

R. Shimada, and T. Yokoyama (Kyoto U.)

Solar magnetic field shows an 11-year activity cycle, represented by the number of sunspots. The maintenance of such a solar magnetic field can be attributed to fluid motion in the convection zone (CZ), i.e., a dynamo. Although the turbulence that exists in CZ is thought to contribute to the solar dynamo, its properties are less understood by observations. Recent high-resolution simulations on CZ suggest that the small-scale dynamo is crucial to understand the dynamics of CZ (e.g. Hotta+ 2015, Hotta+2021).
On the other hand, long-term calculations on the solar cycle with sufficient small-scale dynamo are impractical. From these backgrounds, our final goal is to understand how the turbulence resolved by recent numerical simulations affects the solar cycle. In order to investigate this point, we develop a Sub-Grid Scale (SGS) model which enables us to conduct low-resolution simulations with the physical information on the small-scale dynamo. Turbulent diffusivities in our SGS model are extracted from the shape of the power spectrum from high-resolution simulation. To validate our SGS models, we reproduce the small-scale dynamo whose effect can be parametrized by turbulent diffusivities (Hotta+ 2015, Bekki+ 2017). In this talk, we are going to present the results extracted from our high-resolution simulations. Our methods successfully extract the diffusivity which is consistent with the effect suggested by Bekki+ 2017 about small-scale dynamo.

P-126

Net radiative cooling rates in prominence-like plasmas

S. Gunar (Astronomical Inst. Czech Academy of Sci.),
P. Heinzel (Astronomical Inst. Czech Academy of Sci.), and U. Anzer (MPA)

We present comprehensive tables of Net Radiative Cooling Rates (NRCR) in cool solar plasma with prominence-like properties. The NRCR are based on the 1D non-LTE radiative transfer modelling of prominences in the transitions of 5-level plus continuum hydrogen, Mg II and Ca II species. These transitions are the dominant contributors to the radiative energy balance of prominence-like plasmas.

The derived NRCR describe the balance between the radiative losses from the plasma in all considered transitions and the radiative gains in the form of incident radiation illuminating the prominence plasma from the solar disk. In other words, NRCR represent an energy sink (or source) due to the dominant radiative processes, both optically thick and thin. As such, the NRCR values can be used in conjunction with other energy source or sink terms in studies of energy balance or transport in the cool plasmas with prominence-like conditions - for example, in the evaporation-condensation processes forming the cool plasma, or studies of waves and oscillations in such plasma.

The NRCR are provided for different values of temperature and gas pressure, and also for different distances of the considered unit volume of plasma (voxel) from the nearest illuminated surface.

P-127

Study of prominence formation considering shock and turbulent heating

T. Yoshihisa, T. Yokoyama (Kyoto U.), and T. Kaneko (Niigata U.)

The coronal plasmas often condense into cooler and denser plasmas. This phenomenon has long been observed as prominences, however the formation mechanism and physical properties are not fully understood. The "chromospheric evaporation-condensation model" is one of the most promising mechanisms for prominence formation. In this model, the condensation occurs when the loop undergoes thermally non-equilibrium due to localized heating at the footpoints. Since this process is nonlinear, numerical simulations are used to investigate the dependence of plasma cooling and heating and their time variation. In many previous numerical studies, the heating term was introduced in an ad hoc manner for the simplicity. However, to understand the actual condensation phenomena and the associated conditions, it is necessary to consider the self-consistent heating process resulting from the MHD wave dissipation from the photosphere to the corona. Therefore, in this study, we performed 1.5D MHD simulations, taking into account the coronal heating, along a dipped coronal loop, spanning from the photosphere to the corona. While the localized heating is also added instantaneously to induce the chromospheric evaporation, the background heating is considered to be energy dissipation due to the shock waves and turbulent effects from MHD waves injected at the footpoint. In addition, we investigated the effects on condensation phenomena and the thermal properties of prominence by changing parameters of the footpoint-localized heating and the velocity field at the footpoint. As a result, it is found that the magnitude of the waves incorporated at the boundary affects whether or not condensation occurs.

P-128

IRIS & AIA - Python Usertools and GUIs

N. Freij (LMSAL/BAERI)

Much like the solar wind, heliophysics is slowly expanding into open-source software. The transition from closed-source languages to open-source (whether it be Python, Julia, or others) is an ongoing process. Lockheed Martin Space and Astrophysical Laboratory (LMSAL) is involved with several missions, including the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO), the Interface Region Imaging Spectrograph (IRIS), and the upcoming Multi-slit Solar Explorer (MUSE).

“irispy-lmsal” and “aiapy” were created to serve users of IRIS and AIA, respectively. Both are Python libraries that core members of the instrument teams work on to enable data analysis in Python. In addition, both make heavy use of Python libraries that the SunPy Project maintains, mainly “sunpy” and “ndcube”.

Here, I will be detailing the latest updates for both Python libraries, including moving towards a generalized world coordinate system used by the James Webb Space Telescope (JWST) Python software. In addition, I will provide updates on the CRISPEX-like GUI in Python.

P-129

Data-constrained coronal and interplanetary magnetic field models combining remote-sensing and in-situ observations

G. Shi, L. Feng, and B. Ying (PMO/CAS)

Solar magnetic fields are closely related to various physical phenomena and particle transport, which can be extrapolated by different models via photospheric magnetograms. In this work, we use Magnetohydrostatic (MHS) models to extrapolate coronal and interplanetary magnetic fields (IMFs) comparing with remote-sensing and in-situ observations. Three evaluation parameters are established to quantitatively analyze the prediction quality of models in order to determine the optimal free parameters. Predictions of models have a good consistency with the remote-sensing and in-situ observations. Still, the magnetic field strength along the radial direction is underestimated, called the "Open flux problem" exists near the Sun. While the "missing" magnetic flux will decrease as the heliocentric distance increases. Open flux problem still exists near the Sun, while the missing magnetic flux will decrease as the heliocentric distance increases. Even if the IMF at 1 AU is matched with measurements by artificially increasing the polar magnetic field, the IMFs located near the Sun are still underestimated. Results indicate that the interplanetary process is essential in missing the magnetic flux. This problem might be solved by improving the accuracy of the weak solar field and polar magnetic field, especially considering magnetic activities generated in interplanetary physical processes.

P-130

Images of High-Resolution, Full-FOV Hinode/SOT-SP Magnetic Fields

M. De Rosa (LMSAL)

Maps of the photospheric vector magnetic field in and around active regions show the diversity of magnetic flux structures that shape the overlying chromosphere, transition region, and corona. These structures range from strong umbral fields of several kilogauss, to filamentary penumbral fields, to plage, to relatively weaker quiet sun. The Hinode/SOT Spectro-Polarimeter (SOT-SP) takes high signal-to-noise polarization spectra of the Fe I 6302 A doublet and nearby continuum using a 16"-by-160" slit that is able to scan a region of interest of up to 320" wide. All three components of the photospheric magnetic field can then be determined by applying a spectropolarimetric inversion method. We present here several such 320"-by-160" maps and visualizations of active regions and their surroundings at full spatial resolution (i.e., without binning) in all their glory. These maps were made using the standard SOT calibration, Milne-Eddington inversion, and disambiguation pipeline software.

P-131

KAPPA: Impact Multi-Ionization and Suppression of Dielectronic Recombination by High-Energy Electrons

E. Dzifcakova, J. Dudik, and A. Zemanova (ASU AV CR)

The shape of the electron distribution changes individual ionization, recombination and collisional excitation rates and consequently line intensities. Ionization equilibrium in the coronal conditions with low electron densities is usually calculated as a density independent problem. We added electron impact multi-ionization and density suppression of dielectronic recombination into our calculations of the ionization equilibria for kappa-distributions. We showed that density effects on the ionization equilibrium are almost similar for kappa-distributions and the Maxwellian one. Effect of double ionization on the ionization equilibrium is stronger for kappa-distributions with low values of kappa. However, density dependent dielectronic recombination shifts the ionization peaks to lower temperature similarly for the all of kappa and Maxwellian distributions. The density dependent ionization equilibria were included into the new version of KAPPA package (software and database, http://kappa.asu.cas.cz/). KAPPA provides fast calculations of synthetic spectra for kappa-distributions for different temperatures, electron densities, and values of kappa, newly starting from 1.7. This tool thus enables us to diagnose electron distribution from EUV spectra of flares, active regions or quiet Sun.

P-132

Irregular grids for 3D NLTE radiative transfer in stellar atmospheres

E.R. Udnæs, and T.M.D. Pereira (RoCS)

Three-dimensional NLTE calculations are essential to link simulations to observations, thus providing insight into the physical parameters of stellar atmospheres. However, these calculations require extensive computational power to provide accurate spectra, rendering their broader application not worthwhile.

In order to mitigate the computational demand of 3D NLTE problem, we conduct a first exploration of irregular grids for stellar atmospheres. The main idea is to optimise the computational grid to speed up 3D NLTE calculations, in the same way as depth optimisation can lead to faster running times in 1D.

Radiative transfer on irregular grids is done by constructing a Voronoi tessellation of the grid, and calculating radiation along its Delaunay lines with a modified short-characteristic method. Irregular grids were sampled from different quantities from a 3D Bifrost simulation, with the goal of optimising the 3D NLTE problem. The NLTE problem was solved using Lambda-iterations, assuming statistical equilibrium, and a simplified hydrogen atom. For reference, we compared our results to a standard short-characteristics solver on a regular grid.

Radiative transfer on irregular grids gives similar results to those from a regular grid. We find that irregular grids can reproduce the same continuum intensity with nearly ten times less grid points than a regular grid. Still, while an optimised irregular grid can give good results for the 3D NLTE problem, it is about four times slower per iteration than a regular grid while it converges in the same number of iterations. Therefore our implementation does not lead to an improvement. The design of the irregular grid is crucial for accurate results, and there is no easy method to a priori construct an irregular grid that works well across a wide range of heights.

P-133

Update on global MHD simulations of the solar convective region

A. Popovas (RoCS), Å. Nordlund (NBI/RoCS), M. Szydlarski (RoCS), P. Kohutova (RoCS), V. Hansteen (RoCS/ LMSAL), Q. Noraz (RoCS), and Y. Zhou (AU)

In this contribution we present the latest updates on our global MHD simulations of the Solar convective region using the DISPATCH framework. The simulations span 0.655 - 0.995 Solar radius, over the entire surface using Cartesian patches, arranged in a Volleyball decomposition. We present the latest improvements to the experimental setup and the current status of the simulations.

P-134

Emission Line Intensity Ratios of Fe XXV in Solar Flares Observed by Hinotori

T. Watanabe (NAOJ)

High resolution spectra observed by Solar X-ray spectrometer (SOX) on board the Hinotori mission are revisited: Flat crystals slightly offset to the satellite spin axis produce automatic spectral scans for emission lines emerging from highly charged Fe ions in solar flares every half-spin time period of the satellite. All the downlinked data of the mission are converted to FITS format and major flare spectral data are revived as IDL save files in DARTS/ISAS. Based on these datasets, single temperature fittings are performed for Fe emission line complex at around 1.85 A and compared with theoretical predictions.

Synthetic spectra with single Te estimated by the j/w line intensity ratios fit fairly well for Fe XXVI and Fe XX lines in the wavelengths of 1.85 - 1.88 A, while intensity ratios of Fe XXV lines; x, y, and z to its resonance line; w have systematic excesses. Ion fractions of N(H)/N(He) estimated by Lyα/w intensity ratios in the temperature range of log Te = 7.25 - 7.45 are almost consistent with those values in ionization equilibrium, and these excesses could be due to atomic parameter problems for Fe XXV.

P-135

The 3D non-LTE radiative transfer code Multi3d

J. Leenaarts, J. Bjørgen (Stockholm U.), A. Sukhorukov (IAC),
and F. Calvo (Stockholm U.)

Comparison of observations with the output of 3D radiation-MHD simulations requires detailed modeling of the radiation emitted by the simulations. Radiation processes that should be included for accurate modelling are the effects of 3D spreading of radiation, partially coherent scattering (PRD), and polarization induced by magnetic fields and scattering. The high dimensionaly, and the non-local and non-linear nature of the radiative transfer problem means it is computationally expensive to solve.

In the poster we present the Multi3d radiative transfer code, which can model the processes mentioned above. It has been used to investigate the formation of Ca II H&K, Mg II H&K, Halpha, and He I 10830 in a variety of solar atmospheric simulations. Specialized versions of the code are used for stellar abundance determination. We show results computed with Multi3d highlighting the importance of 3D and PRD effects. A new version of Multi3d is currently under development using an object-oriented design. Once finished, the code will be made publicly available.

P-136

Dual channel imaging system in Ha and HeI 10830A using a universal tunable filter

K, Ichimoto (Ritsumeikan U.), W.Huang, G. Kimura, S. Ueno,
and S. Tokuda (Kyoto U.)

Hydrogen Ha (6562A) and HeI 10830A are the most common spectral lines used for diagnosing the solar chromosphere. They have advantages and disadvantages; Ha line is most sensitive to the density structures in chromosphere while modeling its formation is rather complex. On the other hand, HeI 10830A that forms higher in chromosphere is simpler in its formation and widely used for measuring the magnetic fields, while due to its shallowness, its application is limited to dens chromospheric structures. It is known that these lines show different responses in flares. We aim to investigate the scientific advantage in combining these lines in imaging spectroscopic observation.

The narrowband tunable filter (UTF32, Hagino et al., 2014, SPIE) developed at Hida Observatory of Kyoto University has a wavelength resolution λ/Δλ¥~26000. Simultaneous imaging of two wavelengths is possible by splitting the light with a polarizing beam splitter attached to the exit of the filter and using two cameras. In this study, we have constructed a setup that enables spectroscopic imaging of the Ha and the HeI 1083nm lines almost simultaneously. The full width at half maximum of the transmission in Ha is 0.25A and 0.367A in HeI 1083nm with an additional stage of the Lyot filter. With a 2048x2048 pixel visible light camera and a 640x512 pixel infrared camera for Ha and HeI 1083nm channels, the spatial samplings are 0.121"/pix and 0.396"/pix, and FOV are 248"x248" and 253"x203", respectively. Time required for switching the wavelength is about 0.1 second.

In this presentation, we demonstrate the observing capability of the system and present some examples of observation for a dark filament and arch filament systems. We also discuss the advantage of combining these two lines in view of their responses to the physical condition obtained by a non-LTE calculations.

P-137

Magnetic field structures of solar prominences obtained from spectropolarimetric observations in He I 10830 Å

Y. Hashimoto, K. Ichimoto, Y. Huang, D. Yamasaki, S. UeNo, D. Cabezas, H. Shirato, and Y. Matsuda (Kyoto U.)

The magnetic field of solar prominences is an important quantity that determines their structures and energy balance. Some studies have estimated the magnetic field by spectropolarimetric observations, but the field direction and strength of prominences are discrepant among the studies. In this study, we performed spectropolarimetric observations in He I 10830 Å with the Domeless Solar Telescope at Hida Observatory. Full Stokes profiles of several prominences including both quiescent and active region prominences were obtained, and magnetic fields of each prominence were estimated by the inversion using HAZEL. As a result, the field strengths of the quiescent prominences were less than 40 G, which is consistent with previous studies. On the other hand, the field strengths of the active region prominences were less than 120 G, which is inconsistent with some of the previous studies which estimated field strengths of on-disk filaments as 100 - 800 G. Our results support the statement by Díaz Baso et al. (2016) that such strong fields come from active regions below the filaments. Furthermore, the magnetic field of one of our prominences is consistent with the field of the corresponding filament observed by Yamasaki et al. (2023) a few days later.

P-138

Current Status and Future Modification of XRT Response Functions

R. Fleming, A. Takeda, and K. Yoshimura (MSU)

The X-Ray Telescope (XRT) response functions are subject to CCD contamination, filter fractures (straylight), and filter contamination. The CCD contamination monitoring method is now updated and altered based on phase 5 of straylight monitoring starting June 2022. The new regime is based on empirical data instead of the previous estimated G-band thickness curves. On May 5th, 2023, the 6th straylight event (entering phase 6) occurred causing an increase of saturation in the G-band. We went on to calculate a 125% increase to Al-mesh and Al-poly stray light intensity compared with those at the phase 5. Fortunately, Thin-Be and the combination Al-poly/Ti-poly filters were not affected by the intensity increase. We also produced updated irradiance measures of Al-mesh and Al-poly filters to compare to previous iterations. The new straylight contamination was included in the new irradiance measure. Finally, we are working on the Chianti 10.1 coronal abundance update. This update includes new coronal and photospheric abundances in which we will discuss the differences between Chianti 10 and 10.1. Additionally, we will examine each filter for changes as well as compare to 2006 filter conditions. The resulting response functions will also be reported.

P-139

Influence of magnetic filling factor estimation on the polar magnetic fields as observed with Hinode/SOT-SP

M. Kubo (NAOJ), D. Shiota (NICT/ISEE), Y. Katsukawa (NAOJ),
H. Iijima (ISEE/Nagoya U.), S. Masuda (ISEE/Nagoya U.),
and A. Fujimori (U. Tokyo/NAOJ)

The high spatial resolution and high precision polar magnetic field measurements with Hinode/SOT-SP over one solar cycle provide unique and invaluable data sets. A new database for the polar magnetic fields with Hinode/SOT-SP was published in 2022 at ISEE, Nagoya University (doi: 10.34515/DATA.HSC-00001). The magnetic field vector in this database is derived by the MILOS inversion. We investigate the effect of the estimation of the magnetic filling factor on the radial magnetic flux density in the polar region. Linear polarization contributes more to the determination of the radial magnetic flux density as one approaches the limb. This complicates the relationship between the radial flux density, the field strength, and the filling factor. We compare the assumptions of global and local scattered light profiles in estimating the magnetic filling factor. The global scattered light profile, which is averaged over the entire disk areas in the field-of-view, is used in the Level-2 data in the HAO database and the local scattered light profile, which is averaged over the neighboring pixels, is used in the ISEE database. We confirm that the local scattered light profile provides us better fitting results in the polar region because the intensity difference between the scattered light profile and the observed Stokes I profile becomes small when we use the local scattered light profile in the presence of limb darkening. We also find that the magnetic filling factor becomes small at the extremely high latitudes close to the pole and does not compensate for the decrease in the averaged radial field strength that may be caused by the observations of the upper atmospheres. As a result, the radial magnetic flux is reduced by about half. We will discuss possibilities for the small filling factor values at the extremely high latitudes.

P-140

Compressing Hinode SOT/SP spectral data using autoencoder

J. Batmunkh, Y. Iida (Niigata U.), T. Oba (NAOJ),
and H. Iijima (Nagoya U.)

Solar polarization spectra contain important physical information for investigating various solar events and phenomena. Hinode SOT/SP has been accumulating solar spectro-polarimetry data for more than a decade; however, it is challenging to process this massive amount of multi-dimensional data with existing methods. If we can extract the most important features from this data, it will be highly effective for analyzing spectra in terms of computational cost, time efficiency, and precision. In this regard, our aim is to develop a method for compressing raw spectra into a smaller representation using deep learning models. This method will be useful for further tasks, including detecting anomalous spectra, predicting solar flare, and automatically classifying solar spectra.

We constructed encoder-decoder structured deep autoencoder (DAE) and 1D-convolutional autoencoder (1D-CAE) models for compressing spectro-polarimetry data. Due to the noisy profiles of Stokes parameters, we considered only Stokes I and V in this study. We customized the loss function as a sum of weighted mean absolute errors of Stokes I and V for training.

As for the results, DAE showed a standard deviation (std) percentage as 5.38-5.92% at line centers and 1.95-2.01% at continuums for Stokes I, and 4.22-5.04% at line cores for Stokes V. In the case of 1D-CAE, the std resulted in 1.55-1.73% at line centers and 0.26-0.39% at continuums for Stokes I, whereas for Stokes V, it was 2.54-2.8% at line cores.

To conclude, we experimented with different structured autoencoder models for compressing solar polarization spectra, and from the comparison of the results more potential was confirmed in the 1D-CAE model.

P-141

Solving filament fragmentation problem in the deep learning model by optimizing training settings

T. Sato, Y. Iida, S. Ando, and A. Sasaki (Niigata U.)

The solar filament is a black striated structure on the H-α image. Since solar filament eruptions sometimes cause CMEs, automatic detection has been performed using image processing.

A.Ahmadzadeh et al.(2019) used Mask R-CNN, an object detection model using deep learning, to detect filaments and achieved high detection accuracy competitive with image processing. However, it has been reported that a single filament is fragmented into multiple filaments for detection.

Against this background, this study aims to improve the accuracy of filament detection through appropriate training settings based on the fragmentation problem. We use H-α images taken by the Big Bear Solar Observatory (BBSO) as image data and filament information reported in the Heliophysics Events Knowledgebase (HEK) as annotation data. The data were obtained for the period 2012-2016. The experiment was performed using 1,068 images from the above period.

First, hyperparameter settings were conducted based on the filament shapes. Average Precision (AP) was used as the evaluation metric. As a result, the AP was 0.322. This result indicates that the hyperparameter setting alone is not sufficient for proper filament detection. Second, training data selection was conducted. In order to learn large filaments, small filaments were excluded from the training data. As a result, the AP was 0.441, confirming the improvement in accuracy. This result indicates that excluding the training data is useful in filament detection. Finally, a dataset modification was conducted. Since there were some improper annotations in the dataset, these were corrected. As a result, an AP of 0.480 was achieved, confirming further improvement in accuracy. The fragmentation problem was partially resolved in this experiment.

In this study, we addressed the fragmentation problem observed in filament detection in deep learning. By optimizing the data usage and hyperparameters, we improved the detection accuracy and showed that these methods are effective.

P-142

Development of a coronal hole detection method from extreme ultraviolet images using U-Net

S. Fujiya, and Y. Iida (Niigata U.)

Coronal holes are regions of open magnetic fields which observed as dark areas in the solar corona because of their low density and temperature. In recent years, coronal hole detection methods based on deep learning has been reported by several research, and detection results are expected to be more accurate than conventional detection methods with image processing technique. Although the significant correlation between the coronal hole area and the solar wind parameter has been reported, the model accuracy for coronal hole detection hasn't been directly evaluated.

In this study, we developed a coronal hole detection model using U-Net, a semantic segmentation model that classifies each pixel to the defined categories, evaluated, and improved it focusing on the area of coronal holes. The detection model uses the full-disk EUV images from SDO/AIA as input and classifies each pixels whether it is a coronal hole. We used 754 images of three types in the 171, 193, and 211 angstrom waveband for about two years. Also, we used the coronal hole identification via multi-thermal emission recognition algorithm (CHIMERA; Garton et al., 2017) to create class labels in ground-truth data. CHIMERA analyses multi-thermal images from the AIA/SDO to detect coronal holes with image processing by their intensity ratio across three passbands, e.g. 171, 193, and 211 angstrom.

We achieved F-score=0.859, IoU=0.759 for coronal hole detection using U-Net. In addition, we evaluated using RMSE to compare the area of all coronal hole in the predicted images and the label images, as a result, we achieved RMSE=1098.0[pixel2]. In the next experiment, we focused on the normalization method for input data to improve the accuracy of coronal hole detection. Finally, we achieved F-score=0.881, IoU=0.792 and RMSE=835.1[pixel2] for coronal hole detection by changing to the normalization method.

P-143

Distribution of HINODE archive data and development of a new web tool in conjunction with the HEK database by DARTS.

S. Nakahira (ISAS/JAXA), Y. Iida (Niigata U.),
K. Inada, H. A. Uchida, and K. Matsuzaki (ISAS/JAXA)

DARTS (https://darts.isas.jaxa.jp/), a data archive operated by ISAS, distributes observational data from various scientific satellites or planetary explorers. The HINODE Level0 data are stored from the start of observations in 2006 to the present and are quickly processed and added to the DARTS public data after downlinking.

We are currently planning to develop a new data search tool. First, we have mapped the HINODE observations with the HEK Heliophysics Events Knowledgebase (HEK; https://www.lmsal.com/hek/), so that we can search the data not only with the observation settings, but also with the solar activity itself as a search parameter. The user can then use the data to search for the activity of interest. This makes it easier for the user to find observations where the activity of interest occurs within the field of view and time intervals of the observation. The information can be efficiently referenced from a front-end that implements faceted searching, and API support makes it easy to ingest tabular data using programming languages such as Python.

In this poster, we plan to give an overview of our development and demonstrate the use of a prototype version of the data search tool.

P-144

Development of a robust and divergence-free scheme for the magnetohydrodynamic relaxation method

T. Miyoshi (Hiroshima U.), S. Inoue (NJIT), S. Toriumi (ISAS/JAXA),
and K. Kusano (Nagoya U.)

Various phenomena in the solar atmosphere are caused by the solar atmospheric magnetic field. Since it is difficult to directly measure the solar atmospheric magnetic field with high accuracy, methods for extrapolating the atmospheric magnetic field from the vector magnetic field on the solar surface have been developed so far. The magnetohydrodynamic (MHD) relaxation method, in which an equilibrium is obtained as a converged solution of an initial and boundary value problem for simplified viscous or frictional MHD equations, is a powerful tool to reconstruct the atmospheric magnetic field from real data. In particular, the magnetic field should satisfy the solenoidal condition because it evolves with time according to the induction equation in the MHD relaxation method. However, since conventional finite-difference schemes cannot satisfy the solenoidal condition due to the numerical treatment of the boundary condition, additional divergence-cleaning schemes that advect and/or diffuse divergence errors are required. In this paper, we developed an almost tuning-free robust MHD relaxation method that strictly satisfies the solenoidal condition of the magnetic field by combining an upwind-type numerical scheme and a constrained-transport scheme. A comparison with a semi-analytical solution of the nonlinear force-free magnetic field demonstrated that the present scheme is robust and highly reproducible.

P-145

On the flat filed of the tunable Lyot Filter using Liquid Crystal Variable Retarder

S. Nagata (Kyoto U.), K. Otsuji (NICT), T. Otsu, and T. T. Ishii (Kyoto U.)

The Solar Dynamics Doppler Imager (SDDI) of the Solar Magnetic Activity Telescope (SMART) at Hida Observatory is a full disk H-alpha imaging spectrometer and takes images of wavelength from H-alpha-9 A to H-aplpha+9 A with 0.25A step in 12 sec cadence. The tunable Lyot filter of SDDI utilizes Liquid Crystal Variable Retarder (LCVR), and the filter consists of 7 elements of free spectra range from 0.5 to 32 A. The two-dimensional spectroscopic data is used not only for solar flare and eruption studies (e.g., Cabezas et al. 2019), but also widely used for the stellar flare and eruption research (e.g., Namekata et al. 2021; Otsu et al. 2022) in recent years. For the quantitative analysis of the spatial and temporal variation of the spectroscopic characteristics, the flat field calibration across the whole the measurement wavelength ranges is necessary. So far, we have used an empirical model to estimate the flat field for each data, but it is a time-consuming computing process and sometimes fails due to unknown reason. Thus, we are now developing a physical model of the flat field for SDDI. We compared the flat field derived from the empirical model and that is derived form the Kuhn-Lin algorithm. As a result, we found that the flat the field can be expressed as a composite of flat field of 7 blocks and each block's flat field can be expressed as a function of the block temperature and the voltage applied to the LCVR. Also, the spatial variation of that function is found, and the stability of the model will be examined in coming months. The detailed progress is reported in the poster.

P-146

Soft X-ray High-Speed CMOS Camera System for the Solar Flare X-ray Imaging Spectroscopy Onboard Sounding Rocket Experiment FOXSI-4

R. Shimizu (SOKENDAI), N. Narukage (NAOJ), T. Sakao (ISAS/JAXA),
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F. Hodoshima, T. Koseki (Shimafuji Electric Inc.),
T. Takahashi, S. Nagasawa (Kavli IPMU), and FOXSI team

FOXSI-4, the fourth flight of the Focusing Optics X-ray Solar Imager, is scheduled to be launched in the spring of 2024. One of its objectives is to investigate the release of magnetic energy and its conversion mechanism caused by magnetic reconnection in solar flares. FOXSI-4 will conduct the world's first focused imaging spectroscopic observation of solar flare X-rays, providing high spatial, temporal, and energy resolution throughout the entire solar flare system. This observation will offer valuable physical information about high-temperature and nonthermal plasmas.

For soft X-ray observations at 0.5-10 keV, non-dispersive type X-ray imaging-spectroscopy will be performed using a back-illuminated CMOS sensor. This sensor has a fully depleted silicon thickness of 25 μm and can achieve a high-speed continuous exposure rate of approximately 250 fps for the region of 2048 x 384 pixels. We have conducted an evaluation of the photon counting capability of this sensor within the energy range of 0.8-4.5 keV and 4.5-12 keV at UVSOR and SPring-8, respectively. We will report on the results of this evaluation.

Additionally, we are developing a camera utilizing a ZYNQ UltraScale+ MPSoC device, which integrates a built-in CPU inside an FPGA, to control the sensor and acquire data at the rate of about 300 MB/sec. We are also working on the development of a framework that enables command input and telemetry output using SpaceWire, a standard spacecraft data communication interface. The framework will operate the camera and obtain quick-look data in real-time during the flight for the rocket pointing and real-time data verification. We will introduce the current development status of this soft X-ray camera.

P-147

Evaluation of mirror scattering component for solar observation satellite Hinode/XRT using partial solar eclipse and limb flare events

S. Kashima (ISAS/JAXA/Kwansei Gakuin U.), T. Sakao (ISAS/JAXA),
N. Narukage (NAOJ), Y. Sato (SOKENDAI/NAOJ),
and R. Shimizu (SOKENDAI/ISAS/JAXA)

The X-ray Telescope (XRT) onboard Hinode utilizes Wolter Type-I grazing incidence optics, achieving a spatial resolution of 2 arcseconds (1 arcsecond per pixel on the focal plane detector) with a precisely polished mirror. However, due to the figure error and surface roughness of the mirror, there are scattered X-rays in regions away from the optical axis, resulting in slight X-ray scattering components in the obtained image. Accurate evaluation of the amount of scattered X-rays from bright regions in the corona is crucial for observing dark regions such as coronal holes or dark structures near bright structures in X-rays.

We studied mirror scattering components using partial solar eclipse data and limb flare data taken with XRT. We conducted comprehensive investigations for both partial solar eclipses and limb flares by analyzing data from 2010 to 2023. With partial solar eclipse data, we can investigate pure scattered components by utilizing the portion where the Moon obscures the Sun. In particular, by utilizing events where active regions are partially obscured by the Moon, we can study the scattered components in the vicinity (approximately a few tens of arcseconds) of bright regions on the solar surface. We also investigated the scattered components using limb flare data. In limb flare data, coronal structures of the Sun are overlaid with the scattered components, making evaluation in that region challenging. On the other hand, it is possible to determine the scattered component in regions far away from the flare core.

We evaluated the mirror scattering over a wide off-axis angular range by analyzing these two types of data.

In the presentation, we will report results and prospects of the analysis.

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Improving the Soft X-ray Coronal Plasma Temperature Diagnostic Sensitivity by Including Low-FIP Elemental Abundance Variations

S. Sanchez-Maes (Harvard U.), and C. S. Moore (CfA)

Spectrally resolved soft X-ray measurements provide constraints on the temperature and elemental abundance variations of the quiescent solar corona. While the Hinode/XRT soft X-ray spectrally integrated images, Hinode/EIS EUV and SDO/AIA spectral image measurements have uncovered a wealth of information on the coronal plasma temperature distribution, the measurements do not overlap in the same spectral bandpass. Thus, there can be uncertainties in the consistency of the measurements and hence coordinated observations ascribe roughly a factor of 2 sensitivity offset to the Hinode/XRT measurements. The Dual Aperture X-ray Solar Spectrometer (DAXSS) and the Miniature Solar X-ray Spectrometer (MinXSS) instruments conduct spectrally resolved, spatially integrated soft X-ray measurements which overlap with the Hinode/XRT filter images. In this study, we begin to cross-calibrate DAXSS and MinXSS to Hinode/XRT to determine if low-FIP element (Mg, Si, Ca, etc.) variations are prime contributors to the Hinode/XRT sensitivity offset inferred by Hinode/EIS, SDO/AIA, and NuSTAR simultaneous measurements. This process will improve the plasma temperature diagnostic accuracy in the 1 MK - 10 MK range and allow for better estimations of quiet Sun and quiescent active region heating probes.

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The Correction of the Scattered Light of An Inner-occulted Coronagraph

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The Lijiang Coronagraph Station of Yunnan Observatories, established in 2013, was the first optical coronal observation station in China. A 10 cm Lyot coronagraph was shipped from Norikura Station of NAOJ and installed at Lijiang Station during the summer of 2013. The first coronal image was successfully taken on 2013 October 25. For the ground-based Inner-occulted coronagraph with regular observations, scattering from dust on the objective surface can be slowed down by frequent cleaning of the objective surface and the level of such stray light can be suppressed, the objective surface unable to maintain cleanliness at all times due to weather, atmospheric particle pollution and other factors. Frequent cleaning and multiple disassembly of the objective lens can to some extent cause secondary pollution on the surface of the objective lens. The scattering light of the Coronagraph changes with time, resulting in different amounts of background scattering in the coronal image, which brings great inconvenience to the analysis of the coronal structure and the calibration of the coronal intensity. Based on the Lijiang Coronagraph, we discussed the influence of the surface cleanliness of the objective lens on the coronal intensity through experiments, and corrected the coronal intensity. We created different scattering backgrounds with different objective cleanliness and corrected the coronal intensity through fitting methods. Our method not only effectively improves the quality of coronal images, but also makes weak coronal structures more prominent and clear, which helps us obtain more accurate results when analyzing the decay trend of internal coronal intensity and changes in coronal structure. More importantly, it will help us to analyze the scattered light of the Coronagraph and discuss the influence of other scattered light inside the Coronagraph on the coronal image.

P-150

Flare Lyman-α Spectral Time Series from SORCE/SOLSTICE

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H I Lyman-α (1216 Å) is the strongest emission line in the solar spectrum, but until recently, most instruments have not had the cadence, sensitivity, and duty cycle to capture rapid changes in Lyman-α emission associated with flares. Of the observations that exist, the data are predominantly spatially and spectrally integrated. In January 2021, a new dataset was released from SOLSTICE which scans through the Lyman-α line profile with modest spectral resolution (0.35 Å) on flare timescales (one line scan takes ~1 min). Here, we present the analysis of 4 X- and 13 M-class flares that were observed between 2003-2012. The Lyman-α profile was divided into 5 bands: line core (λ_rest ± 1.5 Å), 'near' wings (λ_rest ± 2-4 Å), and 'far' wings (λ_rest ± 4-6 Å). While relatively low resolution, these measurements of the Lyα line will allow us to determine how the chromosphere responds to flare heating at this wavelength, where in the solar atmosphere the emission is emanating, and how these changes contribute to the solar irradiance. We found the line core had an average enhancement of 3%, while the wings had average enhancements of 9%. These enhancements generally occurred before the GOES soft X-ray (SXR) peak, indicating the line was impulsively heated; however, in a third of the events; the Lyman-α emission peaked after the GOES SXR peak. The wings generally peaked before the core, although wing emission may not contribute as much to broadband observations. However, these results can constrain radiative hydrodynamic models that can be used to interpret observations from future instruments such as SoSpIM and EUVST on Solar-C (and GOES-R/EXIS).

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Effects of solar radiation on the Earth's upper atmosphere

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Lyα (121.6 nm) is emitted from the chromosphere and transition region of the Sun, and have been observed by many instruments (e.g. Solar Orbiter/EUI) because they are the strongest VUV radiation from the Sun. The Lyα is also planned to be observed by SoSpIM (The Solar Spectral Irradiance Monitor) on board the next Japanese solar mission SOLAR-C. The Lyα is considered to contribute to the formation of the Earth's ionosphere due to its radiation, but the Lyβ (102.6 nm) has a shorter wavelength than the Lyα, so the Lyβ radiation is likely to have a greater effect on ionization of the Earth's upper atmosphere. However, since the timing and emission location of Lyα and Lyβ are nearly identical, it is difficult to find differences between these emissions.
Lemaire et al. (2012) investigated the relationship between Lyα and Lyβ emissions over some region and during solar cycles. They reported that the Lyα/Lyβ ratio tends to decrease with increasing Lyα emissions during solar cycles. However, it has not been investigated the relationship between Lyα and Lyβ lines during solar flares and the effects of Lyα and Lyβ lines on the Earth's upper atmosphere. In this study, we investigate the relationship between solar Lyα and Lyβ emissions and their effects on the upper atmosphere.
In this presentation, we will report the variation of Lyα and Lyβ with the solar cycle and during solar flares. And also we discuss the effect of Lyman series emissions from the Sun on the Earth's ionosphere by comparing these emissions with data observed in the Earth's ionosphere by ionosondes and other instruments.

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Global Coronal Plasma Diagnostics Based on Multi-slit EUV Spectroscopy

L. Chen, H. Tian, and X. Liu (PKU)

Full-disk spectroscopic observations of the solar corona are highly desired to uncover the origin of large-scale solar eruptions and solar wind. In this paper, we introduce a multi-slit design (5 slits) to obtain EUV spectra simultaneously with a spatial resolution of 4”. The selected spectrometer wavelength range (184-197 Å) contains 5 bright EUV lines (Fe VIII 185.213 Å, Fe X 184.537 Å, Fe XI 188.216 Å, Fe XII 186.887 Å, Fe XII 195.119 Å) for spectral diagnostics including temperature, density, velocity and line width diagnostics. The multi-slit method offers an unprecedented way to efficiently obtain the global spectral data but the ambiguity from different slits should be resolved. We use a decomposition technique to disambiguate the multi-slit confusion, with the focus of accurately separating the spectra from different slits. We find a good correlation between the model parameters and inverted results at the onset of a CME.

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Measuring electron densities with the C III 97.7/117.6 line ratio

V. Andretta (INAF/Astronomical Observatory of Capodimonte), and L. Teriaca (MPS)

In a fully ionized plasma, the measurement of the electron density provides a direct measurement of the mass density, a fundamental thermodynamical quantity. Perhaps the most reliable method to measure the electron density involves the ratio of spectral lines, or groups of lines, from the same ion but with substantially different spontaneous decay coefficients. These diagnostic ratios typically involve lines arising from forbidden transitions. Normally, however, forbidden lines are also very weak, posing therefore serious problems to the study of even slowly evolving phenomena. One of the most remarkable exceptions is the ratio of the permitted C III 97.7 nm line to the forbidden C III multiplet at 117.6 nm, both lines being very bright features of the solar VUV spectrum and both to be simultaneously observed by the EUVST spectrometer aboard SOLAR-C. However, the 117.6 nm multiplet is blended with autoionization lines from S I. Here we revise the atomic data for the S I autoionization lines by comparing laboratory measurements with solar data. Finally, we evaluate the importance of such a blend in diagnosing electron density in different solar regions and in solar-like stars, discussing in particular the usability of the C III 97.7/117.6 ratio under quiet Sun conditions.

P-154

A case study of a hot coornal loop in the solar plage model

S. Danilovic (Stockholm U.)

One of the main science goals of MUSE and Solar-C EUVST spectrograph is discerning between different mechanisms that heat the corona. In preparation for these missions, we focus on the MURaM_plE run from De Pontieu et al (2022). We study in detail a formation of a feature visible in the Fe XIX–Fe XXI 108 Å spectral band and show what would be the best observational strategy and choice of spectral lines to detect the source of heating.

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Activities of the Hinode and SOLAR-C Science Center at ISEE in Nagoya University

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In collaboration with the Japan Aerospace Exploration Agency (JAXA) and the National Astronomical Observatory of Japan (NAOJ), the "Center for Heliospheric Science (CHS)" was established at the Institute for Space-Earth Environmental Research (ISEE), Nagoya University in FY2022 (see https://chs.isee.nagoya-u.ac.jp/) to promote heliospheric system science. The CHS has been working on the maintenance of data files related to the spacecraft currently in operation such as Hinode, Arase, and BepiColombo/Mio. This center develops/releases integrated analysis software and coordinates operation/observation plans. These are utilized by many researchers in science communities in Japan and abroad (cf. invited talk by Miyoshi et al. in this meeting).

As for Hinode, in addition to maintaining the Hinode flare catalogue (doi: 10.34515/CATALOG.HINODE-00000) and compiling a list of doctoral and master's theses related to Hinode, some databases of higher-level data products processed for scientific purposes have been made available to the public. Following the "Database of Nonlinear Force-free Magnetic Fields in Solar Active Regions" released in FY2021 (doi: 10.34515/DATA.HSC-00000), the "Hinode Polar Magnetic Field Database" was released in FY2022 (doi: 10.34515/DATA.HSC-00001). Each database has been given a unique Digital Object Identifier (DOI) to enable persistent data searches and citations.

Recently we have initiated a design study and discussion on the functions and operations of the SOLAR-C Science Center. In this presentation, we mainly introduce our activities relevant to Hinode and SOLAR-C in the CHS and report on the future prospects.

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The Solar Transition Region UltraViolet Explorer CubeSat

A. G. de Wijn (NCAR/HAO) and the STRUVE Team

We present the Solar Transition Region UltraViolet Explorer (STRUVE) CubeSat mission. STRUVE is a slit-scanning, full-Stokes spectropolarimeter that observes the Sun in the near-UV in the 259-281 nm wavelength band recently identified by Judge et al. (2021) as a particularly promising region for diagnostics of chromospheric magnetic field. The observed wavelength region contains the well-known Mg II h and k lines as well as a plethora of Fe I and II lines that together will allow diagnostics of the magnetized plasma in the volume of the solar atmosphere from the photosphere through the chromosphere, and up to the transition region at the base of the corona. This capability is unprecedented and highly relevant for an improved description of the magnetically connected solar atmosphere. The main objective of STRUVE is to advance our understanding of the energy build-up and storage in the solar atmosphere, and its eventual release through flares and coronal mass ejections. STRUVE observations will fulfill many of the requirements for magnetometry that were outlined in the joint JAXA/NASA/ESA report on the Next Generation Solar Physics Mission (NGSPM) that highlighted the need for coordinated observations of SOLAR-C and MUSE-like instruments with measurements of the chromospheric magnetic field like those provided by STRUVE.

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Why are Active Region Flux Emergence Rates Higher in Simulations than Observations?

A. Norton (Stanford U.), K. Knizhnik, and M. Linton (NRL)

Average flux emergence rates of active regions observed using HMI/SDO are lower than rates found in numerical simulations. Signed, average flux emergence rates for sunspots observed with HMI average 5 x 10^{19} Mx per hour. The observed rates from HMI are put into context with results previously reported from observations using various instruments, including Hinode/SOT, and simulations. A clear trend is seen that larger flux regions emerge faster than smaller flux regions, with rates ($d\Phi/dt$) scaling with total peak flux as a power law $d\Phi/dt \approx \Phi^{0.36}$. Star spot emergence rates on Solar-type stars estimated with Kepler data are reported to follow a similar emergence rate and scaling law. Observed emergence rates may assist in constraining the choice of boundary and initial conditions in 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. Recent work indicates that even with decreased buoyancy in the rising flux tubes, the simulations cannot reproduce active region flux emergence as slowly as what is observed.