IAU S372 ORAL SESSIONS ABSTRACTS

(in order of presentation)

IAUS 372

#2360

Parker Solar Probe in the Multi-Spacecraft Era

Robert Allen[1]
[1]*Space Exploration Sector, Johns Hopkins Applied Physics Lab, United States of America*

Parker Solar Probe (PSP) has provided observations at unprecedentedly close radial distances to the Sun, allowing for the first observations of sub-Alfvénic solar wind and unique observations of the solar corona from the Alfvén surface by WISPR. While these unique vantage points alone have enabled robust explorations of the fundamental nature and evolution of the corona and young solar wind, the combination of PSP with other current and historical datasets allow for the most comprehensive and significant advancements to our understanding of the heliosphere. In this presentation, we highlight some of the scientific contributions made by combining PSP observations with those of other space- and ground-based observatories, as well as the current challenges that exist for utilizing this multi-observatory approach. We also highlight efforts by the PSP Project Science team and the Whole Heliosphere & Planetary Interactions (WHPI) initiative for coordinated multi-observatory campaigns centered around PSP parahelia as we move into the ascending phase of this solar cycle.

IAUS 372

#2620

Recent Results of Solar Microwave Imaging Spectroscopy

Bin Chen[1]

[1]*Physics, New Jersey Institute of Technology, United States of America*

Microwave emission serves as a powerful tool for diagnosing the dynamic coronal magnetic field, thermal structure of the solar atmosphere, and magnetic energy release and particle acceleration processes in solar transient events such as solar flares, coronal mass ejections, and jets. In the past decade, we have enjoyed a major transition in solar microwave observing – it has evolved from total-power dynamic spectroscopy or imaging at a few discrete frequencies to true broadband imaging spectroscopy. Although still in their early stages, these spatially, temporally, and spectrally resolved data have already demonstrated the unique power of microwave imaging spectroscopy. In this talk, I will highlight recent results based on this new technique, using examples from facilities including EOVSA, VLA, MUSER, and SRH.

IAUS 372

#716

The Aditya-L1 Mission of the Indian Space Research Organization

Durgesh Tripathi[1]

[1]*IUCAA, IUCAA, India*

The Aditya-L1 is the first observatory, scheduled to be launched in late 2022, of the Indian Space Research Organization (ISRO) in space dedicated to solar observations. The spacecraft will carry seven payloads providing uninterrupted observations of the Sun using remote sensing and in-situ measurements from the first Lagrangian point. There are four remote sensing instruments: a coronagraph, a full-disk near-ultraviolet (NUV) imager, and full-sun integrated soft X-ray and hard X-ray spectrometers. In addition, there are three instruments, including a magnetometer, to study the solar wind and interplanetary magnetic field variations during energetic events. For the first time, the Aditya-L1 mission aims to provide the coronal magnetic field measurements from space and spatially resolved solar spectral irradiance in NUV, which is central to the Sun-climate relations. This talk will highlight some of the salient features of the mission and the crucial roles it will play in enhancing our knowledge in the science of the solar atmosphere and heliosphere.

IAUS 372

#709

The early science phase of Solar Orbiter

Sami Khan Solanki[1]

[1]*Sun, MPI for Solar-System Research, Germany*

The Solar Orbiter mission of ESA and NASA was launched in February 2020 and is an excellent example of multi-messenger solar physics. Of the 10 science instruments on board, four are in-situ instruments measuring particles and fields at the location of the spacecraft, while six are remote-sensing instruments detecting photons from the Sun or from the Heliosphere. Whereas Solar Orbiter was in its cruise phase during most of 2020 and 2021 when only the in-situ instruments were taking regular observations, it entered its first science orbit after an Earth flyby in November 2021. In March and Early April 2022 Solar Orbiter will pass through its first science perihelion at a distance of 0.33AU to the Sun. During this period, the first set of remote-sensing windows of the mission are scheduled, when the remote sensing instruments will take their first images, spectra and magnetograms of the Sun from up close. After a brief introduction to the mission, the first results, as far as they are available, from the cruise phase and from the first perihelion passage will be presented.

IAUS 372

#1250

The Daniel K. Inouye Solar Telescope: status update and first results

Thomas Rimmele[1]

[1]*DKIST, National Solar Observatory, United States of America*

The National Science Foundation's 4m Daniel K. Inouye Solar Telescope (DKIST) on Haleakala, Maui is now the largest solar telescope in the world. DKIST's superb resolution and polarimetric sensitivity will enable astronomers to unravel many of the mysteries the Sun presents, including the origin of solar magnetism, the mechanisms of coronal heating and drivers of flares and coronal mass ejections. DKIST's instruments provide highly sensitive measurements of solar magnetic fields, including the illusive magnetic field of the faint solar corona. DKIST has started its operations commissioning phase (OCP), during which science observations based on community proposals are being implemented in service-mode and on a shared-risk basis. We provide an overview of the facility and its unique capabilities, discuss progress with the OCP and present first data and early results.The National Science Foundation's 4m Daniel K. Inouye Solar Telescope (DKIST) on Haleakala, Maui is now the largest solar telescope in the world. DKIST's superb resolution and polarimetric sensitivity will enable astronomers to unravel many of the mysteries the Sun presents, including the origin of solar magnetism, the mechanisms of coronal heating and drivers of flares and coronal mass ejections. DKIST's instruments provide highly sensitive measurements of solar magnetic fields, including the illusive magnetic field of the faint solar corona. DKIST has started its operations commissioning phase (OCP), during which science observations based on community proposals are being implemented in service-mode and on a shared-risk basis. We provide an overview of the facility and its unique capabilities, discuss progress with the OCP and present first data and early results.

IAUS 372

#944

Generation of the solar magnetic field

Hideyuki Hotta[1]

[1]*Faculty of Science, Chiba University, Japan*

The solar magnetic field is thought to be generated by the turbulent motion in the solar interior and the surface. The turbulent and chaotic motion in the convection zone leads to several interesting coherent features such as the 11-year activity cycle and butterfly diagram. Due to the difficulties of the numerical approach and the observation for the solar interior, the generation mechanism of the magnetic field is not fully understood, especially for the 11-year cycle. The recent development of the supercomputer and numerical technique enables us to carry out large-scale calculations, which improve our understanding of the sun. At the same time, local helioseismology is significantly improved in the last decade to evaluate the turbulence and the large-scale flow. The numerical simulation and the observation still have important discrepancies that hinder our understanding of solar magnetic generation. The presenter summarizes the recent improvement of numerical and observational studies for the solar interior in the talk.

IAUS 372

#1196

Powering solar-type stars magnetism: how are magnetic cycles established and driven?

Allan Sacha BRUN[1], Antoine Strugarek[1], Quentin Noraz[1], Barbara Perri[2], et al.[3]

[1]*Dept. Astrophysics - AIM, CEA Paris-Saclay, France*
[2]*Dept. Astrophysics - AIM + CMPA, CEA Paris-Saclay + KU Leuven, France*
[3]*-, -, France*

We present an extensive study on the dynamo origin of the solar-type star's magnetism, based on a series of 35 3D MHD numerical simulations.

We assess how the combination of rotation and convection via the Rossby number influences the type of magnetism established (short or long cycles, statistically steady activity) and their expected differential rotation (solar-like, anti-solar, cylindrical or almost solid).

This large survey allows us to explain why the Sun possesses a long decadal cycle and a conical differential rotation.

We further assess the amount of energy needed to maintain such angular velocity profiles and magnetic activity. We find that between 0.1 and 3% of the stellar luminosity can be converted into magnetic energy, giving plenty of energy for surface eruptive events to occur. We also compute the magnetic energy spectra and show that the dipole and quadrupole magnetic fields do not collapse in amplitude when the rotation regime becomes anti-solar in agreement with spectropolarimetric observations, and as such cannot simply explain a break of gyrochronology for large Rossby number.

Finally, we discuss various scaling laws that this study allows to derive and that could be tested with dedicated observations, completing the current observational database. In particular, 2 regimes at low and high Rossby number seems particularly interesting to further quantity and model.

IAUS 372

#1201

Solar cyclic activity reconstruction now extends to cover the last millennium

Ilya Usoskin[1], Sami Solanki[2], Natalie Krivova[2], Bernhard Hofer[2], Gennady Kovaltsov[3], Lukas Wacker[4], Nicolas Brehm[4], Bernd Kromer[5]

[1]*Faculty of Science, University of Oulu, Finland*
[2]*MPS, Max Planck Institute for Solar System Research, Germany*
[3]*Astrophysics, Ioffe Physical Technical Institute, Russian Federation*
[4]*Ion-beam lab, ETH Zurich, Switzerland*
[5]*Institute of Environmental Physics, Univ. Heidelberg, Germany*

The famous 11-year (Schwabe) solar cycle is the dominant pattern of solar magnetic activity reflecting the oscillatory dynamo mechanism in the Sun. Solar cycles have been directly observed since 1700 in sunspot numbers. While solar variability is known over 12 millennia using indirect proxy data, individual solar cycles and their continuity were not resolved before 1610 CE. Here we reconstruct individual solar cycles for the last millennium using the high-precision 14C data and state-of-the-art models. Cyclic solar activity is reconstructed for the period 971–1900 CE with 85 individual cycles, along with its uncertainties. This more than doubles the number of solar cycles known from direct solar observations. The reconstructed cycles are consistent with sunspot data after 1750 CE. Statistical Waldmeier realtion between the solar cycle parameters has been tested and confirmed with the longer dataset. Thus, solar cycles are reconstructed, for the first time, for about 1000 years, in the form of annual (pseudo) sunspot numbers with the full assessment of all known uncertainties.

IAUS 372

#1548

Tracking active regions from the near-Earth to the solar far side by combining SDO/HMI and SO/PHI data

Hanna Strecker[1], Alejandro Moreno Vacas[1], David Orozco Suárez[1], Jose Carlos del Toro Iniesta[1]

[1]*Solar system department, Instituto de Astrofísica de Andalucía, Spain*

The study of the evolution of active regions has been limited in time, both by solar rotation and by the inability to observe the far side solar photosphere from Earth. The Polarimetric and Helioseismic Imager (PHI) on board the Solar Orbiter (SO) satellite provides the unique opportunity to see the solar far side in intensity and magnetic field. Combining SO/PHI far-side observations from opposition with near-Earth observations of the Helioseismic and Magnetic Imager (HMI) on board the Solar Dynamics Observatory (SDO) allows the tracking of active regions almost uninterrupted for a full solar rotation or even longer. We make use of data acquired with the full disc telescope of SO/PHI during Solar Orbiter's first opposition during cruise phase in February 2021. Four active regions are tracked from the near-Earth side in HMI intensity maps and magnetograms, to the far side where they become visible in the field of view of SO/PHI. Three of the active regions are in a decaying stage and do no longer show signals in intensity when reaching the field of view of SO/PHI. One of the active regions, emerging when visible on the near-Earth side, develops pores on the far side and rotates back into the field of view from Earth where the decaying process is observed. We will present the longest almost uninterrupted study of the evolution of the magnetic field of active regions, achieved so far. This shows the uniqueness of combining Solar Orbiter and near-Earth side observations for continuously study the evolution of long-lasting active regions.

IAUS 372

#1515

Origin of extreme solar eruptive activity from the active region NOAA 12673 and the largest flare of solar cycle 24

Bhuwan Joshi[1], Prabir K. Mitra[1], Astrid M. Veronig[2]

[1]*Udaipur Solar Observatory, Physical Research Laboratory, India*
[2]*Institute of Physics & Kanzelhöhe Observatory, University of Graz, Austria*

During 2017, when the Sun was moving toward the minimum phase of solar cycle 24, an exceptionally eruptive active region (AR) NOAA 12673 emerged on the Sun during August 28-September 10. During the highest activity level, the AR turned into a βγδ-type sunspot region, which manifests most complex structure of magnetic fields from the photosphere to the coronal heights. The AR 12673 produced four X-class and 27 M-class flares, along with numerous C-class flares, making it one of the most powerful ARs of solar cycle 24. Notably, it produced the largest flare of solar cycle 24, namely, the X9.3 event on 2017 September 6. In this work, we provide the results of our comprehensive analysis involving multi-wavelength imaging and coronal magnetic field modeling to understand the evolution and eruptivity from AR 12673. We especially focus on the morphological, spectral, and kinematical evolution of the two X-class flares on 2017 September 6. We quantitatively assess the link between the large- and small-scale changes in the magnetic fields of the active region with the occurrence of subsequent outbursts during the X-class flares. We also provide a detailed investigation of various aspects of magnetic flux rope structures along with the topology of coronal magnetic fields in 3-dimension. The study also reports a very interesting case of the anomalous expansion of the CME at the source region on 2017 September 7 which are found to be intimately connected with the non-radial eruption of a double-decker flux rope from a mini-sigmoid region of NOAA 12673. Our study reveals that the combination of ideal ‘torus’ instability and resistive processes is responsible for the onset of eruptions from the source region which eventually resulted into the CMEs.

IAUS 372

#339

Solar flare-CME association

Ting Li[1]

[1]*Research Group of Solar Magnetic Activities, National Astronomical Observatories, Chinese Academy of Sciences, China*

With the aim of understanding how the magnetic properties of active regions (ARs) control the eruptive character of solar flares, we analyze 719 flares of Geostationary Operational Environmental Satellite (GOES) class greater or equal than C5.0 during 2010-2019. We carry out the first statistical study that investigates the flare-coronal mass ejections (CMEs) association rate as function of the flare intensity and the AR characteristics that produces the flare, in terms of its total unsigned magnetic flux (Φ_{AR}). Our results show that the slope of the flare-CME association rate with flare intensity reveals a steep monotonic decrease with Φ_{AR}. This means that flares of the same GOES class but originating from an AR of larger Φ_{AR} are much more likely confined. Based on an AR flux as high as 10^{24} Mx for solar-type stars, we estimate that the CME association rate in X100-class ``superflares" is no more than 50%. Our results imply that Φ_{AR}. is a decisive quantity describing the eruptive character of a flare, as it provides a global parameter relating to the strength of the background field confinement. By considering both the constraining effect of background magnetic fields and the magnetic non-potentiality of ARs, we propose a new parameter (α / Φ_{AR}) to measure the probability for a large flare to be associated with a CME.

We find that in about 90% of eruptive flares, $\alpha_{FPIL} / \Phi_{AR}$ and $\alpha_{HFED} / \Phi_{AR}$ are beyond critical values 2.2 x10^{-24} and 3.2 x10^{-24} Mm^{-1} Mx^{-1}, whereas they are less than critical values in about 80% of confined flares. This indicates that the new parameter (α / Φ_{AR}) is well able to distinguish eruptive flares from confined flares.

Our investigation suggests that the relative measure of magnetic nonpotentiality within the AR core over the restriction of the background field largely controls the capability of ARs to produce eruptive flares.

IAUS 372

#2283

Solar Observations with ALMA: a New Frontier

Timothy Bastian[1]

[1]*Science Support and research, National Radio Astronomy Observatory, United States of America*

Solar observations with Atacama Large Millimeter-Submillimeter Array (ALMA) became available to the community in late-2016. For the first time, high angular resolution (sub-arcsec) and high-time-resolution (1 s) observations of the Sun became possible at millimeter wavelengths, providing observations of the solar chromosphere that are uniquely complementary to those in O/IR and UV wavelengths. This talk will briefly review current ALMA capabilities, present selected results of ALMA observations of the Sun, discuss current and future synergies with other instruments such as IRIS and DKIST, and describe future capabilities. Access to resources to learn more about ALMA and to propose for observing time will be provided.

IAUS 372

#956

MHD waves in chromospheric fibrillar structures as observed with ALMA

Maryam Saberi[1], Shahin Jafarzadeh[1], Ricardo Gafeira[2], Sven Wedemeyer[1], Mikolaj Szydlarski[1]

[1]*Institute of Theoretical Astrophysics, University of Oslo, Norway*
[2]*Center for Earth and Space Research, Geophysical and Astronomical Observatory, University of Coimbra, Portugal*

Waves and oscillations have been shown as a prime means of transporting energy through the solar atmosphere, thus, contributing to the high temperature of the upper layers. In particular, magnetohydrodynamic (MHD) waves are observed in a number of structures in the solar chromosphere, often with observations in the near-ultraviolet (UV) to infrared wavelength range. In this talk, I will present our recent work on identification of MHD wave modes in a number of fibrillar structures using high-temporal resolution (i.e., 2~s cadence) observations with the Atacama Large Millimeter/submillimeter Array (ALMA) in Band 6 (centred at 1.2~mm). Such oscillations are further compared with those identified in observations at near- and far-UV wavelengths (i.e., Mg ii k and C ii spectral lines) with the Interface Region Imaging Spectrograph (IRIS) space telescope.

IAUS 372

#389

Estimating physical parameters of quiet Sun corona using low-frequency spectro-polarimetric radio images

Devojyoti Kansabanik[1], Divya Oberoi[1]

[1]*Astronomy, National Centre for Radio Astrophysics - Tata Institute of Fundamental Research, Pune, India, India*

With improved observations, we are discovering that the so-called “quiet corona” is not so quiet at all. The electron density, temperature, and magnetic field strengths are lower in the quiet Sun regions, as compared to the active regions. As this medium provides the background environment in which all of the coronal dynamics and eruptive phenomena take place, it is important to estimate the plasma parameters of the ambient quiet corona. At higher coronal heights (more than 1.3 solar radii), the emissivity of the corona becomes too low to be measurable in visible, EUV, and X-ray bands. It is hence hard to measure the physical parameters of the corona at higher coronal heights using these observing bands. Low-frequency radio observations are particularly suitable for gathering this information. Using new-generation radio interferometers, like the Murchison Widefield Array (MWA), it is now possible to make high dynamic range spectro-polarimetric solar images of the Sun. Our recently developed robust polarization calibration and imaging pipeline delivers imaging dynamic ranges spanning a few hundred to 10^5 with very low residual instrumental polarization (less than 0.05%). These images can provide the means to estimate the coronal electron density and temperatures at higher coronal heights routinely. Also, though thermal emission is unpolarized, on passing through the inhomogeneous magnetized coronal plasma it picks up a weak circular polarization (less than 1%) due to the birefringent nature of this medium. It is possible, in principle, to measure the large-scale quiet Sun coronal magnetic field by measuring this weak circular polarization. We present the first-ever detection of circular polarization from quiet Sun thermal emission and use it to estimate the large-scale ambient coronal magnetic field. This forms a convincing demonstration that high fidelity spectro-polarimetric imaging at low radio frequencies provides a novel method for estimating the physical parameters of the corona.

IAUS 372

#2444

Forward Modeling of Solar Coronal Magnetic-field Measurements Based on a Magnetic-field-induced Transition in Fe X

Yajie Chen[1], Wenxian Li[2], Hui Tian[1], Feng Chen[3], Xianyong Bai[2], Yang Yang[4], Zihao Yang[1], Xianyu Liu[1], Yuanyong Deng[2]

[1]School of Earth and Space Sciences, Peking University, China
[2]National Astronomical Observatories, Chinese Academy of Sciences, China
[3]School of Astronomy and Space Science, Nanjing University, China
[4]Institute of Modern Physics, Fudan University, China

It was recently proposed that the intensity ratios of several extreme ultraviolet spectral lines from Fe X ions can be used to measure the solar coronal magnetic field based on magnetic-field-induced transition (MIT) theory. To verify the suitability of this method, we performed forward modeling with a three-dimensional radiation magnetohydrodynamic model of a solar active region. Intensities of several spectral lines from Fe X were synthesized from the model. Based on MIT theory, the intensity ratios of the MIT line Fe X 257 Å to several other Fe X lines were used to derive magnetic-field strengths, which were then compared with the field strengths in the model. We also developed a new method to simultaneously estimate the coronal density and temperature from the Fe X 174/175 and 184/345 Å line ratios. Using these estimates, we demonstrated that the MIT technique can provide reasonably accurate measurements of the coronal magnetic field in both on-disk and off-limb solar observations. Our investigation suggests that a spectrometer that can simultaneously observe the Fe X 174, 175, 184, 257, and 345 Å lines and allow an accurate radiometric calibration for these lines is highly desired to achieve reliable measurements of the coronal magnetic field. We have also evaluated the impact of the uncertainty in the Fe X 3p4 3d 4D5/2 and 4D7/2 energy difference on the magnetic-field measurements.

IAUS 372

#1191

How has the solar wind evolved to become what it is today?

Aline Vidotto[1]

[1]Leiden Observatory, Leiden University, Netherlands

The Sun is the best studied star in the whole Universe: we can measure its properties with accuracy like no other star. However, all this information just tells us about how the Sun looks like now. To understand the past, and future, evolution of the Sun, including its wind, magnetism, activity, rotation, and irradiation, we rely on stellar data, in an effort to better place the Sun and the solar wind in a stellar context. In this talk, I will review the long-term evolution of the solar wind (eg, its mass-loss rate), including the evolution of observed properties that are intimately linked to the solar wind: rotation, magnetism and activity. I will also briefly discuss implications of the evolution of the solar wind on the evolving Earth. I argue that studying exoplanetary systems could open up new avenues for progress to be made in our understanding of the evolution of the solar wind.

IAUS 372

#1465

Stirring the Base of the Solar Wind

Adam Finley[1]

[1]*Department of Astrophysics-AIM, CEA Paris-Saclay, France*

Current models of the solar wind must approximate (or ignore) the small-scale dynamics within the solar atmosphere, however these are likely important in shaping the emerging wave-turbulence spectrum and ultimately heating/accelerating the coronal plasma. In this talk, I will make connections between small-scale vortex motions at the base of the solar wind and the resulting heating/acceleration of coronal plasma. We apply the Bifrost RMHD code to produce realistic simulations of the solar atmosphere that facilitate the analysis of spatial and temporal scales which are currently at, or beyond, the limit of modern solar telescopes. The simulation is configured to represent the solar atmosphere in a coronal hole region, from which the fast solar wind emerges. The simulation extends from the upper-convection zone (2.5Mm below the photosphere) to the low-corona (14.5Mm above the photosphere), with a horizontal extent of 24Mm x 24Mm. Photospheric flows are found to efficiently twisted the coronal magnetic field, with Poynting fluxes of up to 2-4kW/m^2 commonly observed inside the twisted structures. Stronger whirlpool-like flows in the convection, concurrent with magnetic concentrations, launch torsional Alfv\'en waves up through the magnetic funnel network, which are expected to enhance the turbulent generation of magnetic switchbacks in the solar wind. Temperature and density contrasts form between regions with active stirring motions and those without. Therefore, stirring motions in the low-corona represent one possible explanation for the patchy nature of switchbacks in the solar wind, observed by Parker Solar Probe.

IAUS 372

#517

Exploring the formation of solar wind, switchbacks and Quiet Sun heating

Vishal Upendran[1], Durgesh Tripathi[1]

[1]*Solar physics, Inter University Centre for Astronomy and Astrophysics, India*

The solar wind formation, acceleration, and solar coronal heating are intimately tied by the prevailing magnetic field topology and the energy deposition mechanism in the solar atmosphere. This dichotomy is seen as excess (reduced) blueshifts (intensity, redshifts) in Coronal holes (CH) over nearby Quiet Sun (QS) regions in the corona. These differences are seen in the transition region (TR) seen only for regions with similar photospheric magnetic flux density (|B|). In this work, we study the chromospheric Mg II h&k, the C II 1334 Å, and the TR Si IV line in CHs and QS as a function of |B|. We find all lines to show an increase of intensities and velocities with |B|. The chromospheric lines show reduced intensity, excess blueshifts, and excess redshifts in CHs over QS for regions with similar |B|. In the TR line, CHs show excess blueshifts and reduced intensity and redshift. We then perform cross-correlation of chromospheric and TR velocities to explore the dichotomy of redshifts across heights. The exercise shows that flows in the same direction are tightly correlated in both regions, while the chromospheric downflows are also correlated with TR upflows. The TR downflows (upflows) are larger in QS (CHs) for similar chromospheric flows. These results may be explained through impulsive heating in a stratified atmosphere causing larger deceleration (acceleration) of downflow (upflow) in QS (CHs), which form due to bidirectional flows generated by impulsive events. The observed flows and intensities may be explained by invoking interchange (closed-loop) reconnection in CHs (QS). Furthermore, our results provide constraints on the formation of switchbacks in the lower atmosphere. These results demonstrate the importance of high spatial, temporal, and spectral resolution observations of quiescent regions in understanding the mass and energy transport across the solar atmosphere and are important in the context of future missions like Aditya-L1, MUSE, SPICE, and EUVST.

IAUS 372

#2795

First science with Solar Orbiter Metis coronagraph

Marco Romoli[1]

[1]*Physics and Astronomy, Università di Firenze, Italy*

Metis is the coronagraph on board Solar Orbiter, that provides images of the extended solar corona in the broadband VL (580-640 nm) with polarimetric capabilities and, simoultaneously, in the narrowband HI Ly-alpha at 121.6 nm. Owing to the eccentricity of the spacecraft orbit, the FoV will cover a variable annular region from 1.7 to 9 solar radii with unprecedented spatial (2000 km) and temporal resolution (1s). The near-Sun multi-wavelength coronal imaging performed with Metis, combined with the unique opportunities offered by the Solar Orbiter mission, will address key issues such as: the acceleration of the fast and slow solar wind streams; the transient ejection of coronal mass and its evolution; the large scale magnetic morphology of the solar corona; and the origin of the solar energetic particles, thus, improving the understanding of the region connecting the Sun to the heliosphere. Metis is operating and will operate in synergy with present and future space- and ground-based solar observatories providing a multi-messanger, multi-spacecraft and multi-point-of-view insight of the solar corona. VL total brightness and linearly polarized images combined with HI images allow us to determine the physical properties, such as dentities and velocities, of the two major constituents of the solar corona: hydrogen and electrons, and obtain a characterization of the F-corona, produced by the scattering of interplanetary dust grains.

Solar Orbiter mission entered the nominal mission phase at the end on November 2021 and Metis observed almost continuosly since the cruise phase. A summary of the main results obtained by Metis is given: on the determination of the solar wind speed by means of the Doppler dimming technique, the analysis of transient phenomena like CMEs and filament eruption, coronal density fluctuations. A review of the present in-flight calibration will also be provided together with the coordination and synergies with present missions (SOHO, STEREO, and PSP) and future missions (PROBA3/ASPIICS, Aditya).

IAUS 372

#2480

Solar Orbiter/EUI very wide field observations of the EUV corona

Frédéric Auchère[1], David Berghmans[2], Udo Schuehle[3], David Long[4], Louise Harra[5], Luca Teriaca[3], Regina Aznar Cuadrado[3], Emil Kraaikamp[2], Susanna Parenti[6], Phillip Smith[4], Koen Stegen[2], Francis Verbeeck[2]

[1]Institut d, Université Paris Saclay, France
[2]-, Royal Observatory of Belgium, Belgium
[3]-, Max Planck Institut für Sonnensystemforschung, Germany
[4]-, Mullard Space Science Laboratory, United Kingdom
[5]-, PMOD, Switzerland
[6]-, Insititut d'Astrophysique Spatiale, France

At 3.8°, the field of view (FOV) of the Full Sun Imager (FSI) on Solar Orbiter is by far wider than that of any previous solar EUV imager. Depending on the distance of the probe to the Sun along its orbit, this corresponds to 14 to 4 solar radii, to be compared to the 3.5 Rs of STEREO/EUVI or Proba2/SWAP. This very large field of view opens up a new discovery space into a region largely unexplored in the EUV. Since it was expected that stray-light would dominate beyond 2 Rs, a moveable occulting disk can be inserted in the optical path to block light rays up to 0.78° off the optical axis. On March 21 2021, at 0.51 AU, FSI acquired deep exposures at 17.4 and 30.4 nm with the occulting disk in place. The data reveals solar structures extending up to 5 Rs which, to our knowledge, is the furthest ever recorded at these wavelengths. We compare the morphology of the observed structures with close in time observations in white light by the Metis coronagraph. We present a comparison of the measured signal fall-off as a function of distance to Sun-center with a model of coronal emission taking into account collisional excitation and resonant scattering.

IAUS 372

#1282

The heliosphere in 3D from multi-spacecraft observations

Christian Moestl[1]

[1]*Space Research Institute, Austrian Academy of Sciences, Austria*

There is now an amazing fleet of spacecraft present in the inner heliosphere that is bound to revolutionize our current understanding of how the Sun shapes the heliosphere. It is the combination of in situ and remote sensing data from Solar Orbiter, Parker Solar Probe (PSP), BepiColombo, STEREO-Ahead and SOHO, ACE, Wind and DSCOVR in near-Earth space that allows us to discover new processes and to check where and how our simulations and models fail, and how to improve them. These multi-messenger observations are much needed to make progress on the understanding of many unsolved problems, for example concerning the global magnetic configuration of coronal mass ejections and high-speed solar wind streams, real-time space weather forecasting, the magnetic connectivity of the solar wind to the Sun, and the propagation of solar energetic particles. I will present an overview of some recent discoveries and the development of innovative methods. Additionally, event catalogs that have been meticulously built up in the last few years provide a quick entry for validating simulations without the need to comb through the data first. I will then present an outlook on whats to come in this decade, from PSP routinely crossing the the Alfvén surface, the possibility that PSP crosses a CME close to the Sun twice, to how Solar Orbiter improves ambient solar wind modeling by imaging the solar poles, and provide much anticipated additional data by in situ instruments away from the ecliptic. The upcoming PUNCH mission will allow for the first time to extract 3D information from heliospheric images. All these unique observations in the solar wind will also help to deepen our knowledge of stellar CMEs. These novel results and methods are then expected to lay the groundwork for real-time application through data by the ESA Vigil mission, a dedicated space weather outpost at the Sun-Earth L5 point, planned to be launched by the end of the decade.

IAUS 372

#916

CME-CME interaction in the interplanetary space: Observation and simulation

Roksoon Kim[1]

[1] *Space Science Division, Korea astronomy and space science institute (KASI), Republic of Korea*

To understand CME-CME interaction in the interplanetary space, we investigated solar wind observation near-Earth space including solar radio burst, proton event, and ICME's arrival, and compared to EUHFORIA simulation. For this, we selected 6 isolated CME-CME pairs which are expected to meet near-Earth based on their ejecting time and propagating speed. Assuming that their interaction phase can be inferred from the time difference of preceding and following CMEs' expected arrivals at the Earth, we found that (1) there can be reverse drifting in the radio spectrum meaning density increase for the events in the phase of just before and during the interaction. (2) Also, in that phase, there can be magnetic hole structures separating two magnetic clouds, which are characterized by abrupt change and subsequent recovery in the solar wind condition such as density and magnetic field. (3) The thicknesses of the sheath and magnetic cloud have strong linear relationships with the arrival time difference, and this can be explained by the elongated components due to the interaction. Based on the observation and the EUHFORIA simulation results, it can be inferred that as the two CMEs get closer, the interaction starts with density increase in the solar wind and a magnetic hole is formed, and then finally the interaction ends as the thickness of the sheath and the magnetic cloud gradually thickens.

IAUS 372

#2246

2Pi steroradian radio observations of the 28-10-2021 solar flare

Juan Carlos Martinez Oliveros[1]

[1]*Space Sciences Laboratory, University of California Berkeley, United States of America*

Type III radio bursts are causally associated with solar flares. The energy stored in the coronal magnetic fields when released heats plasma and accelerates electrons and ions to high energies. Interplanetary radio emission is produced by flare accelerated electron beams interacting with ambient plasma as they propagate in the interplanetary medium. On 28 October 2021 a X1 GOES Class solar flare (SOL2021-10-28) was observed by several heliophysics observatories, in particular, by the Solar Dynamics Observatory (SDO), Parker Solar Probe (PSP), Solar Orbiter (SolO) and the Solar TErrestrial RElations Observatory (STEREO). We report the results of the radio flux and radio direction-finding analysis and their possible implications for the process of generating radio emission from the electron beams associated with the bursts.

IAUS 372

#2381

A revisit to the source regions of solar energetic particles by the synchronic potential field source surface model

Jinhye Park[1], Hyun-Jin Jeong[2], Yong-Jae Moon[2]

[1]*Department of Astronomy & Space Science, Kyung Hee University, Republic of Korea*
[2]*School of Space Research, Kyung Hee University, Republic of Korea*

We revisit magnetic field configurations of the source regions of 6 solar energetic particle (SEP) events accelerated near or behind the limbs. For this, we use a new potential field source surface model (AI-PFSS) at $2.5R_{\odot}$, on a near real-time basis using AI-generated farside magnetograms by Jeong et al. (2020). By comparing AI-PFSS and conventional PFSS from HMI synoptic data (HMI-PFSS), we find several interesting differences on the SEP source regions and their magnetic field configurations between them. 1) The structure and size of source active regions (ARs) are significantly changed. The total unsigned magnetic field fluxes of the ARs are mostly stronger in AI-PFSS rather than HMI-PFSS except for one case. 2) In particular, newly emerging ARs are observed near the SEP source regions in the AI-PFSS for two cases. The locations of the emission features in the full-sun EUV synchronic maps are consistent with ARs in the AI-PFSS. 3) The inversion lines are changed due to the appearance and/or disappearance of ARs. The propagation directions of the source eruptions in the running difference EUV images are consistent with the configurations of the inversion lines in the AI-PFSS. This study shows that AI-PFSS is able to give a better understanding of SEP source regions and their magnetic field connections.

IAUS 372

#980

Complete restructuring of a magnetic flux rope during a solar eruption

Tingyu Gou[1]

[1]*Department of Geophysics and Planetary Sciences, University of Science and Technology of China, China*

Solar eruptions are magnificent and energetic explosions in the heliosphere, among which the magnetic flux rope is a fundamental structure. In the standard model, a magnetic flux rope builds up into a CME through magnetic reconnection that continually converts the overlying, untwisted magnetic flux into twisted flux enveloping the pre-existent rope. However, only about one third of in-situ detected CMEs have the flux-rope configuration, which casts doubt on the universality of such a well-organized enveloping process. Here we present observations of the complete restructuring of a pre-forming flux rope during its eruption. The formation process is featured by the growth of a hot seed and simultaneous slipping and expansion of its footpoint into being enclosed by a trapezoid-shaped ribbon. During the subsequent eruption, the flux rope's feet migrate to new places, indicative of a complete replacement of magnetic fluxes in the original flux rope. Our study signifies the three-dimensional reconnection between the flux rope and the surrounding magnetic fields, and provides new clues for the development of the CME.

IAUS 372

#2730

Understanding solar local dynamo

Elena Khomenko[1]

[1]*Instituto de Astrofisica de Canarias, Spain*

Solar local dynamo is the process which is believed to be responsible for the appearance of the magnetic fields of the quiet Sun. It operates at the near surface layers of the solar envelope. High resolution realistic simulations of solar convection reproduce the action of the local solar dynamo, with the magnetic field growing from a small seed value toward the saturated value of about 10^2 G, which is apparently close to the one observed in the quiet Sun. There are however controversial results as for the conditions required for the dynamo to work in the numerical models, since none of the current models reach the realistic Reynolds or Prandtl numbers. At the same time, there is yet no agreement as for the cycle dependence of the quiet Sun magnetic fields. Observations of magnetic flux recirculation, a dynamical process underlying the local dynamo, have not been yet obtained at the required resolution. This talk will summarize our current observational and theoretical understanding of solar local dynamo, and future challenges to be addressed by high resolution data from new instruments and missions.

IAUS 372

#2508

Plasma heating along a current sheet in nonequilibrium ionization and non-Maxwellian electron velocity distribution

Jin-Yi Lee[1], John C. Raymond[2], Katharine K. Reeves[3], Chengcai Shen[2], Stephen Kahler[4], Yong-Jae Moon[5], Yeon-Han Kim[6]

[1]*Astronomy and Space science, Kyung Hee University, Republic of Korea*
[2]*Solar, Stellar, and Planetary Sciences, The Center for Astrophysics | Harvard & Smithsonian, United States of America*
[3]*High Energy Astrophysics, The Center for Astrophysics | Harvard & Smithsonian, United States of America*
[4]*Battlespace Environment Division, Air Force Research Laboratory, United States of America*
[5]*School of Space Research, Kyung Hee University, Republic of Korea*
[6]*Space Science Division, Korea Astronomy & Space Science Institute, Republic of Korea*

We investigate plasma heating along a current sheet considering nonequilibrium ionization states and non-Maxwellian electron velocity distributions. We assume continuous heating as the plasma expands after rapid heating at the beginning of the eruption. We calculate ion fractions solving a time-dependent ionization equation with various Kappa values, representing non-Maxwellian electron velocity distributions, with the heated temperatures. Then, we simulate the count rates using the calculated ion fractions and compare them with the observations on 2017 September 10 by the Atmospheric Imaging Assembly on board the Solar Dynamic Observatory. Finally, we discuss the heating rates and Kappa values that satisfy the observations. This could guide the studies on other solar events considering the nonequilibrium states.

IAUS 372

#292

Why Are Solar Prominences Filamentary?

Gwangson Choe[1], Inhyeok Song[2], Sibaek Yi[1], Minseon Lee[3]

[1]*School of Space Research, Kyung Hee University, Republic of Korea*
[2]*Institute of Astronomy, National Tsing Hua University, Taiwan*
[3]*Department of Astronomy and Space Science, Kyung Hee University, Republic of Korea*

Solar prominences are cool and dense structures suspended in hot and tenuous solar corona. They are of the shape of ribbons or a stack of threads, and thus are also called solar filaments. It has been thought that the prominence material is formed by thermal condensation instability of optically thin, hot coronal plasma. Although the conventional thermal instability theory can explain contraction of gas volume by cooling, it can hardly explain why the cooled gas has filamentary substructures. An interesting, but poorly understood observation in solar prominences is ubiquitous counter-streaming flows along their filamentary fine structures. Although thermal instability in optically thin plasmas has quite extensively been studied in various situations, it has rarely been studied in relation to shear flows. In this paper, we present a study on thermal instability in magnetized plasmas with shear flows based on linear stability analysis. We have found that for sub-Alfvenic shear flows, the density and temperature eigenfunctions of condensation modes (thermally unstable modes) are of the form of delta functions unless the shear velocity is extremely small (a millionth of the Alfven velocity), and the condensation takes place only in discrete sheets. For a super-Alfvenic shear velocity, a Kelvin-Helmholtz instability sets in as is well-known, and no thermal instability arises. In this regard, it is to be noted that the counter-streaming flows observed in solar prominences are always sub-Alfvenic. Our results indicate that any non-uniform velocity field with a shear magnitude larger than 10 m/s in the solar corona can generate discrete eigenfunctions of the condensation mode. We therefore suggest that filamentary condensation (condensation at discrete layers or threads) should be quite a natural and universal process whenever a thermal condensation instability arises in magnetized plasmas with any unignorable velocity shear.

IAUS 372

#676

Detection of Propagating Alfvenic Waves in the Solar Chromosphere

Jongchul Chae[1]

[1]*Department of Physics and Astronomy, Seoul National University, Republic of Korea*

Alfvenic waves are regarded as an important process in understanding coronal heating, solar wind acceleration, and the fractionization of low first-ionization-potential (FIP) elements. Recently, significant progress has been made in the detection of propagating Alfvenic waves in the solar chromosphere using two different methods: the imaging method and the spectroscopic method. The imaging method detects Alfvenic waves that oscillate in the direction perpendicular to the line of sight, and the spectroscopic method, those that oscillate in the line of sight direction. We have applied the spectroscopic method to the imaging spectral data taken by the FISS on GST at Big Bear. As a result, we detected a number of propagating Alfvenic wave packets and found that there are two distinct groups: three-minute period waves, and ten-minute period waves. We propose two tales on the origin of Alfvenic waves in the chromosphere; the three-minute waves are excited by the upward-propagating slow waves in the chromosphere through mode conversion, and the ten-minute waves represent the chromospheric manifestation of the kink waves driven by convective motions in the photosphere.

IAUS 372

#2249

Formation of activity indicators in a 3D model atmosphere

Sneha Pandit[1], Sven Wedemeyer[1], Mats Carlsson[1]

[1]*Institute of Theoretical Astrophysics, Rosseland Centre for solar Physics, Norway*

The Sun, being the nearest star, can be used as a reference case for solar-like stars due to the availability of many spatiotemporally resolved solar spectra. Amongst several spectral lines, some of the strongest chromospheric diagnostics are the Ca II H & K lines which can be used to gauge the temperature stratification of the atmosphere as the line core and wings are formed in different regions of the solar atmosphere. Furthermore, the H α line is a tracer for the magnetic structures and its line core gives an estimate of the mass density. These two diagnostics together can provide insights into the stellar structure.

The 1.5D radiation transfer codes RH and Multi3D are used to obtain synthetic spectra for the Ca II lines and the H α line from an enhanced network atmosphere model simulated with the state-of-the-art Bifrost code. The activity indices generated from these lines could further be used to compare the spectra of sun-like stars with the solar spectrum. These indices can shed light on the physical properties like temperature stratification, magnetic structures, mass density distribution in the stellar atmospheres. Meanwhile, brightness temperatures from ALMA observations provide a new complementary view on the activity and the thermal structure of stellar atmospheres. The synthetic Ca II and H α spectra are therefore compared to corresponding millimetre continuum maps. The overall aim of the presented study is to establish more robust solar/stellar activity indicators using ALMA observations in comparison with classical diagnostics.

IAUS 372

#1961

Application of Deep Learning to Solar and Space Weather Data

Yong-Jae Moon[1]

[1]*School of Space Research, Kyung Hee University, Republic of Korea*

In this talk, we introduce our recent applications of deep learning to solar and space weather data. Our major applications are (1) generation of solar farside magnetograms and global field extrapolation, (2) generation of solar UV/EUV images, (3) denoising solar magnetograms, (4) generation of modern satellite images from Galileo sunspot drawings, (5) improvement of global IRI TEC maps, (6) one-day forecasting of global TEC maps, (7) generation of high-resolution magnetograms from Ca II K images, (8) generation of super-resolution magnetograms, (9) flare classification and visual explanation, and (10) forecasting solar X-ray profiles. We also discuss future plans for integrated space weather models based on deep learning.

IAUS 372

#833

Heliophysics Events Knowledgebase support for Multi-Messenger Solar Physics

Neal Hurlburt[1], Ryan Timmons[2]

[1]*Space Sciences & Instrumentation, Lockheed Martin Advanced Technology Center, United States of America*
[2]*Space Sciences and Instrumentation, Lockheed Martin Advanced Technology Center, United States of America*

Modern studies of the Sun involve coordinated observations collected from a collage of instruments on the ground and in orbit. Each instrument has its own constraints, such as field of view, duty cycle, and scheduling and commanding windows, that must both be coordinated during operations and be discoverable for analyses of the resulting data. Details on the observed solar features, i.e. sunspots or filaments, and solar events, i.e. flares or coronal mass ejections, are also incorporated to help guide data discovery and data analysis pipelines. The Heliophysics Events Knowledgebase (HEK) provides a standards-based system for collecting and presenting observations collected by distributed, ground and space based solar observatories and cross referencing them with solar phenomena. The HEK currently supports all instruments on the Interface Region Imaging Spectrograph (IRIS) and Hinode missions as well as associated ground-based observatories. The flexible design of the HEK is capable of supporting other data and events such as heliospheric imagers and *in situ* events. Here we review the tools the HEK provides scientists to record solar observations, enable flexible searches on observation metadata and solar features and events.

IAUS 372

#2078

Deep neural network estimator for image refinement and estimation on radiation formation heights

Henrik Eklund[1]

[1]*Department of Astronomy, Stockholm University, Norway*

The point spread function generally constitutes the resolution element in astronomical observations, which degrades the intensity contrasts and leaving structures at smaller angular resolution unresolved. The solar atmosphere is highly dynamic and the intensities and height of formation of the radiation is strongly connected to the small scale dynamics, which is utilised in the current work to perform estimations and improve the analysis of solar observations.

An artificial deep neural network is trained to recognise dynamic patterns of features in both the spatial and temporal domains, to perform estimations on the intensity contrast degradation and the height of formation of the radiation. The neural network is trained on radiative transfer calculations from 3D MHD Bifrost simulations of the solar atmosphere and is applied to perform estimations on millimeter wavelength observations with ALMA to acquire more precise intensities and corresponding height of formation.

The deep neural network can to large accuracy distinguish whether a brightening event or feature is well resolved and to what degree it is over or underestimated. Using this method as a diagnostics tool for small-scale dynamics in solar ALMA observations, where the intensity is closely related to the plasma temperature, enables to study the potential heating at small scales of different layers of the upper solar atmosphere.

IAUS 372

#500

Automatic Extraction of Solar Filaments Using Machine Learning Techniques

Andrea Diercke[1], Robert Jarolim[2], Christoph Kuckein[3], Sergio Javier González Manrique[4], Marco Ziener[5], Astrid Veronig[2], Carsten Denker[6], Werner Pötzi[2], Tatiana Podladchikova[7]

[1]-, National Solar Observatory (NSO), United States of America
[2]Institute of Physics, University of Graz, Austria
[3]-, Instituto de Astrofisica de Canarias, Spain
[4]-, Leibniz-Institut für Sonnenphysik, Germany
[5]-, Tidy GmbH, Germany
[6]-, Leibniz-Institut für Astrophysik Potsdam (AIP), Germany
[7]-, Skolkovo Institute of Science and Technology, Russian Federation

Filaments are omnipresent features in the solar chromosphere. Regular full-disk H-alpha observations allow us to analyze statistical properties of filaments. Therefore, filaments have to be extracted from the images. Manual extraction is tedious and takes too much time; extraction with morphological image processing tools produces a large number of false-positive detections. Automatic object detection and extraction in a reliable manner allows us to process more data in a shorter time. The Chromospheric Telescope (ChroTel), Tenerife, Spain, the Kanzelhöhe Solar Observatory (KSO), Austria, and the Global Oscillation Network Group (GONG), provide regular full-disk observations of the Sun in the core of the chromospheric H-alpha absorption line. We will present a machine learning application allowing us to reliably extract solar filaments from H-alpha filtergrams. First, we train the object detection algorithm YOLOv5 with labeled filament data of ChroTel H-alpha filtergrams. The accuracy of the object detection is very high and it is possible to apply the algorithm to other H-alpha filtergrams to create a larger training data set for the further steps. In a second step, we apply a semi-supervised training approach, where we use the bounding boxes of filaments, that were created with YOLOv5, to learn a pixel-wise classification of solar filaments. Therefore, we utilize a standard deep learning model for semantic segmentation, i.e., DeepLabv3. With the resulting segmentation masks, physical parameters such as the area or tilt angle of filaments can be easily determined and studied. In a last step, we apply the filament detection and the segmentation of filaments on a different H-alpha data set belonging to ChroTel, KSO and GONG, to estimate the general applicability of our method.

IAUS 372

#597

Generation of coronal white light images from SDO/AIA EUV images using deep learning

Bendict Lawrance[1], Harim Lee[1], Eunsu Park[1], Il-Hyun Cho[1], Yong-Jae Moon[2], Jin-Yi Lee[1], Shanmugaraju Annamalai[3], Sumiaya Rahman[4]

[1]*Astronomy and Space Science, Kyung Hee University, Republic of Korea*
[2]*Astronomy and Space Science, School of Space Research, Kyung Hee University, Republic of Korea*
[3]*Department of Physics, Arul Anandar College, India*
[4]*School of Space Research, Kyung Hee University, Republic of Korea*

Solar white light observations are very important to understand the low coronal features, but they are rarely made. We generate the MLSO K-coronagraph like white light images from SDO/AIA EUV images using a deep learning model based on conditional generative adversarial networks. We train the model using pairs of MLSO K-coronagraph images and their corresponding SDO/AIA EUV (171, 193 & 211Å) images considering the field of view between 1.11 to 1.25 solar radii. For this image translation, we made seven (single channels and combination of multiple channels) deep learning models. Our results from the study are summarized as follows. First, the multiple channel 'AIA 193 & 211Å' model is the best among seven models in-view of metrics such as correlation coefficient and normalized root mean square error. Second, major low coronal features like helmet streamers, pseudo-streamers and polar coronal holes are well identified in the AI-generated images by this model. The positions and sizes of the polar coronal holes of the AI-generated images are consistent with those of the target ones. Third, from AI-generated images, we successfully identified a few interesting phenomena: jets and CMEs. We hope that our model provides us with complementary data to study the low coronal features in white light during non-observable cases (during night-time, poor atmospheric conditions and instrumental maintenance).

IAUS 372

#1194

Modeling efforts for multi-mission science

Clementina Sasso[1], Alexis P. Rouillard[2]

[1]*Osservatorio Astronomico di Capodimonte, INAF (Istituto Nazionale di Astrofisica), Italy*
[2]*IRAP (Institut de Recherche en Astrophysique et Planétologie), CNRS (Centre National d'Études Spatiales), France*

The Solar Orbiter spacecraft, launched in February 2020, is equipped with both remote-sensing (RS) and in-situ (IS) instruments to record novel and unprecedented measurements of the solar atmosphere and the inner heliosphere. To take full advantage of these new datasets, we have developed tools and techniques to ease multi-instrument and multi-spacecraft studies that will be presented here. In particular the yet inaccessible low solar corona below two solar radii can only be observed remotely and techniques must be used to retrieve coronal plasma properties in time and in 3-D space. These properties are useful to drive numerical models and test the different theories proposed to describe the fundamental processes of the solar atmosphere. In addition, the last decades of research have shown that the coupling between the solar corona and the heliosphere is most efficiently studied by combining RS with IS data. During the last remote sensing windows, planned for the Solar Orbiter instruments, we ran complex observation campaigns to maximize the likelihood of linking IS data to their source region near the Sun, by directing some RS instruments to specific targets on the solar disk just days before data acquisition. We will present the results of these efforts directed to improve our understanding of how heliospheric probes connect magnetically to the solar disk.

IAUS 372

#1725

Coordinating Solar Orbiter Operations: The Story so far and What to Expect Next

Andrew Walsh[1], Anik De Groof[1], Daniel Mueller[2], David Williams[1], Ioannis Zouganelis[1]

[1]*ESAC, European Space Agency, Spain*
[2]*ESTEC, European Space Agency, Netherlands*

After a Cruise Phase of 21 months, Solar Orbiter began its first scientific orbit on 27 November 2021 with a Gravity Assist Manoeuvre (GAM) by the Earth. The spacecraft entered a highly elliptical orbit that took it past its first close perihelion on 26 March 2022, some 0.32AU from the Sun. In the following years, further GAMs by Venus will lead it even closer to the Sun and also out of the ecliptic plane to give us our first view of the Sun's poles.

Solar Orbiter's main goal is to study the connection between solar activity close to our star's surface and its effects as seen in the heliosphere, the bubble-like region of space under the Sun's influence including all solar planets. Therefore, its main scientific goals can only be achieved by coordinated observations of both the 6 remote-sensing telescopes on board, observing the dynamic Sun, and the 4 in-situ instruments measuring the effects in the solar wind surrounding the spacecraft.

This coordination takes careful planning and optimisation of the mission resources in order to fully exploit the capabilities of this exciting mission, and the fantastic opportunities for Solar Orbiter to work together with other missions, including Parker Solar Probe and DKIST. Here, we explain how this is done, how you can contribute, and what's planned for the second close perihelion and beyond.

IAUS 372

#2647

DKIST Coordination: Status and Current Strategies

Alexandra Tritschler[1]

[1]*National Solar Observatory/AURA, United States of America*

Co-Observing efforts have a long-standing tradition at the National Solar Observatory (NSO). The NSO's new high-resolution flagship the National Science Foundation's (NSF) Daniel K. Inouye Solar Telescope (DKIST) currently in its Operations Commissioning Phase will follow this tradition building on the lessons learned and challenges encountered during its transition into regular operations and beyond. In this presentation we will provide an overview of the status of these science enhancing synergies and discuss future strategies.

IAUS 372

#1927

Progresses of ASO-S mission

Yang Su[1], Weiqun Gan[1], on behalf of ASO-S team S.[1]

[1]*Key Laboratory of Dark Matter and Space Astronomy, Purple Mountain Observatory, Chinese Academy of Sciences (CAS), China*

The Advanced Space-based Solar Observatory (ASO-S) is a comprehensive solar observatory, the first in its category of China's space missions. The main scientific objectives of ASO-S are solar flares, coronal mass ejections (CMEs), solar magnetic field, and their relationship. Three scientific payloads (FMG, LST, and HXI) are deployed onboard the ASO-S to simultaneously observe full-disk solar vector magnetic field, solar hard X-ray bursts, and Lyman-α images up to 2.5 solar radii. ASO-S observations will also provide support for space-weather forecasts and warnings of hazardous events. The mission is now in Phase D and scheduled for launch in October 2022. A brief introduction to the scientific objectives, the payloads, and the status of the mission will be presented in this talk.

IAUS 372

#2818

Challenges and opportunities in solar and heliospheric physics at the dawn of the multi-messenger era

Valentin Martinez Pillet[1]

[1]*National Solar Observatory, United States of America*

In the 90s, the Ulysses mission's resulst substantiated the heliosphere as a multi-messenger paradigm. In this decade, the start of operations of the NSF's Daniel K Inouye Solar Telescope (DKIST) coincides with the science phases of two solar encounter missions, Parker Solar Probe (NASA) and Solar Orbiter (ESA/NASA). The three facilities constitute a multi-messenger suite destined to help us understand how the heliosphere is magnetically connected back to the Sun. By getting closer to the Sun, the two spacecraft can measure in-situ the pristine consequences of the processes observed at the solar surface with unprecedented detail and sensitivity using DKIST. The ability to detect spectropolarimetric signals from the Solar Corona is a novel and unique capability that DKIST will contribute to this effort. In this talk, I will outline some multi-messenger science cases that will benefit from combining the three facilities using different vantage configurations created by their orbits around the Sun.

IAU S372 E-POSTERS ABSTRACTS

(in alphabetical order)

(e-posters can be viewed on the Gallery at the main IAU GA webpage: http://www.iauga2022.org)

IAUS 372

#595

Long term evolution of magnetic field proxies as deduced from Archival data

Dipankar Banerjee[1]

[1] *ARIES, Aryabhatta Research Institute of Observational sciences, India*

The regular observation of the solar magnetic field is available only for about the last five cycles. Thus, to understand the origin of the variation of the solar magnetic field, it is essential to reconstruct the magnetic field for the past cycles, utilizing other data sets. Long-term uniform observations for the past 100 yr as recorded at the Kodaikanal Solar Observatory (KoSO) provide such an opportunity. I will demonstrate some examples of reconstruction of the solar magnetic field using the synoptic observations of the Sun's emission in the Ca II K and Hα lines from KoSO. The reconstruction method is based on the fact that the Ca II K intensity correlates well with the unsigned magnetic flux, while the sign of the flux is derived from the corresponding Hα map that provides the information of the dominant polarities. How these recontructed synoptic maps helps in our understadning of solar dynamo will be highlighted.

IAUS 372

#2562

Spatio-temporal Characterization of Hot Chromospheric Fibrils

Gianna Cauzzi[1]

[1]*National Solar Observatory, AURA, United States of America*

The exact mechanisms leading to chromospheric heating are still ill-defined. While the presence of magnetic elements is undoubtedly necessary, the details of the heating, and its spatio-temporal distribution remain poorly understood.

We contribute to this topic by analyzing the behavior of hot chromospheric fibrils surrounding network and plage elements, identified via the broader H-alpha profiles observed along their length; the H-alpha line width parameter has indeed been previously shown to correlate with the local chromospheric temperatures through comparison with ALMA millimeter-continuum brightness temperatures. We make use of loop tracing and analysis software to investigate fibrils' characteristics including their length, number density, transverse spatial extension and proximity to magnetically active regions, as well as their dynamical properties. Finally, we discuss how understanding of these features can benefit from combined observations with complementary diagnostics as provided by ALMA and SPICE on Solar Orbiter, as well as from observations obtained at different vantage points.

IAUS 372

#2264

Coronal condensation in magnetic dips as the source of quasi-steady supersonic downflows into sunspots

Hechao Chen[1], Hui Tian[1], Leping Li[2], Hardi Peter[3], Lakshmi Pradeep Chitta[3], Zhenyong Hou[1]

[1]*School of Earth and Space Sciences, Peking University, China*
[2]*National Astronomical Observatories,, Chinese Academy of Sciences, China*
[3]*Max Planck Institute for Solar System Research, Max Planck Institute for Solar System Research, Germany*

With the launch of the Interface Region Imaging Spectrograph (IRIS), transition region (TR) downflows at supersonic speeds have been commonly detected above most sunspots. In IRIS spectra, these supersonic downflows (SDs) are often observed as strongly redshifted secondary emission peaks with a speed of ~100 km/s and last for at least several hours. However, how these long-lived supersonic downflows form and what mechanisms are responsible for the substantial and stable mass supply remain unclear since their first discovery in the 1980s. With multi-messenger joint observations from IRIS and several other telescopes at multiple vantage points, a series of TR SDs in NOAA AR 12740 and their associated coronal dynamic processes were investigated. The formation of a quasi-steady SD event was tracked for the first time. Dual-perspective EUV imaging observations reveal that these downflows originate from the cooling and condensation of hot coronal plasma at magnetic dips along a large-scale closed magnetic loop system spanning the sunspot region and a remote region. In the magnetic dip region, condensed materials soon accumulate as a transient prominence in the dip region and thus form a mass reservoir available to feed a long-lasting rain flow. As the rain persistently drains into the sunspot along different trajectories in funnel-like magnetic structures (sunspot plumes), the funnel effect of this magnetic geometry further reshapes the clumpy rain at the coronal height into a more elongated and stream-like one when reaching the lower atmosphere, leading to the quasi-steady SDs. In the dip region, the total mass of condensation and condensation rate were found to be large enough to sustain this long-lived SSD event. As downflows fall into the sunspot, they eventually impart their energy into the lower atmosphere of sunspots and result in a long- lived localized brightening in the umbra. This indicates that SDs play an important role in the chromosphere-corona mass cycle of the sunspot atmosphere. Based on imaging observations and magnetic field extrapolations, a reconnection-facilitated coronal condensation scenario was proposed to interpret all these results.

IAUS 372

#3227

High Resolution Observations of a Plume's Footpoint in Solar Coronal Hole

Kyung-Suk Cho[1]

[1]*Space Science Division, KASI, Republic of Korea*

Plumes are hazy open structures in coronal holes extending from the solar surface to the corona and are considered a possible source of solar wind. Plumes are thought to be rooted in strong unipolar photospheric flux patches (network/plage region). The magnetic activities at the base of plumes play a crucial role in producing the outflows and propagating disturbances (PDs). However, the role of photospheric/chromospheric activities (e.g., jets/spicules) at the base of plume and its connection to PDs is poorly understood. Using high-resolution observations of a plume on July 23, 2020, from the 1.6 m Goode Solar Telescope (GST), Interface Region Imaging Spectrograph (IRIS), and SDO/AIA, we analyzed chromospheric/transition region activities at the base of the plume and its connection to outflows/PDs in the plume. GST Visual Imaging Spectrograph (VIS) images reveal repetitive spicules with blue-shifted emission (pseudo-Doppler maps) at the plume's footpoint. In addition, the photospheric magnetograms provide the evidence of mixed polarities at the base of the plume. IRIS Mg II h Dopplergrams show strong blue-shifted emission (~50 km/s) and a high brightness temperature region (Mg II k2 line) at the footpoint of the plume. The long period PDs (P~20-25 min) along the plume (AIA 171 Å) match the periodicity of spicules in the chromospheric images; suggesting a close connection between the spicules and PDs. We suggest that the interchange reconnection between close and open flux at the plume's footpoint is the most likely candidate to produce outflow and associated PDs along the plume.

IAUS 372

#1006

The emerging flux meets the magnetic canopy: chromospheric heating in current sheets and cooling rates

Joao M. Da Silva Santos[1], Sanja Danilovic[2], Jorrit Leenaarts[2], Jaime de la Cruz Rodriguez[2], Xiaoshuai Zhu[3], Stephen M. White[4], Gregal J. M. Vissers[2], Matthias Rempel[5]

[1]*n/A, National Solar Observatory, United States of America*
[2]*Department of Astronomy, Stockholm University, Sweden*
[3]*Key Laboratory of Solar Activity, National Astronomical Observatories, Chinese Academy of Sciences, China*
[4]*Space Vehicles Directorate, Air Force Research Laboratory, United States of America*
[5]*High Altitude Observatory, National Center for Atmospheric Research, United States of America*

The interaction between emerging magnetic fields and the preexisting magnetic canopy in active regions is a complex process but essential for understanding the onset of transient brightenings driven by magnetic reconnection and their role in energy/mass deposition in the chromosphere and above. We present the results of a comprehensive analysis of SST optical/infrared spectropolarimetry and ALMA millimeter brightness temperature maps of a solar active region using nonlocal thermodynamic equilibrium inversions, magnetohydrostastic field extrapolations, and a snapshot of a 3D radiative magnetohydrodynamics simulation. Inversions of the SST+ALMA data set provide constraints on the atmospheric stratification and show that enhanced chromospheric temperatures and cooling rates are associated with strong and inclined magnetic fields that connect patches of opposite magnetic polarity in the photosphere as corroborated by the field extrapolation. The simulation shows that energy dissipation in current sheets during flux emergence leads to a range of observational signatures in the millimeter continuum from compact, transient brightenings to warm fibril-like structures, which is consistent with the observations.

IAUS 372

#1005

Subarcsecond imaging of a solar active region filament with ALMA and IRIS

Joao M. Da Silva Santos[1], Stephen M. White[2], Kevin Reardon[3], Gianna Cauzzi[3], Stanislav Gunár[4], Petr Heinzel[4], Jorrit Leenaarts[5]

[1]*n/A, National Solar Observatory, United States of America*
[2]*n/a, Space Vehicles Directorate, Air Force Research Laboratory, United States of America*
[3]*n/a, National Solar Observatory, United States of America*
[4]*n/a, Astronomical Institute of the Czech Academy of Sciences, Czech Republic*
[5]*Department of Astronomy, Stockholm University, Sweden*

An understanding of the processes that lead to the formation of fine threads in filaments or prominences in the solar atmosphere is still elusive. ALMA observations in the millimeter continuum offer a powerful diagnostic of the thermal conditions in filament fine structures. Because of their smaller spatial scales, active region (AR) filaments, in particular, could not previously be resolved in that wavelength range. We present interferometry maps of an AR filament taken with ALMA Bands 6 and 3 with significantly improved spatial resolution (0.6 arcsec at 1.25 mm) compared to previous single-dish observations, and we compare them to ultraviolet imagery provided by IRIS and SDO/AIA and photospheric magnetograms obtained by Hinode/SOT. The 1.25 mm map reveals high-contrast, dark, fine threads co-spatial with the filament body seen in the IRIS Mg II core images and in the AIA 304 passband, but there are significant opacity variations across the filament body on time scales of a few minutes. Surprisingly, the 3 mm maps do not show the same dark/cool structures. In the absence of suitable models in the literature, our results underline the need for follow-up radiative transfer modeling of the radio continuum and the Mg resonance lines to constrain the thermodynamics of AR filaments.

IAUS 372

#1634

The Coronal Solar Magnetism Observatory (COSMO)

Sarah Gibson[1], Steven Tomczyk[1]

[1]*HAO, NCAR, United States of America*

Magnetism is the dominant force in the solar corona. It plays a key role in structuring the corona on all spatial scales, in heating the corona, and accelerating the solar wind. The storage and release of magnetic free energy in the corona powers solar eruptions that are responsible for space weather with serious consequences for our technological society. Daily synoptic measurements of the magnetic structure of the global solar corona are needed to advance our understanding of these critical physical processes and to enable a predictive capability of solar eruptive events.

The lack of synoptic measurements of global coronal magnetism is due to a technology gap in our current capabilities. One pathway to bridge this gap is to observe the Zeeman and saturated Hanle effects of forbidden emission lines in the visible and IR portions of the coronal spectrum with a ground-based coronagraph. The IR has the advantage that the Zeeman splitting scales as the wavelength squared. A dedicated, high-throughput coronagraph/polarimeter that combines a large aperture with a large field of view is needed to observe the weak circular polarization signals and monitor the evolution of coronal magnetism. The Coronal Solar Magnetism Observatory (COSMO) Large Coronagraph represents a proposed instrument able to meet this technological challenge, complementing the recently built Daniel K. Inouye Solar Telescope that has a large aperture and high spatial resolution, but is limited in FOV and is not a dedicated coronal facility. The COSMO-LC joins the COSMO K-Coronagraph (K-Cor), currently operating at Mauna Loa, which observes the low corona in broad band light, ideal for tracking CMEs and for providing information on coronal density, and the Chromospheric and prominence Magnetometer (ChroMag), which measures magnetic field and plasma conditions below the corona using polarized light from emission lines of the chromosphere and photosphere.

The crucial plasma and magnetic measurements obtained by COSMO, in combination with in-situ particle measurements, provide a new avenue for understanding the processes that govern the storage and explosive release of magnetic free energy in the corona and enable us to protect our critical infrastructures.

IAUS 372

#1641

Scattering Polarization Diagnostic of the UV Corona.

Sarah Gibson[1], Roberto Casini[1], Jeffrey Newmark[2], Silvano Fineschi[3], Holly GIlbert[1]

[1]*HAO, NCAR, United States of America*
[2]*GSFC, NASA, United States of America*
[3]*OATO, INAF, Italy*

The structuring of coronal plasma by the magnetic field is the key to understanding the fundamental physical processes of energy build up, storage, and release throughout the solar corona. Measurements of the coronal magnetic field vector in the global corona are thus crucial to understanding and modeling coronal dynamics and space weather. Ground-based efforts are largely limited to the observation of forbidden emission lines in the low corona. They also require large telescopes to reveal the small polarization signatures of the Zeeman effect produced by the weak coronal field.

A complementary, and largely unexplored diagnostic of the coronal magnetic field vector is offered by the linear polarization signature of the Hanle effect of far ultraviolet (FUV) resonance lines. In particular, H I Lyman-alpha offers an almost unique opportunity for a comprehensive view of the solar corona and its structuring by the magnetic field. This line's scattering polarization is sensitive to fields between a few gauss to about 100 gauss, allowing the direct measurement of closed fields above active regions and in coronal prominence cavities and arcades. At larger coronal heights and in coronal regions dominated by weaker open fields, the Lyman-alpha polarization is instead practically insensitive to the magnetic field, and it becomes a proxy for diagnosing solar wind outflows and plasma temperature anisotropies. The strong linear polarization signal produced by resonance scattering in the FUV coronal lines, and its sensitivity to the magnetic field strength and topology via the Hanle effect, make these diagnostics accessible to modest aperture (10-30 cm) telescopes, e.g., the Coronal Lyman-α Resonance Observatory (CLARO).

The crucial magnetic measurements obtained by CLARO, in combination with remote-sensing plasma diagnostics and in-situ particle measurements, provide a new avenue for understanding the processes that govern the storage and explosive release of magnetic free energy in the corona and enable us to protect our critical infrastructures.

IAUS 372

#586

Improvements of AI-generated solar farside magnetograms and their applications

Hyun-Jin Jeong[1], Yong-Jae Moon[1], Eunsu Park[2], Harim Lee[2]

[1]*School of Space Research, Kyung Hee University, Republic of Korea*
[2]*Department of Astronomy and Space Science, Kyung Hee University, Republic of Korea*

Here, we have greatly improved AI-generated solar farside magnetograms from STEREO Ahead (A) and Behind (B) EUV observations than before. We have modified our previous deep learning model and configuration of input datasets to generate more realistic magnetograms. First our model, which is called pix2pixCC, uses an updated loss function which includes correlation coefficients between the real and generated data. Second, we construct input datasets of our model: solar farside EUV observations together with frontside data pairs of EUV observations and magnetograms. We expect that the frontside data pairs give the model the historic information of magnetic field polarity distributions. Our results show that the present model is much better than our previous model (Jeong et al. 2020, ApJ Letter) in view of several metrics. In addition, the AI-generated farside magnetograms produce consistent polar field strengths and magnetic field polarities with those of nearby frontside SDO/HMI magnetograms for solar cycles 24 and 25. Our AI-generated Solar Farside Magnetograms (AISFMs) are now publicly available at Korean Data Center for SDO. We present several applications and results using AISFMs. We construct synchronic global magnetic field maps with SDO/HMI and AISF magnetograms, and extrapolate solar coronal magnetic fields from them. We show that our results are much more consistent with EUV observations than those of the conventional method in view of solar active regions and open field regions (coronal holes). The results show more consistently the sequences of coronal structure changes over several solar rotation. Finally we suggest several prospects to study global magnetic connectivity with multi-view point observations, e.g., STEREO, Parker Solar Probe, and Solar Orbiter.

IAUS 372

#3229

Synoptic acquisition of full-disk magnetic fields in the photosphere and the chromosphere by an infrared spectro-polarimeter on the Solar Flare Telescope

Yukio Katsukawa[1], Satoshi Morita[1], Yoichiro Hanaoka[1], Kazuya Shinoda[1], Tomoya Iju[1], Takashi Sakurai[1]

[1]*Solar Science Observatory, National Astronomical Observatory of Japan, Japan*

The National Astronomical Observatory of Japan (NAOJ) has been running a synoptic acquisition of full-disk magnetic fields in the solar photosphere and the chromosphere with the Solar Flare Telescope (SFT) since 2010. SFT has a 15 cm aperture refractive telescope equipped with an infrared spectro-polarimeter capable of simultaneous observations of Stokes profiles at the Fe I 1 1564.8 nm and Si I 1082.7 nm lines for photospheric vector fields as well as at the He I 1083.0 nm line for chromospheric and filament magnetic fields. The spectro-polarimeter uses two InGaAs detectors, one for the 1564.8 nm line and the other for the 1082.7 and 1083.0 nm lines, with 640 x 512 format as focal-plane cameras which are synchronously read-out triggered by a rotating waveplate with a rotation speed of 4.1 rps. The solar disk is covered by two swaths (the northern and southern hemispheres) of 640 pixels each. The final magnetic field maps are made of 1200 x 1200 pixels with a pixel size of 1".8. The observations have revealed statistical properties of magnetic fields in dark filaments and solar-cycle dependence of quiet Sun magnetic fields in the photosphere. We are working on improving the calibration of polarimetric data, including correction of detector non-linearity, removal of polarization cross-talks, improvement of waveplate wobbling, and removal of polarization fringes, etc. The knowledge gained through the calibration and processing of the data should be useful for future synoptic observations using an infrared spectro-polarimeter such as ngGONG.

IAUS 372

#3115

Plasmoids, flows, and Jets During Magnetic Reconnection in a Failed Solar Eruption

Pankaj Kumar[1], Judith T. Karpen[2], Spiro K. Antiochos[3], C. Richard DeVore[2], Peter F. Wyper[4], Kyung-Suk Cho[5]

[1]*Heliophysics Science Division, American University/NASA GSFC, United States of America*
[2]*Heliophysics Science Division, NASA GSFC, United States of America*
[3]*Physics, University of Maryland, United States of America*
[4]*Physics, Durham University, United Kingdom*
[5]*Space Science Division, Korea Astronomy and Space Science Institute, Republic of Korea*

We report a detailed analysis of a flare/failed eruption in Active Region 12018 on April 3, 2014, using observations from SDO/AIA, IRIS, STEREO and Hinode/SOT. Initially, we observed multiple jets originating from the cusp of a large coronal bright point (null-point topology) 1-2 hours prior to the slow rise of a filament. The subsequent filament eruption, which was outside the IRIS field of view, was accompanied by a flare but remained confined. Multiple blobs were observed, most likely formed in a breakout current sheet near the cusp during the filament slow rise. During the explosive flare reconnection phase, plasmoids also appeared and moved bidirectionally (speed=100-285 km/s, periodicity~70 s) in the flare current sheet below the erupting filament. The tiny jet-like features in the fan loops were detected during the filament slow-rise/pre-flare phase associated with slow interchange/breakout reconnection at 3D null followed by multiple plasmoids moving along the fan-loops/separatrix. We will discuss why our interpretation is more robust than the nanoflare heating/flows suggested by Antolin et al. (2021).

IAUS 372

#3360

Spectroscopic detection of Alfvénic waves in the chromospheric fibrils of a solar quiet region

Hannah Kwak[1], Jongchul Chae[1]

[1]*Department of Physics and Astronomy, Seoul National University, Republic of Korea*

We report observations of transverse magnetohydrodynamic (MHD) waves in fibrils of a quiet Sun region using spectroscopic data. Different from previous studies that measured transversal displacements of fibrils in imaging data, we investigated the line-of-sight (LOS) velocity oscillations of the fibrils in spectral data. The observations were carried out with the Fast Imaging Solar Spectrograph of the 1.6 meter Goode Solar Telescope of the Big Bear Solar Observatory. By using the spectral data of the Hα and Ca II 8542 Å lines, we measured the LOS velocities at two adjacent points along each fibril in a quiet region. In the case of the velocities showing high cross-correlation, we determined as Alfvénic wave packets. From our analysis, we identified numerous Alfvénic wave packets in the quiet Sun fibrils. The dominant periods of the waves are in 3, 5, 10 minute bands. In addition, we statistically investigated their wave properties such as propagation speed, velocity amplitude and propagation direction. We conclude that Alfvénic waves are pervasive in the quiet Sun fibrils.

IAUS 372

#573

Generation of solar UV and EUV data from Ca II K Images by Deep Learning

Harim Lee[1], Eunsu Park[1], Hyun-Jin Jeong[2], Gyungin Shin[3], Yong-Jae Moon[1]

[1]*Department of Astronomy & Space Science College of Applied Science, Kyung Hee University, Republic of Korea*
[2]*School of Space Research, Kyung Hee University, Republic of Korea*
[3]*Department of Engineering Science, University of Oxford, Republic of Korea*

We generate solar UV and EUV data from Ca II K data using a deep learning model. For this, we consider a deep learning method (pix2pixHD) based on conditional Generative Adversarial Networks (cGAN). We use Ca II K 393.3 nm images from the Precision Solar Photometric Telescope at the Rome Observatory and Solar Dynamics Observatory (SDO)/Atmospheric Imaging Assembly (AIA) nine-passband (9.4, 13.1, 17.1, 19.3, 21.1, 30.4, 33.5, 160.0, and 170.0 nm) UV/EUV data. We use data from 2011 January to 2015 June except for June and December for training and the remaining one for test. Our model successfully generates SDO/AIA-like solar UV/EUV images from Ca II K images. The mean correlation coefficient (CC) of intensities between AI-generated and real ones with 4 x 4 binning ranges from 0.79 to 0.95 except 17.1 nm one (0.68). We estimate differential emission measures (DEMs) of several structures (coronal loops in an active region, quiet region, and coronal hole) using two data sets: six-channel SDO/AIA images and the AI-generated EUV images from Ca II ones. The estimated DEMs from both methods are similar to each other, demonstrating that the AI-generated data from Ca II ones are feasible for scientific study.

IAUS 372

#992

Fast Multi-Layer Spectral Inversion of the Hα And Ca II 8542 Line Spectra Using a Deep Neural Network

Kyoung Sun Lee[1], Jongchul Chae[1], Eunsu Park[2], Yong-Jae Moon[2], Hannah Kwak[1], Kyuhyoun Cho[1]

[1]*Astronomy program, Department of Physics and Astronomy, Seoul National University, Republic of Korea*
[2]*School of Space Research, Kyung Hee University, Republic of Korea*

Recently a multilayer spectral inversion (MLSI) model has been proposed to infer the physical parameters of plasmas in the solar chromosphere from strong absorption line profiles taken by the Fast Imaging Solar Spectrograph (FISS). We apply a deep neural network (DNN) technique to the MLSI to reduce computational costs. We train the model using pairs of absorption line profiles from FISS and their 13 physical parameters calculated from the MLSI for 49 scan rasters (~ 2,000,000 datasets). We use a fully connected network with skip connections and multi-branch architecture to avoid the problem of vanishing gradients and improve the model's performance. Our test shows that the DNN model successfully reproduces the physical parameter maps of a scan raster observation with high accuracy and a computing time of about 2 seconds, which is about 4300 times faster than the MLSI. We also confirm that the DNN model reliably provides the variation of physical parameters with time. Taking advantage of the high performance of the DNN model, we plan to provide the physical parameter maps from all the FISS observations to understand the chromospheric plasma conditions in various solar features.

IAUS 372

#1965

Dynamical and Thermal Properties of RBEs and RREs derived from Fast Imaging Solar Spectrograph

Eun-Kyung Lim[1]

[1]*Space Science Division, KASI, Republic of Korea*

A rapid blueshifted excursion (RBE) or rapid redshifted excursion (RRE) is appeared as a ‘sudden widening of the line profile’ on the blue or red side of the line, following the definition given by Langangen. RBEs are often regarded as on-disk counterparts of Type II spicules based on their rapid upward Doppler speed (~40km/s) without following downward motion. On the other hand, there are some reports on the transition from RBEs to RREs indicating material falling back after ejections. We observe tiny spicular features that show a spectral shift from RBE to RRE in an enhanced network field of a quiet Sun region, using the fast imaging solar spectrograph built at the Goode Solar Telescope of Big Bear Solar Observatory. Two strong chromospheric lines, Hα and CaII 854.2 nm, are used for spectroscopy. Multi-layer spectral inversion technique is applied to both lines to obtain spectral parameters, including line-of-sight velocities and temperatures in time. Two events of our interests reveal spectral transitions from RBEs to RREs, with corresponding IRIS counterparts that clearly show the parabolic up and down motion. We also detected intensity enhancements in AIA 193 and 304 channels at the early phase of RBEs, indicating possible heating at the time of ejections. The temperature of the spicular structure shows a monotonic decrease during the RBE phase suggesting continuous cooling after the energy deposit. We could not find any heating signatures after the RBE phase that is normally expected from type II spicules, and both RBE events we analyze show typical properties of small-scale jets.

IAUS 372

#3206

Power spectra of the sun's large-scale magnetic field during solar cycles 23 and 24

Yukun Luo[1], Jie Jiang[1], Ruihui Wang[1]

[1]*School of Space and Environment, Beihang University, China*

The magnetic power spectrum analysis provides an effective way to understand the observed distribution of the photospheric magnetic fields and their interaction with plasma motions. Past attempts concentrate on Fourier decomposition of local magnetograms. Here we aim to investigate the power spectra using spherical harmonic decomposition of SOHO/MDI and SDO/HMI synoptic magnetograms for cycles 23 and 24. The power spectra derived from the HMI and MDI radial magnetograms during the period of overlap show the same distribution for l<200 (22 Mm), but the spectral densities from HMI magnetograms is 50% lower than that of MDI magnetograms, which is used for the calibration of MDI data so that it can be consistent with HMI data. We separate each cycle into two parts according to the activity amplitude stronger or weaker than the half cycle amplitudes. The average power spectra for the four parts, i.e., strong/weak phases of cycles 23 and 24, are studied. Two peaks are clearly presented on the four power spectra. They are l=30 and l=120, corresponding to the typical sizes of active regions (146 Mm) and supergranulations (36 Mm), respectively. The slope between the two characteristic scales is about -0.7 during the strong phase of cycle 23. The weaker the solar activity is, the flatter the slope of the power spectrum and the weaker spectral densities are. For l<30 the average power spectra of the four parts show a similar power index, which is 1.2.

IAUS 372

#903

Understanding Weak Impulsive Narrowband Quiet Sun Emissions (WINQSEs)

Divya Oberoi[1], Surajit Mondal[2], Shabbir Bawaji[3], Ujjaini Alam[3], Rohit Sharma[4], Ayan Biswas[1]

[1]*National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, India*
[2]*Expanded Owens Valley Solar Array, New Jersey Institute of Technology, United States of America*
[3]*e4r, Thoughtworks, India*
[4]*University of Applied Sciences and Arts Northwestern Switzerland, Fachhochschule Nordwestschweiz, Switzerland*

The confluence of the data from the Murchison Widefield Array (MWA) and an imaging pipeline tailored for spectroscopic snapshot images of the Sun at low radio frequencies have led to enormous improvements in the imaging quality of the Sun. Among other science advances, these developments have lowered the detection threshold for weak nonthermal emissions by up to two orders of magnitude as compared to earlier studies, and have enabled our discovery of Weak Impulsive Narrowband Quiet Sun Emissions (WINQSEs). Their typical flux densities lie in the range of a few mSFU (1 SFU = 10,000 Jy) and they are found to occur in large numbers all over the quiet Sun regions. In the solar radio images, they appear as compact sources and our estimate of their median duration is limited by the instrumental resolution of 0.5 s. Their spatial distribution and various other properties are consistent with being the radio signatures of coronal nanoflares hypothesized by Parker (1988) to explain coronal heating in the quiet Sun emissions. As steps towards exploring this tantalising possibility of making progress on the coronal heating problem, we have been pursuing multiple projects to improve our ability to detect and characterise WINQSEs. These include attempts to look for WINQSEs in multiple independent datasets; using different independent detection techniques; attempting to characterise their morphologies in radio maps using Machine Learning based approaches; looking for their counter parts in EUV wavelengths; estimating the energy associated with groups of WINQSEs; and investigation of the spectro-temporal structure of WINQSEs. Here we present the current status of these projects.

IAUS 372

#1780

How density profiles of global coronal waves influence their interaction with coronal holes

Isabell Piantschitsch[1], Jaume Terradas[2], Elie Soubrié[3]

[1]*Department of Physics, University of the Balearic Islands (UIB), Spain, Spain*
[2]*Department of Physics, University of the Balearic Islands (UIB), Spain*
[3]*Institut d'Astrophysique Spatiale, CNRS, Univ. Paris-Sud, Université Paris-Saclay, France*

Interactions between global coronal waves (CWs) and coronal holes (CHs) reveal many interesting features about reflected waves and coronal hole boundaries but have fairly been studied so far. Among the reasons for the lack of observational studies are for example the weak signal of the reflected waves and the only limited time cadence which prevents us from analysing the CWs in detail. However, magnetohydrodynamic (MHD) simulations can help us to better understand what is going on during these interaction events, and therefore, to achieve a broader understanding of the parameters involved in these interactions. It is particularly crucial to interpret and understand the observational time-distance plots which give us important information about the dynamical behaviour of the incoming and the reflected waves. By using numerical simulations, we are capable of partially reconstructing the interaction event, and hence, to find out which CW parameters cause certain interaction features. One important result about the reconstruction and the direct comparison to the observations is the fact that, in order to explain the main features of the interaction event, it seems to be necessary to define the incoming wave in the simulations as a composite of a density enhancement and a subsequent depletion instead of considering the wave as a purely enhanced pulse, as it has been done in many studies so far. This result does not only have implications for the interaction with CHs but also for the interaction with any other obstacle in the corona, such as for example prominences. Therefore, we believe that it is crucial to consider the density profiles of global CWs in future MHD simulations of coronal dynamics.

IAUS 372

#2253

Fast generation of 3D solar coronal parameters based on MAS by a deep learning method

Sumiaya Rahman[1], Yong-Jae Moon[1]

[1]*School of Space Research, Kyung Hee University, Republic of Korea*

Modeling of the three-dimensional structure of the solar corona requires an accurate empirical description of the coronal plasma parameters like density, magnetic field, and temperature. Magnetohydrodynamic (MHD) models provide a quantitative 3D distribution of the magnetic field and the plasma parameters in the solar corona. This study is the first attempt to generate 3D coronal parameter distributions using a well-known deep learning model. We consider synoptic photospheric magnetic fields as an input to obtain 3D solar coronal parameters. 4272 pairs of inputs and outputs are considered for training, validation, and testing from 2010 June to 2020 May, which is simulated with the MHD Algorithm outside a Sphere (MAS) model. We train 54 separate deep learning models to cover from 2 to 30 solar radii for solar coronal parameters. The generated 3D solar parameters are consistent with those of the simulated ones at not only lower solar radii but also higher radii with high mean correlation coefficients (0.98). The most impressive result is that the computing time of the 54 models for each solar coronal parameter is about 35 secs under NVIDIA TITAN XP GPU, which is much less than a typical simulation time of MAS. Our study shows that the synthetic coronagraphic images estimated from the deep learning models are similar to the SOHO/LASCO C3 images, especially during solar minimum period. We have a plan to use synchronic magnetic field data from SDO/HMI and AI-generated farside magnetograms as input data. The generated coronal density distribution can be used for space weather models on a near real-time basis.

IAUS 372

#1218

Self-consistent nanoflare heating in model active regions: MHD avalanches in curved coronal arcades

Jack Reid[1], James Threlfall[2], Alan W. Hood[1]

[1]*School of Mathematics & Statistics, University of St Andrews, United Kingdom*
[2]*Division of Computing and Mathematics, Abertay University, United Kingdom*

MHD avalanches involve small, narrowly localized instabilities spreading across neighbouring areas in a magnetic field. Cumulatively, many small events release vast amounts of stored energy.

Straight cylindrical flux tubes are easily modelled, between two parallel planes, and can support such an avalanche: one unstable flux tube causes instability to proliferate, via magnetic reconnection, and then an ongoing chain of like events.True coronal loops, however, are visibly curved, between footpoints on the same solar surface.

With 3D MHD simulations, we verify the viability of MHD avalanches in the more physically realistic, curved geometry of a coronal arcade. MHD avalanches thus amplify instability across strong solar magnetic fields and disturb wide regions of plasma.

Contrasting with the behaviour of straight cylindrical models, a modified ideal MHD kink mode occurs, more readily and preferentially upwards in the new, curved geometry. Instability spreads over a region far wider than the original flux tubes and than their footpoints.

Consequently, sustained heating is produced in a series of `nanoflares', collectively contributing substantially to coronal heating. Overwhelmingly, viscous heating dominates, generated in shocks and jets produced by individual small events.

Reconnection is not the greatest contributor to heating, but is rather the facilitator of those processes that are. Localized and impulsive, heating shows no strong spatial preference, except a modest bias away from footpoints, towards the loop's apex.

Remarkable evidence emerges of `campfire'-like events, with simultaneous, reconnection-induced nanoflares at separate sites along coronal strands, akin to recent results from Solar Orbiter.

Effects of physically realistic plasma parameters, and the implications for thermodynamic models, with energetic transport, are discussed.

IAUS 372

#2560

Generation of He I 1083nm Images from SDO AIA Images using a Deep Learning Model

Jihyeon Son[1], Yong-Jae Moon[1], Harim Lee[2], Eunsu Park[2], Gyungin Shin[3], Hyun-Jin Jeong[1]

[1]*School of Space Research, KyungHee Univ., Republic of Korea*
[2]*Department of Astronomy and Space Science, KyungHee Univ., Republic of Korea*
[3]*Department of Engineering Science, University of Oxford, Republic of Korea*

In this study, we generate He I 1083 nm images from Solar Dynamic Observatory (SDO)/Atmospheric Imaging Assembly (AIA) images using a novel deep learning method (pix2pixHD) based on conditional Generative Adversarial Networks (cGAN). He I 1083 nm images from National Solar Observatory (NSO)/Synoptic Optical Long-term Investigations of the Sun (SOLIS) are used as target data. We make three models: single-input SDO/

AIA 19.3 nm image for Model I, single-input 30.4 nm image for Model II, and double-input (19.3 and 30.4 nm) images for Model III. We use data from 2010 October to 2015 July except for June and December for training and the remaining one for test. Major results of our study are as follows. First, the models successfully generate He I 1083 nm images with high correlations. Second, Model III shows better results than those with one input image in terms of metrics such as correlation coefficient (CC) and root mean square error (RMSE). CC and RMSE between real and synthetic ones for model III with 4 by 4 binnings are 0.88 and 9.49, respectively. Third, synthetic images show well observational features such as active regions, filaments, and coronal holes. This work is meaningful in that our model can produce He I 1083 nm images with higher cadence without data gaps, which would be useful for studying the time evolution of the chromosphere and transition region.

IAUS 372

#719

Quiet Sun heating using machine learning

Durgesh Tripathi[1], Vishal Upendran[1]

[1]*IUCAA, IUCAA, India*

The solar corona consists of a million-degree Kelvin plasma. The ever-existing Quiet Sun, which forms a background over which large, dynamic events occur, is also at a million-degree Kelvin. The energetics and heating of this background must hence be studied well to get to the roots of the coronal heating problem. In this work, we analyze > 300,000 light curves from individual pixels using machine learning-driven by the empirical forward model of Pauluhn and Solanki (2007). The impulsive heating forward model has the flaring frequency, flaring timescale, and power-law slope α as free parameters. Our Convolutional neural network-based inversion scheme can infer these free parameters and their associated uncertainties. We apply this inversion scheme on light curves from each pixel in the 171, 193, and 211 Å first and find impulsive events to be a viable source of generating intensity. These events have a typical time scale of 10-20 minutes and occur at 2-3 events per minute. Furthermore, we find the correlations between free parameters may be explained by the domination of conduction losses and the existence of an energy reservoir. We then apply this scheme on full disc integrated and flux-calibrated light curves from X-ray Solar Monitor onboard Chandrayaan-2. Such an inversion gives us a lower bound of the energy flux in QS resulting from luminosity. We find the X-ray results to consistently follow the trends on moving from cooler to hotter plasma emission, though the smallest of events are noted to be of the order of 1e20 ergs. These findings give us a deeper understanding of the viability of impulsive events in heating the solar corona and the advantages offered by data-driven ML algorithms in accelerating science. Finally, these findings stress the importance of future high spatial resolution and time cadence observations to infer the presence of sub-resolution heating events in the corona

IAUS 372

#1252

Photospheric magnetic field variations during solar flares

Santiago Vargas Domínguez[1], Willinton Caicedo[1], Juan Camilo Buitrago[2]

[1]*Observatorio Astronomico Nacional, Universidad Nacional de Colombia, Colombia*
[2]*Space Sciences Laboratory, University of California - Berkeley, Colombia*

Solar flares are an explosive manifestation of the complex magnetic structuring of active regions in the solar atmosphere. The photospheric magnetic field is found to change rapidly, abruptly, and significantly during flaring events. Previous studies are mainly based on line-of-sight or low cadence data. In this work, we focus on the temporal and spatial evolution of the permanent changes in the magnetic field of solar flares from high-cadence vector data (135 seconds) of the imaging system (dopplergrams and magnetograms) of the SDO/HMI instrument. The highly energetic events under analysis occurred during the solar cycle 24, covering low and high energy ranges, according to GOES classification. This work stands also as a crucial input for the characterization and understanding of sunquakes.

IAUS 372

#3292

Multi-messenger investigations of a sunspot as a source of slow solar wind.

Arturs Vrublevskis[1], Boris Ryabov[1]

[1]*Ventspils International Radio Astronomy Centre (VIRAC), Ventspils University of Applied Sciences, Latvia*

We present complementary research of the AR 8535 sunspot magnetic field structure and atmosphere. We establish the existence of open field line structures in agreement with EUV observations, identify corresponding solar wind features in near-Earth measurements from the Advanced Composition Explorer (ACE) spacecraft, and construct a sunspot atmosphere model that includes an open field line component and qualitatively reproduces the observed reduced microwave brightness temperature in the northern part of the sunspot in Very Large Array (VLA) observations from 13 May 1999. These investigations motivate further research of similar ARs as sources of slow solar wind using the current state-of-the-art probes Solar Orbiter and Parker Solar Probe and the proposed Frequency Agile Solar Radiotelescope (FASR).

IAUS 372

#3205

Automatic detection of solar active regions from SOHO/MDI and SDO/HMI synoptic magnetograms

Ruihui Wang[1], Jie Jiang[1], Yukun Luo[1]

[1]*School of Space and Environment, Beihang University, China*

Solar active regions (ARs) play an essential role in solar physics. They not only provide insight into the solar dynamo but also lead to long and short-term solar variability.

In this work, we aim to develop a new method to automatically detect ARs from SOHO/MDI and SDO/HMI synoptic magnetograms and to provide a new database of ARs between 1996 and 2020. The detection method has five modules: (1) adaptive threshold segmentation to remove the background magnetic fields with different thresholds in different pixels; (2) morphological closing operation and opening operation to remove small magnetic segments and get the kernel pixels of ARs, (3) region growing to get single whole ARs, (4) closing operation and removing small decayed ARs segments further; and (5) merging neighbor regions and removing unipolar regions.

Since MDI and HMI synoptic magnetograms have different resolutions, we use the magnetograms during the overlap period to calibrate the parameters used in HMI magnetograms to obtain the same ARs detections as in MDI magnetograms. Thus we obtain the homogenous ARs dataset including location, area, and flux for cycles 23 and 24. The dataset is evaluated by comparing it with other datasets, i.e., sunspot number, NOAA AR number and area, SMARPs and SHARPs number, area and flux, and BARD number, area and flux. Moreover, we find that although cycle 24 is about twice weaker than cycle 23 based on the sunspot number, the numbers and total flux of median and weak ARs in the two cycles are almost the same.

IAUS 372

#3065

The Effect of the Chromospheric Temperature on Coronal Heating

Haruka Washinoue[1], Munehito Shoda[2], Takeru Suzuki[1]

[1]*School of Arts and Sciences, University of Tokyo, Japan*
[2]*Earth and Planetary Science, University of Tokyo, Japan*

Recent observational and numerical studies show a variety of thermal structures in the solar chromosphere. Given that the thermal interplay across the transition region is a key to coronal heating, it is worth investigating how different thermal structures of the chromosphere yield different coronal properties. In this work, through the MHD simulation of coronal loops, we study how the coronal properties are affected by the chromospheric temperature. When the temperature in the underlying chromosphere is higher, because the chromosphere extends to a larger height, the coronal part of the magnetic loop becomes shorter, which enhances the conductive cooling. A larger loop length is then required to maintain the hot corona against the thermal conduction. From our numerical simulations, we derive a condition for the coronal formation with respect to the half loop length l_loop in a simple form: $l\_loop > \alpha T\_min + l\_th$, where T_min is the minimum temperature in the atmosphere and parameters α and l_th have negative dependencies on the coronal field strength. Our conclusion is that the chromospheric temperature has a non-negligible impact on coronal heating for loops with small length and weak coronal field. In particular, the enhanced chromospheric heating could prevent the formation of the corona.

IAUS 372

#1590

Coronal Magnetic Field Reconstruction Using the Poloidal-Toroidal Representation

Sibaek Yi[1], G. S. Choe[1], Minseon Lee[2]

[1]*School of Space Research, Kyung Hee University, Republic of Korea*
[2]*Department of Astronomy and Space Science, Kyung Hee University, Republic of Korea*

For coronal magnetic field reconstruction, quite a few numerical methods have been proposed and are being applied to practical problems. However, their outcomes are often disparately different for complex real coronal fields. One of the most difficult configurations for them to reconstruct is tightly wound flux ropes. Many extant codes produce blandly sheared fields or double crossed flux tubes in place of a single flux rope. Such problems are attributed to a loose connection between the boundary condition and the resulting field within the domain. To resolve these problems, we have devised a numerical method, in which the implementation of the boundary condition is straightforward and its influence is readily permeated into the domain. Our numerical method uses a poloidal-toroidal representation of magnetic field, which guarantees the divergence-freeness of magnetic field and allows to fix the boundary condition once and for all. The iteration scheme is non-variational and seeks a stationary solution in a direct manner. We will present and compare the solutions of our code and other extant codes for Titov-Démoulin flux ropes and some active region magnetic fields.

IAUS 372

#3208

A new mechanism for the butterfly diagram of the solar cycle

Zebin Zhang[1], Jie Jiang[2], Haowei Zhang[2]

[1]School of Space and environment, Beihang university, Beijing, China, China
[2]School of Space and environment, Beihang university, Beijing, China

The butterfly diagram of the solar cycle shows the equatorward migration of the emergence latitudes of sunspots as the solar cycle evolves. The equatorward meridional flow at the bottom of the convection zone is believed to be responsible for this migration.
However, helioseismological studies indicate controversial forms of the meridional flow, which even presents poleward flow at the bottom. This motivates us to explore a new mechanism for the butterfly diagram. This study aims to demonstrate that the latitude-dependent radial flux transport could cause the butterfly diagram. Using a data-driven Babcock-Leighton-type dynamo model, we carry out simulations to explore how the latitude-dependent radial flux transport, e.g., the latitude-dependent pumping, affects the migration of the toroidal field, under different meridional flows profiles. The results indicate that when the radial transport speed at higher latitudes is larger, the magnetic fields at higher latitudes are transported downward earlier than that at lower latitudes whatever the meridional flow profiles are. Therefore, the bottom toroidal fields at higher latitudes are regenerated earlier than that at lower latitudes. Hence the butterfly-like pattern, which corresponds to the time-latitude evolution of the toroidal field, can be generated.

IAU S372 E-TALKS ABSTRACTS

(in alphabetical order)

(e-talks can be viewed on the Gallery at the main IAU GA webpage: http://www.iauga2022.org)

IAUS 372

#2255

Plasma flows in the active-region as seen by IRIS

Suresh Babu Balaji[1], Pradeep Kumar Kayshap[1], Sharad Chandra Tripathi[1]

[1]Physics, VIT Bhopal University, India

We have utilized the spectroscopic observations (e.g., Mg II k 2796.35 Å, Mg II h 2803.52 Å, C II 1334.53 Å, Si IV 1402.77 Å, and O IV 1401.52 Å) from the Interface-region Imaging Spectrograph (IRIS) to diagnose the plasma flows of an active-region (AR). We have investigated the Doppler velocity profile, i.e., Doppler velocities versus the formation temperature of selected spectral lines. We have chosen many locations within the AR, and performed the statistical diagnostics of Doppler velocity profiles. It is found that transitions-region lines (i.e., Si IV 1402.77 Å, and O IV 1401.5 Å) have maximum Doppler velocity while the chromospheric lines (i.e., Mg II k 2796.35 Å and Mg II h 2803.52 Å) have the least Doppler velocity. However, the CII 1334.53 Å line shows the intermediate values of Doppler velocity. Hence, we can conclude that redshift decreases as we go from the transition-region to the chromosphere, and it is consistent with the Parker's Nanoflare theory.

IAUS 372

#2072

Investigating small scale brightening events and the impact of angular resolution of solar ALMA observations

Henrik Eklund[1]

[1]*Department of Astronomy, Stockholm University, Norway*

An algorithm was developed to automatically detect brightening events in solar ALMA data and determine their lifetimes, sizes and velocities. The intensities of the millimeter wavelength radiation is closely linked to the local plasma temperature, which enables to study the potential heating of the chromosphere in connection to the events. However, the brightening events are of comparable scales as the angular resolution of solar ALMA observations and their magnitudes are significantly degraded.

The instrumental limitations were estimated by performing simulated solar ALMA observations which then were applied on millimeter wavelength observables calculated from 3D radiation-MHD Bifrost models in order to acquire the magnitude of the degradation and correction factors that could be applied to observational data. The correction factors provides more accurate values of the magnitudes of the brightening events which is imperative when deriving the transport of energy and the potential contribution to the heating of the chromosphere by propagating shock waves.

In addition, the height of formation of the millimeter wavelength radiation is strongly connected to the small scale dynamics and varies from low chromosphere to the transition region. The radiation formation height was studied in connection to specific brightening events and estimations on the formation heights across the field of view of observational data were acquired by statistical correlation to the small scale dynamics.

These estimations and improved methodologies of analysis help to perform meaningful interpretation of solar ALMA data, that can provide estimations on the potential heating by shock waves at different layers in the solar atmosphere.

IAUS 372

#2850

Signature of tilt quenching from observation of tilted bipolar magnetic regions on the Sun

Bibhuti Kumar Jha[1], Bidya Binay Karak[2], Sudip Mandal[3], Dipankar Banerjee[1]

[1]*Solar Astrophysics, ARIES Nainital, India*
[2]*Solar Physics, IIT-BHU, India*
[3]*Solar Physics, Max Planck Institute for Solar System Research, India*

The tilt of the bipolar magnetic region (BMR) is crucial in the Babcock–Leighton process for the generation of the poloidal magnetic field in the Sun. Based on the thin flux-tube model of the BMR formation, the tilt is believed to be caused by the Coriolis force acting on the rising flux tube of the strong toroidal magnetic field from the base of the convection zone. We analyze the magnetic field dependence of BMR tilts using the magnetograms of the Michelson Doppler Imager (1996–2011) and Helioseismic and Magnetic Imager (2010–2018). We observe that the distribution of the maximum magnetic field ($B_{\max}$) of BMRs is bimodal. Its first peak at the low field corresponds to BMRs that do not have sunspots as counterparts in the white-light images, whereas the second peak corresponds to sunspots as recorded in both types of images. We find that the slope of Joy's law (γ_0) initially increases slowly with the increase of $B_{\max}$. However, when $B_{\max} \gtrsim 2$ kG, γ_0 decreases. The Scatter of the BMR tilt around Joy's law systematically decreases with the increase of $B_{\max}$. The decrease of observed γ_0 with $B_{\max}$ provides a hint to a nonlinear tilt quenching in the Babcock–Leighton process. We finally discuss how our results may be used to make a connection with the thin flux-tube model.

IAUS 372

#632

Study of Ionospheric behaviour during the intense geomagnetic storms in 24th solar cycle over different Latitudes and Longitudes

Bhupendra Malvi[1], Sharad C Tripathi[2], Pramod Purohit[3]

[1]*Electronics, Barkatullah University, Bhopal, Madhya Pradesh, India, India*
[2]*Physics, School of Advanced Sciences and Languages, VIT Bhopal University, Sehore - 466114, Madhya Pradesh, India*
[3]*Applied Sciences, National Institute of Technical Teachers' Training and Research, Bhopal - 462 002 M.P., India*

One of the most important scientific goals in solar physics is to understand how the interplay between the Sun, the space weather that creates storms, and the impacts on the Earth are all related to each other. The ionospheric perturbations during intense geomagnetic storms caused the disturbance in the earth's magnetic field. A geomagnetic storm leads to a number of disruptions in technological applications such as space vehicle operation, interrupted radio communication, and disrupted power grids. The devastating effects of such events could easily cause trillions of dollars in damage. The responses of these selected storms to the ionosphere have been investigated around the globe. In this paper, we have studied the behaviour of the Ionospheric Total Electron Content (TEC) in both hemispheres (Northern and Southern) in the 0^0–360^0 longitude ranges during the 24^{th} solar cycle over different geographic latitudinal and longitudinal stations using data recorded from geomagnetic observatories for extreme storm investigations. The analysis has been done in this paper provides a detailed summary of the nature and extent of the latitudinal ionospheric irregularities.

IAUS 372

#1402

Eruption of the EUV Hot Channel from the Solar Limb and Associated Moving Type IV Radio Burst

Vemareddy Panditi[1], Pascal Demoulin[2], Sasikumar Raja[1], Jie Zhang[3], Nat Gopalswamy[4], Vasantharaju N.[5]

[1]*Sun and Solar System, Indian Institute of Astrophysics, India*
[2]*Sun and Solar System, Observatory of Paris, France*
[3]*Department of Physics, George Mason University, United States of America*
[4]*Heliophysics Division, Goddard Space Flight Center, United States of America*
[5]*Department of Physics and Astronomy, University of Catania, Italy*

Using the observations from the Solar Dynamics Observatory, we study an eruption of a hot-channel flux rope (FR) near the solar limb on 2015 February 9. The pre-eruptive structure is visible mainly in EUV 131 Å images, with two highly sheared loop structures. They undergo a slow rising motion and then reconnect to form an eruptive hot channel, as in the tether-cutting reconnection model. The J-shaped flare ribbons trace the footpoint of the FR that is identified as the hot channel. Initially, the hot channel is observed to rise slowly at 40 km s^{-1}, followed by an exponential rise from 22:55 UT at a coronal height of 87+/-2 Mm. Following the onset of the eruption at 23:00 UT, the flare reconnection then adds to the acceleration process of the coronal mass ejection (CME) within 3 $R_{\odot}$. Later on, the CME continues to accelerate at 8 m s^{-2} during its propagation period. Further, the eruption also launched type II radio bursts, which were followed by type III and type IVm radio bursts. The start and end times of the type IVm burst correspond to the CME's core height of 1.5 and 6.1 $R_{\odot}$, respectively. Also, the spectral index is negative, suggesting that nonthermal electrons are trapped in the closed loop structure. Accompanied by this type IVm burst, this event is unique in the sense that the flare ribbons are very clearly observed together with the erupting hot channel, which strongly suggests that the hooked parts of the J-shaped flare ribbons outline the boundary of the erupting FR.

IAUS 372

#2872

Effect of Coronal rain on oscillation properties of Coronal loops

Arpit Shrivastav[1], Vaibhav Pant[1], Dipankar Banerjee[1]

[1]*Astronomy, Aryabhatta Research Institute of Observational Sciences, India*

Active region Coronal loops are frequently subjected to footpoint heating which initiates thermal instability in the corona leading to plasma condensation in the time scale of minutes, hence forming the coronal rain. Transverse oscillations of coronal loops triggered by coronal rain are observed, but the change in their oscillation properties due to coronal rain is not yet confirmed. We present the analysis of an event of coronal rain simultaneously observed by Interface Region Imaging Spectrograph (IRIS) and Atmospheric Imaging Assembly (AIA). The oscillation properties of the coronal loop are investigated before and after the formation of coronal rain. We found an increase in the period and amplitude of oscillations during coronal rain for a few instances. The amplitude of oscillation captured by AIA 171 channel, before and after coronal rain, is in the range of 50 to 200 Km, and in Optically thick channels, during coronal rain, is in the range of 100 to 400 Km, whereas the period of oscillation, before and after coronal rain, is in the range of 1 to 3 min and during coronal rain, it is in the range of 1 to 5 min. The increase in the period can be due to density enhancement at the loop top as in the long-wavelength limit; the period will be directly proportional to loop density. The observed emission of loop apex in individual SDO/AIA and IRIS/SJI bandpasses showed the cooling of loop top material and can be linked with the appearance of oscillations in distance-time maps.

IAUS 372

#2935

Investigation of coronal mass ejection at different heliospheric distances using Solar Orbiter, BepiColombo, and Wind data

Shirsh Lata Soni[1], Selva Kumaran[1], Satheesh Thampi[1]

[1]*Planetary Science Branch, Space Physics Laboratory, Vikram Sarabhai Space Center, India*

This paper addresses the investigation of the ICMEs encountered by Solar Orbiter, BepiColombo and Wind spacecrafts on April 19-20, 2020, from both an observational and a modeling perspective. A coronal mass ejection (CME) was observed in situ by Solar Orbiter on April 19, 2020, at a heliocentric distance of nearly 0.8 AU. The CME was later detected in situ by the Wind and BepiColombo spacecrafts on April 20, while BepiColombo was quite near to Earth. Because the spacecraft were separated by less than 5° in longitude, this CME gives an excellent opportunity for a triple radial alignment investigation. The CME, which was initiated on April 15, was caused by an almost completely isolated streamer explosion. The event was remotely detected by the Solar Terrestrial Relations Observatory (STEREO)-A satellite from 75 degree longitudenal angle, which is an extremely well-suited perspective for heliospheric observing filed of view of an Earth-directed CME. The four spacecraft's configuration provided an extraordinarily significant relationship between global imaging and in-situ investigations of the CME. To estimate the global structure of the CME and its evolution as it travelled through the inner heliosphere, we employed in situ measurements from Solar Orbiter, Wind, and BepiColombo, as well as distant observations from STEREO-A. When examination of magnetic field strength relationships indicates that the CME expansion is unlikely to be self-similar or cylindrically symmetric. Additionally, we compare in situ magnetic field measurements from distinct spacecraft, we observe that the influence of the highest magnetic field strength on heliocentric distance reduces.

IAUS 372

#2385

An automatic algorithm to track bipolar magnetic regions in magnetograms to study the evolution of their properties

Anu B Sreedevi[1], Bibhuti Kumar Jha[2], Bidya Binay Karak[1], Dipankar Banerjee[2]

[1]Department of Physics, Indian Institute of Technology (BHU), India
[2]Solar Astrophysics, ARIES, Nainital, India

The bipolar magnetic regions (BMRs) acts as proxies of intense solar photospheric magnetic field. Properties of BMR, particularly, the tilt angle play a critical role in generating the observed polar magnetic field and its reversal. Hence, a long-term study of BMR over its lifetime is crucial not only to understand the solar dynamo but also to identify the origin of the properties of BMR. In our work, we have developed an automatic algorithm to detect and track the BMRs from the line-of-sight magnetograms of MDI (1996-2012) and HMI (2012-2021) over their lifetime/disk passage. Our algorithm provides information about various properties of BMRs, such as tilt, lifetime, area, position and magnetic properties. Unlike the already existing data products of tracked active region information, our algorithm provides a homogeneous dataset with all the information of tracked BMRs from 1996. Also, our algorithm can be implemented on any available magnetograms. Here, we present the details of our algorithm and the features of BMR, particularly the tilt angle, magnetic field strength and lifetime.

IAUS 372

#2952

Sun-as-a-star spectroscopic observations of the line-of-sight velocity of a solar eruption on October 28, 2021

Yu Xu[1], Hui Tian[1], Zhenyong Hou[1], Zihao Yang[1], Yuhang Gao[1], Xianyong Bai[2]

[1]*School of Earth and Space Science, Peking University, China*
[2]*National Astronomical Observatories, Chinese Academy of Sciences, China*

The propagation direction and true velocity of a solar coronal mass ejection, which are among the most decisive factors for its geo-effectiveness, are difficult to determine through single-perspective imaging observations. Here we show that Sun-as-a-star spectroscopic observations, together with imaging observations, could allow us to solve this problem. Using observations of the Extreme-ultraviolet Variability Experiment onboard the Solar Dynamics Observatory, we found clear blue-shifted secondary emission components in extreme ultraviolet spectral lines during a solar eruption on October 28, 2021. From simultaneous imaging observations, we found that the secondary components are caused by a mass ejection from the flare site. We estimated the line-of-sight (LOS) velocity of the ejecta from both the double Gaussian fitting method and the red-blue asymmetry analysis. The results of both methods agree well with each other, giving an average LOS velocity of the plasma of ~423 km/s. From the 304 angstrom image series taken by the Extreme Ultraviolet Imager onboard the Solar Terrestrial Relation Observatory-A (STEREO-A) spacecraft, we estimated the plane-of-sky (POS) velocity from the STEREO-A viewpoint to be around 587 km/s. The full velocity of the bulk motion of the ejecta was then computed by combining the imaging and spectroscopic observations, which turns out to be around 596 km/s with an angle of 42.4 degrees to the west of the Sun-Earth line and 16.0 degrees south to the ecliptic plane.

IAUS 372

#2449

MAGNETOSEISMOLOGY FOR THE SOLAR CORONA: FROM ~10 GAUSS TO CORONAL MAGNETOGRAMS

Zihao Yang[1], Christian Bethge[2], Hui Tian[1], Steven Tomczyk[3], Richard Morton[4], Giulio Del Zanna[5], Scott McIntosh[3], Bidya Binay Karak[6], Sarah Gibson[3], Tanmoy Samanta[1], Jiansen He[1], Yajie Chen[1], Xianyong Bai[7], Linghua Wang[1]

[1]*School of Earth and Space Sciences, Peking University, China*
[2]*Universities Space Research Association, Universities Space Research Association, United States of America*
[3]*High Altitude Observatory, National Center for Atmospheric Research, United States of America*
[4]*Department of Mathematics, Physics and Electrical Engineering, Northumbria University, United Kingdom*
[5]*Department of Applied Mathematics and Theoretical Physics, Centre for Mathematical Sciences, University of Cambridge, United Kingdom*
[6]*Department of Physics, Indian Institute of Technology (Banaras Hindu University), India*
[7]*National Astronomical Observatories, Chinese Academy of Sciences, China*

Magnetoseismology, a technique of magnetic field diagnostics based on observations of magnetohydrodynamic (MHD) waves, has been widely used to estimate the field strengths of oscillating structures in the solar corona. However, previously magnetoseismology was mostly applied to occasionally occurring oscillation events, providing an estimate of only the average field strength or one-dimensional distribution of field strength along an oscillating structure. This restriction could be eliminated if we apply magnetoseismology to the pervasive propagating transverse MHD waves discovered with the Coronal Multi-channel Polarimeter (CoMP). Using several CoMP observations of the Fe XIII 1074.7 nm and 1079.8 nm spectral lines, we obtained maps of the plasma density and wave phase speed in the corona, which allow us to map both the strength and direction of the coronal magnetic field in the plane of sky. We also examined distributions of the electron density and magnetic field strength, and compared their variations with height in the quiet Sun and active regions. Such measurements could provide critical information to advance our understanding of the Sun’s magnetism and the magnetic coupling of the whole solar atmosphere.