4th Swiss SCOSTEP Workshop Abstracts

Nicole Vilmer, LESIA & Station de Radioastronomie de Nançay

Radio observations of flares and coronal mass ejections: space weather aspects

Electromagnetic radiation from the Sun as well as energetic particles associated with flares or coronal mass ejections (CMEs) can affect the terrestrial environment (e.g. radio black outs, radiation damage) on short timescales (8 minutes to a few hours). The solar wind and its perturbations (shocks, coronal mass ejections) affect the Earth's environment on a longer time scale (2 to 4 days). The continuous survey of the sun and of its activity in view of space weather applications is nowadays in a phase of full development.
Radio emissions associated with flares, shocks and CME's are produced by energetic electrons either through various plasma mechanisms (narrow band emissions observed in particular below 1000 MHz) or by gyrosynchrotron emissions (large broadband continuum emission observed predominantly above 1000 MHz). Radio emissions from solar eruptions are either associated with the shock of the coronal mass ejection or with the destabilization of flux ropes in the corona leading to the further development of the CME. I shall review here some of the observations in the decimetric to decametric radio domain and discuss how they can be used as a diagnostic of plasma conditions in the CME including magnetic field measurements in the core of the flux rope and of the locations of electron acceleration. I shall discuss the implication of these diagnostics on the CME eruptive dynamics in the early stages of their evolution (<10 Rsun) . I will also discuss how radio observations can be used to follow the CME evolution in the corona and heliosphere and how radio observations in general can be used and improved for space weather science and applications.

Daniel Marsh, NCAR and University of Leeds

A Whole Atmosphere View of Solar-Terrestrial Coupling

Predicting the response of the atmosphere and geospace to changes in solar irradiance and energetic particle fluxes on timescales from minutes to several decades remains a significant challenge. It is becoming increasingly apparent that this response is driven not only by forcing of solar origin but also forcing from the lower atmosphere, and so necessitates a 'whole atmosphere' view. In this talk, I will describe efforts to represent how changes in solar output affect Earth's energetics, composition, and dynamics within two 'high-top' options of the NCAR Community Earth System Model: The Whole Atmosphere Community Climate Model (WACCM), with a model lid around 140 km, and WACCM-X, with the lid extended to approximately 700 km. These models include the coupling between atmospheric layers and so can simulate such phenomena as the ionospheric effects of gravity waves, tides and planetary waves that have their origin in the troposphere. As a climate model, it is also capable of simulating the effects of anthropogenic global change through the entire atmosphere, including changes in thermospheric density and temperature. In addition, it can be used to look at how space weather impacts the lower atmosphere, e.g., the response of ozone in the mesosphere and stratosphere to energetic electron and proton precipitation. A goal of PRESTO, the next SCOSTEP scientific program, is to advance understanding that enables improvements in the accuracy of prediction of the solar-terrestrial system. A possible pathway to improving predictability is via the integration of a whole atmosphere view to solar-terrestrial coupling through the development of models such as WACCM.

Säm Krucker, FHNW/UC Berkeley

First results from Solar Orbiter/STIX

The Spectrometer/Telescope for Imaging X-rays (STIX) onboard Solar Orbiter was successfully commissioned in April/May 2020. While commissioning was not focused on science operation, STIX nevertheless recorded a total of 69 solar microflares. This presentation will give an overview of the STIX instrument and present first results.

Louise Harra, PMOD/WRC and ETH-Zürich

Connecting solar activity to Parker Solar Probe data during Encounter 1 and 2.

In this work, we explore the first two encounters of Parker Solar Probe (PSP). In the first encounter, we analyse the period when PSP was connected to a small coronal hole. SDO/AIA data is analysed to determine where activity is coming from that could lead to input to the fast solar wind measured by PSP. In the second encounter, we study the early period, when there were frequent type III bursts, and a small non-flaring active region was on the solar disk. We analyse the low level activity in the active region using Hinode/EIS and SDO/AIA data to determine the source of the type III bursts. This work is part of an ISSI team entitled 'Exploring the solar wind in regions closer than even observed before'.

Olena Podladchikova, PMOD/WRC

Prospects for improving existing space weather forecasting schemes using Extreme Ultraviolet Imager data onboard Solar Orbiter

The Extreme Ultraviolet Imager aims to study the propagating coronal features, providing the necessary connection between the solar surface and the outer corona, with previously missing information on this zone in which structures of the interplanetary environment are formed before they travel to Earth and cause space weather conditions. We discuss how EUI data can contribute to space weather research.
Research of the earliest signs of geo-efficient coronal mass ejections enabling a better understanding of the CME initiation phase.
Measurement of solar flares parameters, the strongest of which can cause strong radio blackouts on Earth.
Solar wind originating in the equatorial coronal holes compress the magnetosphere and generate elevated fluxes of energetic electrons responsible for the electric charging of satellites. With Solar Orbiter being close to the Sun, a strong improvement is expected in the correlation establishing between CH parameters and solar wind measurements.

Michele Bianda, IRSOL/USI

News about the European Solar Telescope

The talk is an upgrade about the work performed at European and Swiss level related to the 4 m aperture European Solar Telescope (EST), foreseen to be constructed in La Palma, Canary Islands.

Margit Haberreiter, PMOD/WRC

LUCI onboard the upcoming ESA Space Weather Mission

LUCI (Lagrange eUv Coronal Imager) is a solar imager in the Extreme UltraViolet (EUV) that is being developed as part of the Lagrange mission. The instrument is designed to be positioned at the L5 Lagrangian point to monitor space weather from its source on the Sun, through the heliosphere, to the Earth. LUCI builds on the heritage of PROBA2/SWAP and SolO/EUI and at the same time but also includes new design aspects. Specifically, LUCI will have a novel off-axis wide field-of-view, designed to observe the solar disk, the lower corona, and the extended corona in direction to the Sun-Earth line. These observations allow for the detection coronal holes, prominences, and active regions, as well as transient phenomena such as solar flares, limb Coronal Mass Ejections (CMEs), EUV waves, and coronal dimmings. PMOD/WRC is involved in the pre-developement of the front-end-electronics and the thermo-mechanical design. The launch of Lagrange mission is currently foreseen in 2027.

André Csillaghy, FHNW

JHelioviewer on the way to be the Solar Orbiter data visualizer, and beyond

JHelioviewer has stablished itself as an important tool to visualize solar data, particularly from the Solar Dynamics Observatory, but also from SOHO and STEREO. It allows to make movies, and to visualize data in 3D. Furthermore, it has the ability to display other sources of data. This is currently being extended to include remote sensing data from Solar Orbiter, using a direct connection to the Solar Orbiter Data Archive (SOAR) at ESAC. At FHNW, we work on standardizing the way external data can also be included, such as the data from RHESSI or IRIS (STIX will be available through ESAC). In this presentation, we will show the current state of our development and present also our plans for a light version that will be available on the web and on mobile devices.

Andrea Francesco Battaglia, FHNW and ETHZ

Imprints of torsional Alfvén pulses in magnetic swirls

Vortical flows in the quiet solar atmosphere have received increasing attention in recent years as a potential source for heating the outer quiet solar atmosphere. Employing the radiative magneto-hydrodynamic simulation tool CO5BOLD, we investigate their origin and propagation. We apply the swirling strength criterion and its recently discovered evolution equation in order to identify vortical motions and to study their dynamics. We find evidences of unidirectional swirling pulses which propagate upwards with the local, time-dependent Alfvén speed. Moreover, we show that in these swirls the rotation of the plasma co-occurs with a twist of the magnetic field in the opposite direction, which is a clear signature of torsional Alfvén waves. We conclude that the swirling events observed in numerical simulations are tightly coupled to perturbations of the magnetic field, forming Alfvén pulses that propagate from the bottom of the photosphere upwards into the chromosphere.

Krzysztof Barczynski, PMOD/WRC Davos; ETH Zurich

A Comparison of the Active Region Upflow and Core Morphologies Using Simultaneous Spectroscopic Observations from IRIS and Hinode

The origin and morphology of the coronal upflow region remain open questions. In the upflow region and the active region (NOAA 12687), we investigated how the plasma properties (flux, Doppler velocity, and non-thermal velocity) change throughout the solar atmosphere, from the chromosphere via the transition region to the corona. We analyzed spectroscopic data simultaneously obtained from Hinode/EIS and IRIS (MgII, CII, SiIV, FeXII, FeXIII, and FeXIV). We studied the mutual relation between the plasma properties for each line, as well as compared the plasma properties in the close formation temperature lines. We classified the most characteristic spectra with the machine learning technique k-means. We found several mutual relations between the plasma parameters in different spectral lines. These relations and the spectra classification results suggest that the plasma upflow begins in the solar corona, but the nature of the upflow region can be determined from the underlying layers.

Diego de Pablos, MSSL (University College London)

Analysis of time-domain correlations between EUV and in-situ observations of coronal jets

We investigate the role played by coronal jets in forming the solar wind by testing whether temporal variations associated with jetting can be identified within outflowing solar wind plasma. This is a challenging problem due to inherent differences between remote-sensing observations of the source and in-situ observations of the outflowing plasma, as well as its travel time and evolution throughout the heliosphere. To overcome these issues, we propose a novel algorithm combining signal filtering, two-step solar wind backmapping, and Empirical Mode Decomposition. The algorithm enables the direct comparison of temporal signatures within remote sensing observations of eruptive phenomena in the corona to in-situ measurements of solar wind parameters. The method is first validated using synthetic data before being applied to measurements from the Solar Dynamics Observatory, and Wind spacecraft.

Jean-Philippe Montillet, PMOD/WRC

A New Methodology for Degradation Correction of the SOHO/VIRGO Total Solar Irradiance Time Series Using Machine Learning and Data Fusion

Over the last decades, starting in 1978, various space missions have measured the total solar irradiance (TSI), among them the VIRGO experiment on the SOHO mission, which started in 1996 and is still operational. The process to merge all observations into a composite is source of a debate in the community due to different opinions how to correct time series of individual instruments and how to merge them. The results often reflect on human judgment and manual refinement of the raw measurements. We propose a new approach using a machine learning and data fusion algorithm to produce automatically the degradation-corrected TSI time series based on a small number of assumptions. The algorithm is applied to the VIRGO/PMO6 and VIRGO/DIARAD observations and compared to previous PMOD releases together with other processing centers. The results show that these new time series agree with previous releases at 1 sigma (0.2 W/m^2).

Rohit Sharma, FHNW

Probing spatial and temporal solar emission variations at meter wavelengths.

The Sun is a vast laboratory of plasma. In solar corona, the plasma rests in the heterogeneous magnetic field networks, which are rooted in the photosphere. Besides, the nature of solar plasma in corona is also dynamic, making solar emission is inherently variable in space and time. The MWA solar observations have captured this variability and produced most detailed solar maps at meter wavelengths at a fine time cadence.At meter wavelengths, the spatial distribution of the solar emission is highly dominated by propagation effects like scattering and refraction. Using MWA's picket-fence mode observations, we study the impact of scattering on the spatial structures in the solar maps within the entire range of meter wavelengths, which span a broad range in coronal heights ~0.08 to 0.65 solar radii. For this purpose, we quantitatively compared the brightness distribution of the MWA solar maps with simulated thermal bremsstrahlung at MWA frequency bands. We find that the scattering extensively re-distributes the brightness within the solar disk. We modelled the scattered emission by radiative transfer and obtained constraints on the density inhomogeneities (1%-10%) responsible for scattering. Also, we find a weak temporal emission sub-SFU flux level emission background. I will discuss the role of scattering in dispersing the brightness of the solar features in detail and low-level temporal fluctuations in solar emission

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Emilia Capozzi, Istituto Ricerche Solari Locarno (IRSOL)

Magneto-optical effects in the wings of the Ca I 4227 Å line

Recent studies have shown that the large scattering polarization signals observed in the wings of strong resonance lines such as the Ca I 4227 Å line are not insensitive to the presence of a magnetic field, as previously thought.
Instead, they present a clear magnetic sensitivity through the magneto-optical (MO) effects that produce a rotation of the plane of linear polarization as the radiation propagates through the solar atmosphere (or Faraday rotation).
Here, we show the first evidences that hitherto unexplained spatial variations of the wing scattering polarization signals of the Ca I 4227 Å line observed at IRSOL can be explained in terms of these effects. Furthermore, we present the first results of a series of radiative transfer investigations applied to this line, in which we study the potential of these MO effects for probing the magnetic fields present in the solar atmosphere, which could provide complementary information to that obtained via the Zeeman effect.

Franziska Zeuner, IRSOL

Absolute high precision solar polarimetry

Polarimetric observations of the Sun are predominantly limited by the optics of telescopes and instruments. High precision polarization measurements can be reached with the ZIMPOL system, the polarimeter actually used at IRSOL, Locarno. Together with a new technique, based on a telescope calibration unit, spurious instrumental signatures can be removed as well as the absolute polarization level can be determined with high accuracy. This technique will also be testet at the GREGOR telescope on Tenerife, Canary Islands. Here, we present the first performance test results at IRSOL. This work is part of the SOLARNET project.

Ernest Alsina Ballester, Istituto Ricerche Solari Locarno (IRSOL)

Radiative transfer modeling of spectral line polarization considering complex atomic models

Modeling the intensity and polarization signals of the radiation emerging from the Sun by solving the radiative transfer (RT) problem in semi-empirical models of the solar atmosphere, taking into account the complex physics of matter-radiation interaction, allows us to greatly deepen our understanding of the physical processes occurring therein. At IRSOL, we have recently developed a new RT code that accounts for a series of physical ingredients that are essential for modeling the polarization signals of many strong chromospheric lines. We show two illustrative examples of the investigations carried out with this code, namely the successful modeling of the enigmatic linear scattering polarization signal of the sodium D1 line, and the possibility of interpreting the broadband observations reported by the CLASP sounding rocket mission in terms of the magnetic sensitivity of the linear polarization wings of the Lyman alpha line arising from magneto-optical effects.

Gioele Janett , IRSOL

Radiative transfer modeling of spectral line polarization accounting for angle-dependent PRD effects

Obtaining information on the magnetic fields present in the chromosphere and transition region is an ongoing challenge in solar physics research. This information is encoded in the polarization of strong resonance lines, whose modeling requires taking into account partial frequency redistribution (PRD) effects, i.e., frequency correlations between the incoming and outgoing radiation in scattering processes. Developing the numerical and computational tools necessary to perform radiative transfer calculations for polarized radiation, accounting for angle-dependent PRD effects, is the goal of a “Sinergia” project that involves IRSOL, the Institute of Computational Sciences (ICS), and the Instituto de Astrofisica de Canarias (IAC). In this talk we show the first results of this work, highlighting the differences between our new calculations and those that are obtained under the so-called angle-averaged assumption, which has often been introduced in the past to simplify the problem.

Svetlana Berdyugina, KIS

Vector magnetic field through the solar atmosphere

Knowing vector magnetic field through the solar atmosphere is essential for understanding the energy transport from the convection zone to the chromosphere and corona and into the heliosphere. In this talk I will present an overview of our current ability to extract 3D magnetic structures in the solar photosphere, chromosphere and corona, and how ground-based telescopes can contribute to monitoring and forecasting geosignificant events and space weather.
