Mini-workskop, Wrocław, 13 May 2024

Location:
Astronomical Institute, University of Wrocław, Kopernika 11, 51-622 Wrocław, Poland

1) 10:00 – 10:30 CEST
Space Physics of Habitability: Systems Science Approach
Vladimir Airapetian (NASA GSFC/SEEC (Sellers Exoplanet Environments Collaboration), USA)

Discovery of over 5500 exoplanets with Kepler mission, TESS, the Hubble Space Telescope, and JWST suggests that rocky exoplanets in the habitable zones around G, K, and M dwarfs are common in our Galaxy. These detections open a new era in the characterization of the planetary atmospheric environments, the critical step in the search for conditions suitable for life and signatures of their biospheres. Are biospheres of terrestrial-type exoplanets a common phenomenon? How can we detect a (pre)biosphere from a rocky exoplanet? Can we search for Earth twins? Critical examination of the heliophysical and physico-chemical conditions that supported the emergence of life on the early Earth and other inner planets in our Solar System is a promising way to address these fundamental questions. Understanding the conditions for habitability requires the characterization and assessment of several factors: retention of a relatively thick atmosphere, presence of basic molecular compounds, and availability of persistent external energy fluxes. The consistent characterization of space environments and their impact on exoplanetary upper atmosphere and climate requires a new system science approach to characterize habitability as the evolving physico-chemical phase of an exoplanetary system. In this talk, I suggest that while we have no consistent ideas about forms of exoplanetary life other than our own, pre-life conditions that required the formation of prebiotic chemistry are well specified under laboratory conditions. These factors could have promoted the emergence and complexification of biological systems on early Earth and possibly Mars. First, I will describe our recent observational campaigns of young solar-like analogs, and data-constrained state-of-the-art MHD and kinetic models of stellar coronae, transient events (CMEs and SEPs) and discuss the impact of solar/stellar eruptive events on atmospheric escape. Second, I will discuss how the extreme space weather in the form of flares, coronal mass ejections, and energetic particle events (like 775AD event) from the recent past of our Sun provides critical insights into the atmospheric chemistry of early Earth and terrestrial-type exoplanets and assessment of their role in the formation of biologically relevant molecules. Third, I will present the recent results of laboratory experiments that reproduce the energy fluxes of particles from the young Sun and study the expected formation of amino acids and carboxylic acids, the chemical precursors of life. I will also introduce the design of our recently approved Exoplanetary Particle Irradiation Chemistry laboratory (EPIC Lab) at NASA GSFC.

2) 10:30 – 11:00 CEST
Recent/ongoing multi-wavelength campaign observations of stellar flares.
Yuta Notsu (University of Colorado Boulder/LASP/NSO)

In recent years, our group has conducted various multi-wavelength campaign observations of stellar flares especially M-dwarf flares. Through this, we have investigated line asymmetries & broadening of chromospheric lines, and continuum emission evolution. In this

presentation, I will overview those recent & ongoing results (especially M-dwarf flare campaigns), and discuss future prospects including studies using solar-based observation/modeling studies.

3) 11:00 – 11:30 CEST
Coronal Mass Ejections on Young Suns: Insights from Solar and Stellar Observations and Models
Kosuke Namekata (Kyoto University, Japan)

Recent discoveries have revealed exoplanets orbiting young Sun-like stars, offering a window into the early solar system. The young stars are known to produce extreme magnetic explosions, called superflares, about once a day, potentially triggering fast and massive coronal mass ejections (CMEs). Recent studies suggest such ejections could induce atmospheric loss and chemical reactions in early exoplanet atmospheres. However, the association of CMEs with superflares is still unexplored. Here we present the results of 5-years multi-wavelength observations of young Sun-like stars, providing the critical clues to the common picture of solar and stellar CMEs. First, through optical spectroscopic observations, we found four of eleven superflares are associated with fast prominence eruptions, precursors to CMEs. The stellar data greatly resemble solar counterparts, indicating a common picture of solar/stellar eruptions. Second, one of the eruptions is associated with potential coronal dimming in X-rays, indicating that the prominence eruptions evolved into stellar CMEs propagating through interplanetary space. Furthermore, the extension of solar MHD model supports the above indication and suggests that the eruption originates from the observed magnetic active region. This comprehensive study suggests that further advancing the use of solar model could provide the first empirical inputs into calculations of atmospheric escape and chemical reactions for young planets.

4) 11:30 – 12:00 CEST
Spectroscopic observations of flares and superflares on AU Mic and CC Eri
Petra Odert (Institute of Physics, University of Graz, Austria)

We present results from a campaign dedicated to the spectroscopic characterization of flares and superflares on flare-active stars selected from TESS. We monitored several of the most active flare stars with the Echelle spectrograph PUCHEROS+ mounted on the ESO1.52m telescope in La Silla, Chile, hosted by the PLATOSpec consortium. One prominent example is the young planet-hosting M dwarf AU Mic which was observed for 56 nights between 2022 and 2023. We analyzed several prominent chromospheric spectral lines in the covered wavelength range (~400-700nm) and detected 24 flares, including one extreme flare event during which the chromospheric line fluxes were raised by factors of a few more than in any other strong flare from this star. We estimate that this event has likely reached superflare energies in the optical chromospheric lines alone. A similarly strong event was found on the active binary CC Eri.

---------- BREAK 12:00 – 12:30 CEST ----------

5) 12:30 – 13:00 CEST
Beyond Flatland: A Star of Many Dimensions
Sarah Gibson (High Altitude Observatory, National Center for Atmospheric Research, Boulder, Colorado, USA)

The more we learn about the Sun, the more we can appreciate its essential complexity. Multi-wavelength observations reveal its structured coronal atmosphere, and ever-higher temporal and spatial resolutions expose its spectacular dynamics. Helioseismology penetrates its depths, and spacecraft views from off the Sun-Earth line yield the beginnings of a three-dimensional perspective. Underlying this complexity is solar magnetism – the consequence of a cycling dynamo and the cause of solar eruptions that originate in stressed and twisted magnetic fields. In this talk, I will highlight critical areas of solar physics, presenting recent advances and open questions associated with the generation, storage and release of magnetic energy and resulting space weather at the Earth. I will then look to the future, considering how sustained observations from the Sun's poles and from a truly global view on solar and heliospheric magnetic fields could change the paradigm of Sun-Earth investigations.

6) 13:00 – 13:30 CEST
Solar flares and flare-CME association: present understanding and prospects with Aditya-L1 observations
Bhuwan Joshi (Udaipur Solar Observatory, Physical Research Laboratory, India)

The investigations of solar flares are crucial not only to probe the physics of magnetic reconnection and reconnection-driven processes but also to explore the triggering mechanism of coronal mass ejections (CMEs) which altogether ultimately link toward understanding the space weather phenomena. Contemporary multi-wavelength solar observations, mainly from space, have revealed various small-to-large scale features during the evolution of solar flares that have enabled us to explore analogies between the circumstances that govern the onset of jets, confined flares, or CMEs. In this talk, I discuss observational features vis-à-vis theoretical understanding of solar flares in view of 2D and 3D models of magnetic reconnection. We also briefly summarize the science cases and gap areas that can be probed with the upcoming data from the Aditya-L1 mission.

7) 13:30 – 14:00 CEST
Magnetic topology analysis on solar flares
Jun Chen (Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing, China)

Magnetic reconnection preferentially takes place at the intersection of two separatrices or two quasi-separatrix layers (QSL), which can be quantified by the squashing factor Q. We developed a method (FastQSL) optimized for obtaining Q and the twist number in a 3D data cube, and applied the method to a survey of EUV late phase (ELP), which presents a second peak in the extreme ultraviolet sometimes appears during the gradual phase of solar flares. Cooling may be the dominant factor causing the delay of the ELP peak relative to the main-phase peak, because the loop system responsible for the ELP emission is generally larger than, and well separated from, that responsible for the main-phase emission. Circular-ribbon flares can be well explained by a composite "dome–plate" quasi-separatrix layer (QSL). Some appilcations in MHD simulation will also be prensented.