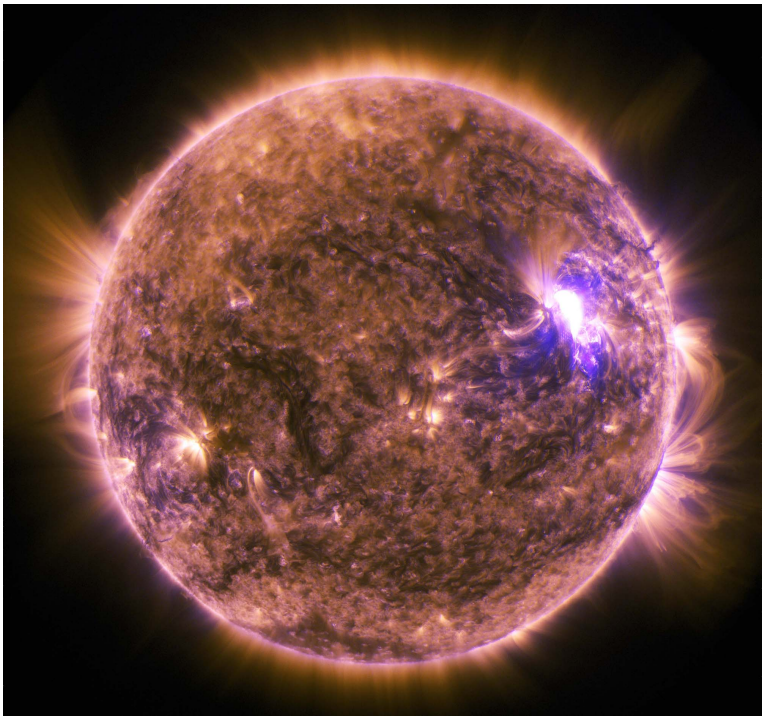
EST Meeting
in Bairisch Kölldorf, Austria

Oct. 9 -11 2017



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PRE-EST, Austrian Academy of Sciences, Univ. Graz, Bad Gleichenberg

Oct. 9 th

14.30-15.00 registration, come together

15.00 official opening of the meeting, A. Hanslmeier, M. Collados

Session: Current status and financial issues, public outreach of EST

15.15-17.00

15.15-15.45

The European Solar Telescope: the future of European ground-based solar physics

Talk
Author: **Manuel Collados**
Co-Authors: EST Team
Affiliations: Instituto de Astrofisica de Canarias
Abstract text: Nowadays it is clear that solar magnetic phenomena extend through the whole atmosphere, from the deep photosphere (and below it) up to the corona. Flux emergence, flares, magnetic reconnection or magnetic-guided MHD waves are examples of events that affect a large number of different layers. For their accurate observation, description and interpretation, a large-aperture solar telescope with adequate capabilities and instrumentation is required. The European Solar telescope (EST) is designed to meet these requirements. EST will be the first solar telescope with a powerful multi-conjugate adaptive optics system since first light. With it, it is expected to collect the best images ever taken from the Sun. In addition, the telescope has a complete suite of instruments for simultaneous imaging and spectropolarimetric measurements of the photosphere and the chromosphere to take full advantage of its innovative polarimetrically compensated optical design. Recent developments with integral field units have paved the way to novel 2D

spectropolarimetric instruments. In this talk, all these aspects will be reviewed, together with some example science cases for which the contribution of EST will be fundamental

15.45-16.00

Preparation of the EST Governance Structure

Talk
Author: **Markus Roth**
Co-Authors:
Affiliations:
Abstract text: In the coming four years the governance structure for the European Solar Telescope (EST) needs to be defined. For this various governance models for multi-national collaborations need to be studied. In this presentation I will define the important steps to arrive at the EST governance structure. These steps follow general principles to define organizational models. Furthermore, the requirements already defined by the EU in form of practical guidelines for defining the legal framework for a consortium operating such an infrastructure and the European Charter for Access to Research Infrastructures will be reviewed.

16.00 Short comments on the status of EST Activities in different countries

Austria

Croatia

Czech Rep.

Germany

Slovakia

Spain

16.30 EST Public outreach issues Luis Bellot Rubio

17.45 Buschenschank Excursion

Oct 10 th

Numerical Simulation and modelling

10.00-10.30

NUMERICAL SIMULATION OF LARGE SCALE AMPLITUDE CORONAL WAVES INTERACTING WITH CORONAL HOLES

Talk

Author: **Isabell Piantschitsch**
Co-Authors: Bojan Vrsnak, Arnold Hanslmeier, Astrid Veronig, Birgit Lemmerer
Affiliations:

Abstract text: We developed a new numerical code that is capable of performing 2.5D simulations of magnetohydrodynamic (MHD) wave propagation in the corona and its interaction with a low density region like a coronal hole (CH). We observe that the impact of the wave on the CH leads to effects like reflection and transmission of the incoming wave, stationary features at the CH boundary, reflections inside the CH or formation of a density depletion. The formation of stationary bright fronts was one of the primary reasons for the development of pseudo-wave theories. Here we show that stationary features at the CH boundary can be the result of the interaction of an MHD wave with a CH. We compare cases of different densities inside the CH and varying initial density amplitudes of the incoming wave. Morever, we analyze morphology and kinematics of primary and secondary waves, i.e. we describe the temporal evolution of density, magnetic field, plasma flow velocity, phase speed and position of the wave amplitude.

10.30-11.00

Estimation of the magnetic field azimuth in the solar chromosphere

Talk
Author: **Jan Jurcak**
Co-Authors: Jiri Stepan
Affiliations: Astronomical Institute of the Czech Academy of Sciences
Abstract text: We present the novel possibilities of the 4-meter class telescopes to estimate the azimuth of the magnetic field from the linear polarisation signals of spectral lines that are in the Hanle saturation regime. The method is illustrated on synthetic spectral profiles of the Ca II 8542 line calculated by applying the radiative transfer code PORTA to the 3D model of solar chromosphere carried out with the Bifrost code. To show the sensitivity of the method, we degrade the synthetic profiles with point spread functions corresponding to telescopes of different apertures and add a noise of different amplitudes. The results imply the importance of the planned European Solar Telescope that will be able to achieve the necessary spatial resolution along with the required signal-to-noise ratio.

11.00-11.30 Coffee Break

11.30-12.00

Study of photospheric shock propagation based on radiation hydro- and magnetohydrodynamic models

Talk
Author: **Peter Leitner**
Co-Authors: B. Lemmerer, A. Hanslmeier, T. Zaqarashvili, M. Temmer, A. Veronig, F. Calvo, H.J. Muthsam, O. Steiner
Affiliations: Institute of Physics, University of Graz
Abstract text: Simulations of the solar convection including radiation transport allow us to examine and track photospheric shock waves in detail unparalleled by direct observation. It is still not clear which processes trigger shocks and how

significant a role they play for the energy transport to the upper layers of the atmosphere. Apart from traditional techniques of shock wave detection that rely on a search for the concentration of contour lines of pressure, density, and temperature and for the localization of Mach number isosurfaces, we employ recent post-processing methods specifically aimed at the analysis of computational fluid dynamics (CFD) data that allow us to more accurately locate and segment shock fronts as they propagate through the photospheric plasma. We present an application of different detection algorithms on radiation hydrodynamics (RHD) and radiation magnetohydrodynamics (RMHD) simulation data of the photosphere that are based on an edge detection technique as well as a method to locate shock surface normals based on the local pressure gradient. We will compare the emergence of shock patterns in these two qualitatively different simulations and discuss the correlation of the shock structures with the underlying flow field.

12.00-12.30

Spectral Inversion of the Halpha and Ca II 8542 A Lines Observed by SST/CRISP in Chromospheric Jets

Talk

Author: **Julius Koza**
Co-Authors: Jan Rybak (1), Teimuraz Zaqarashvili (2,3), Zurab Vashalomidze (3), Arnold Hanslmeier (2)
Affiliations: (1) Astronomical Institute of the Slovak Academy of Sciences, Tatranska Lomnica, Slovakia (2) IGAM, Institute of Physics, University of Graz, Austria (3) Abastumani Astrophysical Observatory at Ilia State University, Tbilisi, Georgia

Abstract text: We present results of spectral inversion of the Halpha and Ca II 8542 A lines observed by the imaging spectropolarimeter CRISP at the Swedish 1-m Solar Telescope in chromospheric jets identified in the quiet-Sun atmosphere. The inversion aims to reveal increased turbulence in these jets as a possible consequence of Kelvin-Helmholtz instabilities expected for strongly-sheared plasma flows at jet interfaces. To verify the results physical parameters of the chromospheric jets are inferred by different variants of cloud model inversion technique. The cloud model parameters of the chromospheric jets are supplemented by their lifetimes, widths, maximum lengths, apparent longitudinal velocities, transversal displacements, and transversal velocities to compare them with parameters of Rapid blueshifted events.

13.00 -15.00 Lunch Break

Session: High Resolution observations

15.00-15.30

High resolution analysis of chromospheric fine structure with ALMA

Talk

Author: **Roman Brajsa**
Co-Authors: Davor Sudar(1), Ivica Skokić(1), Arnold O. Benz(2), Matej Kuhar(2)
Affiliations: (1) Hvar Observatory, Faculty of Geodesy, University of Zagreb, Zagreb, Croatia; (2) University of Applied Sciences and Arts Northwestern Switzerland, Windisch, Switzerland

Abstract text: The Commissioning and Science Verification (CSV) data of the Sun from the test observing campaigns performed with ALMA radio telescope in December 2014 and in December 2015 were released in January 2017. The dataset which we use consists of intensity-calibrated maps of the Sun recorded in two ALMA observing bands: Band 3 (wavelength = 3 mm, frequency = 100 GHz) and Band 6 (wavelength = 1.21 mm, frequency = 248 GHz). Both single-dish and interferometric measurements of the Sun were performed. The single-dish (also called the total power) full-disc solar images were obtained by a single antenna performing the scanning of the Sun using the double-circle pattern. The interferometric images of a small portion of the Sun were obtained using mosaic of 149 pointings with about 30 antennas. The single-dish ALMA maps of the Sun reveal large-scale structures in the solar atmosphere, while the high resolution interferometric maps enable an analysis of the fine-scale chromospheric structures. The ALMA images are compared with images in the EUV (SDO/AIA: 170 nm, 160 nm, 33.5 nm, 30.4 nm, 21.1 nm, 19.3 nm, 17.1 nm, and 9.4 nm), in the H-alpha line (core and wing, NISP, Cerro Tololo), in the He 1083 nm line (core and wing, NSO/SOLIS), and with the LoS magnetograms (SDO/HMI) recorded at approximately the same times as the ALMA solar observations. The discernibility of active regions, sunspots, inversion lines of global magnetic field, prominences on the disc, coronal holes and coronal bright points is investigated in ALMA images and their average brightness temperature is measured and compared with the brightness temperature of the quiet Sun regions. The measured brightness temperatures of various solar structures is then compared with model-based predictions considering thermal bremsstrahlung as the dominant radiation mechanism and using contemporary models of the solar atmosphere. A detailed analysis of a complex active region is performed. High resolution interferometric images and their comparison with images at other wavelengths reveal the potential

of ALMA for high resolutions imaging and study of the solar chromosphere. This will especially be important when, with more antennas, extended antenna configurations and using higher bands (shorter sub-mm wavelengths), even much better spatial resolution will be achieved. Such images will be appropriate for comparison with optical images of comparable resolution (e.g., using EST).

15.30-16.00

Effect of center to limb brightness variations on high resolution solar observations

Talk
Author: **Davor Sudar**
Co-Authors: Roman Brajša, Ivica Skokić
Affiliations: Hvar Observatory, Faculty of Geodesy, Zagreb
Abstract text: We analyze the center to limb brightness variations on full disk solar ALMA images. We present a procedure to calculate the empirical relationship of quiet Sun brightness variations in two available ALMA frequency bands. The effect of this variation on proper interpretation of high resolution ALMA and other large telescopes images is also discussed.

16.00 -16.30

Continuum intensity - magnetic field relation in sunspots

Talk
Author: **Michal Sobotka**
Co-Authors: Reza Rezaei
Affiliations: (1) Astronomical Institute of the Czech Academy of Sciences, Ond\v{r}ejov, Czech Republic; (2) Instituto de Astrof\'\i sica de Canarias, La Laguna, Tenerife, Spain
Abstract text: We present high-resolution full-Stokes measurements of sunspots, using the highly-sensitive full-split (g=3) infrared line Fe I 1564.85 nm, and compare them with simultaneous continuum intensity measurements. We extend the classical work of Kopp & Rabin (1992, Solar Phys. 141, 253) from the intensity to the full Stokes vector. The data were obtained with the GREGOR Infrared Spectrograph (GRIS) on May 11, 2015, using the adaptive optics system. The observations include three large sunspots of active region 12339, with spatial resolution better than 0.5" in the spectral scans. The continuum intensity is

corrected for instrumental scattered light and the brightness temperature is calculated. Magnetic field strength and inclination are derived directly from the line split and ratio of Stokes components. The continuum intensity relation to the field strength and inclination are studied separately in the umbra, light bridges, and penumbra. The results agree with previous studies but the higher spatial resolution leads to a larger scatter of values in the continuum intensity (temperature) and magnetic-field relations.

16.30 -17.00

Data Analysis and Management for High-Resolution Solar Physics -

Image Restoration and Imaging Spectroscopy at the GREGOR Solar Telescope

Authors: **Carsten Denker**, Christoph Kuckein, Meetu Verma, Sergio J. Gonzalez Manrique, Andrea Diercke, Harry Enke, Jochen Klar, Horst Balthasar, Rohan E. Louis, Ekaterina Dineva

Abstract. In high-resolution solar physics, the volume and complexity of photometric, spectroscopic, and polarimetric ground-based data significantly increased in the last decade reaching data acquisition rates of terabytes per hour. This is driven on the one hand by the desire to capture fast processes on the Sun and on the other hand by the necessity for short exposure times "freezing" the atmospheric seeing, thus enabling post-facto image restoration. Solar features move with velocities of several kilometers per second in the photosphere and several tens of kilometers per second in the chromosphere, often exceeding the speed of sound. Eruptive phenomena in the chromosphere reach even higher velocities in excess of 100 kilometers per second. The coherence time of wavefront distortions is of the order of milliseconds under daytime seeing conditions. Consequently, large-format and high-cadence detectors are nowadays used in solar observations to facilitate image restoration. Based on our experience during the "early science" phase with the 1.5-meter GREGOR solar telescope (2014-2015) and the subsequent transition to routine observations in 2016, we describe data analysis and data management tailored towards image restoration and imaging spectroscopy. We outline our approaches regarding data processing, analysis, and archiving for two of GREGOR's post-focus instruments, i.e., the GREGOR Fabry-Perot Interferometer (GFPI) and the newly installed High-Resolution Fast Imager (HiFI). The

heterogeneous and complex nature of multi-dimensional data arising from high-resolution solar observations provides an intriguing but also a challenging example for "big data" in astronomy - in particular when considering the next generation of 4-meter aperture solar telescopes. The big data challenge has two aspects: (1) creating a Collaborative Research Environment, where computationally intense data and post-processing tools are co-located and collaborative work is enabled for scientists of multiple institutes and (2) establishing a workflow for publishing the data for the whole community and beyond. This requires either collaboration with a data center or frameworks and databases capable of dealing with huge data sets based on Virtual Observatory and other community standards and procedures. We present working approaches for both.

17.00 Excursion to wine tasting and conference Dinner

Oct 11 th

Solar Activity

9.00-9.30

Magneto-Rossby waves in the solar tachocline

Talk
Author: **Teimuraz Zaqarashvili**
Co-Authors:
Affiliations:
Abstract text: Recent discovery of Rossby waves in coronal bright points confirmed their importance in large-scale dynamics of solar interior and atmosphere. Dispersion relations of magneto-Rossby waves in the solar tachocline and their relations with observed periodicities in solar activity will discussed.

9.30-10.00

The role of flux emergence in triggering solar eruptive events

Author: **B. Vrsnjak**
The role of flux emergence in triggering kink and torus instability of pre-existing coronal magnetic flux-rope/arcade configuration is analysed. Two aspects/effects are considered: i) a direct supply of the poloidal flux to the rope; ii) reconnection of the emerging flux with the pre-existing arcade flux. Both effects are quantified applying the analytic-modelling approach, to enable a better understanding of the pre-eruptive gradual evolution of metastable coronal structures characterized by a semi-toroidal magnetic flux-rope embedded in the magnetic arcade.
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10.00-10.30

In-situ observations of magnetic reconnection in space

Author: **Zoltan Voros**
Co-Authors:
Affiliations: Institute of Physics, University of Graz, Austria
Abstract text: Magnetic reconnection converts magnetic energy to kinetic and thermal energy and accelerates particles in different laboratory, space and astrophysical plasmas. The in-situ signatures of magnetic reconnection are routinely observed at large-scale boundaries such as the Earth's magnetopause and the magnetotail current sheet. Yet, the details of reconnection physics, specifically over macroscopic and kinetic scales, or in a turbulent environment, are largely unknown. First, on the basis of recent multi-spacecraft missions, we list the most important in-situ signatures of an ongoing magnetic reconnection. Then we present, for the first time, both fluid-scale and kinetic-scale in-situ signatures of reconnecting current sheets in turbulent plasma. Some of the difficulties of the observations of magnetic reconnection in turbulent plasma are also outlined.

10.30-11.00

Science challenges for large solar telescopes

Author: **Oskar Steiner**, Kiepenheuer Institut

From numerical simulations of highest spatial resolutionand high resolution observations, we may guess thescience questions to be tackled with future large solar telescopes. Selected examples are discussed, trying to determine the instrument requirements for answeringquestions regarding polarimetric accuracy or spatial and temporal resolution. Besides such foreseeable sciencequestions,however,it is worthwhile to recall that the best discoveries come unexpectedly and to wonder about what instrument capabilities may be most likely conducive to the unexpected

11.00-11.30 Coffee break

11.30-12.00 ON THE GENERATION MECHANISMS OF RIBBONS IN A CONFINED FLARE

Author: **Aaron Hernandez-Perez**
Co-Authors: **Julia K. Thalmann, Astrid M. Veronig, Yang Su, Peter Gomory, and Ewan C. Dickson**
Affiliations: IGAM/Institute of Physics, University of Graz, A-8010 Graz, Austria; Key Laboratory of Dark Matter & Space Astronomy, Purple Mountain Observatory Chinese Academy of Sciences, 2 West Beijing Road, 210008 Nanjing, China; Astronomical Institute, Slovak Academy of Sciences, 05960 Tatransk
Abstract text: We analyze a conned multiple-ribbon M2.1 flare that originated from a fan-spine coronal magnetic field coguration, within active region NOAA 12268. The observed ribbons form in two steps. First, two primary ribbons form at the main flare site, followed by the formation of secondary ribbons at remote locations. We observe a number of plasma flows at extreme-ultraviolet temperatures during the early phase of the flare (as early as 15 min before the onset) propagating towards the formation site of the secondary ribbons. The secondary ribbon formation is co-temporal with the arrival of the pre-flare generated plasma ows. The primary ribbons are co-spatial with RHESSI hard X-ray sources, whereas no enhanced X-ray emission is detected at the secondary ribbons sites. The (E)UV emission, associated with the secondary ribbons, peaks 1 min after the last RHESSI

hard X-ray enhancement. A nonlinear force-free model of the coronal magnetic eld reveals that the secondary flare ribbons are not directly connected to the primary ribbons, but to regions nearby. Detailed analysis suggests that the secondary brightenings flare produced due to dissipation of kinetic energy of the plasma flows (heating due to compression), and not due to non-thermal particles accelerated by magnetic reconnection, as is the case for the primary ribbons.

12.00 Closing remarks

12.20 Lunch