EP 2: Sun and Heliosphere I

Time: Monday 16:45–18:15 Location: ZHG101

Invited Talk EP 2.1 Mon 16:45 ZHG101

Sunrise III 2024: Flight and first scientific results — •Andreas Korpi-Lagg[1], H.N. Smitha[1], Sami K. Solanki[1], Achim Gandorfer[1], Alex Feller[1], Tino Riethmüller[1], Pietro Bernasconi[2], Thomas Berkefeld[3], Jose Carlos del Toro Iniesta[4], Yukio Katsukawa[5], and Sunrise III Team[1,2,3,4,5] — [1]MPS, Göttingen — [2]JHUAPL, Laurel, USA — [3]KIS, Freiburg, Germany — [4]IAA, Granada, Spain — [5]NAOJ, Tokyo, Japan

Sunrise III completed a highly successful science flight in July 2024 on a stratospheric balloon. The seeing-free observing conditions and the high optical quality of the telescope combined with the superb pointing and image stabilization system delivered diffraction-limited images to the three science instruments, spanning a wavelength range from the near-ultraviolet (SUSI, 309-417 nm), over the visible (TuMag, 517-525 nm), to the near infrared (SCIP, 765-855 nm). The flight was controlled from the Göttingen Operations Center at MPS.

The high activity level of the Sun allowed Sunrise III to observe a wide variety of solar features: Maps and sit-and-stare scans of quiet-sun and plage regions, sunspots, pole and limb from the two spectropolarimeters and the imaging spectropolarimeter allow seamless determination of the atmospheric conditions including the magnetic field vector with an unprecedented combination of spatial resolution and height coverage, from the deep photosphere to the upper chromosphere.

I present a summary of the flight, and an overview of the Sunrise III observations with a few early highlights from all three science instruments.

EP 2.2 Mon 17:15 ZHG101

Solar small-scale magnetic elements in the ultraviolet — •Ajay Kumar Yadav[1], Natalie Krivova[1], Tino Riethmüller[1], Smitha Narayanamurthy[1], Sami Solanki[1], Durgesh Tripathi[2], Anamparambu Ramaprakash[2], Andreas Korpi Lagg[1], Alex Feller[1], and Achim Gandorfer[1] — [1]Max Planck Institute for Solar System Research, Göttingen, Germany — [2]Inter-University Centre for Astronomy and Astrophysics, Pune, India

Solar UV irradiance is crucial for the chemistry and ozone balance in the terrestrial atmosphere and, thus, its variations could influence the climate. Existing models attributing irradiance vari- ability to solar surface magnetism have been very successful in reproducing the total and some of the spectral irradiance measurements. However, significant discrepancies between various data and models persist in the range 200*400 nm. The brightness contrast of small-scale magnetic features, which strongly depends on the magnetic field strength, their position on the solar disk, and the wavelength, can provide critical constraints and help resolving the existing discrepancy. UV data suitable for such an analysis were not available until recently. This has changed with the launch of the Aditya-L1 mission carrying the Solar Ultraviolet Imaging Telescope (SUIT) and the third flight of the ballon-borne Sunrise-3 telescope. We will present initial results from the analysis of the available images of the Sun at UV wavelengths in the range 200*400 nm

EP 2.3 Mon 17:30 ZHG101

Towards a reconstruction of the annual solar Irradiance over the past 9 millennia — •Duresa Temaj[1], Natalie Krivova[1], Sami Solanki[1], Illya Usoskin[2], and Bernhard Hofer[1] — [1]Max planck institute for solar system research, Goettingen, Germany — [2]Space Climate Research Unit, University of Oulu, Finland

Space-based observations of solar irradiance since the 1970s revealed its variability, but these records are too short to reliably assess solar impact on Earth's climate. Therefore, irradiance reconstructions are needed, which requires proxies of past solar activity. The longest direct proxy is the sunspot number, recorded for the past 400 years. We employ the Spectral And Total Irradiance REconstructions (SATIRE) model, using the sunspot number as input, while also accounting for the emergence of small-scale magnetic features, to reconstruct solar irradiance from direct sunspot observations.

Furthermore, concentrations of cosmogenic isotopes, e.g. 14C and 10Be, in terrestrial archives, allow reconstructions of sunspot numbers over nine millennia, albeit at a decadal resolution, except the last millennium. Thus, solar cycles remain unresolved. Based on previous findings that cycle strength and length correlate well with the mean solar activity, we study the relationships between the decadally averaged sunspot numbers and solar cycle parameters. We validate this approach using synthetic records constructed from telescopic data and find a fair agreement with the observed record. We apply the derived relationships to reconstruct the annual sunspot number and then irradiance over the nine Millennia.

EP 2.4 Mon 17:45 ZHG101

Global inertial oscillations of the sun — •Laurent Gizon — Max-Planck-Institut für Sonnensystemforchung, 37077 Göttingen — Georg-August-Universität Göttingen, Institut für Astrophysik und Geophysik, 37077 Göttingen

Global oscillations of the Sun consist of two known classes: the well-studied 5-minute acoustic oscillations, which are used in helioseismology, and the recently discovered inertial oscillations with periods on the order of the Sun's rotation period (Gizon et al. 2021). All observed inertial modes propagate more slowly than the equatorial rotation rate and, due to latitudinal differential rotation, these modes have critical latitudes where their phase speeds match the local rotation rate. Linear forward modeling indicates that the mode eigenfrequencies and eigenfunctions are highly sensitive to the Sun's internal differential rotation, as well as to poorly understood properties of solar convection zone, such as the superadiabatic temperature gradient. Additionally, nonlinear simulations (Bekki et al. 2024) suggest that the high-latitude modes with the largest amplitudes are baroclinically unstable and play a significant dynamical role in shaping the Sun's internal rotation profile. In this presentation, we will present a progress report on this highly promising new field of solar physics.

EP 2.5 Mon 18:00 ZHG101

Nonlinear saturation mechanism of solar high-latitude inertial modes — •Muneeb Mushtaq, Damien Fournier, and Laurent Gizon — Max-Planck Institute for Solar System Research, Goettingen, Germany

At high latitudes the solar rotation rate drops fast with increasing latitude and is linearly unstable. In this presentation we discuss the nonlinear saturation mechanism, which controls the amplitude of the high-latitude solar inertial modes. Using nonlinear numerical simulations of purely toroidal modes on the sphere, we show that the bifurcation is supercritical.This justifies the use of the weakly nonlinear theory to model the development of the disturbance amplitude and to determine to what value it saturates. We find a simple relationship between the mode amplitude and the linear growth rate of the mode.