25th SOLAR PHYSICS MEETING

A B S T R A C T S

Chromospheric heating by acoustic waves II – Middle and upper chromosphere

Abbasvand V.[1], Sobotka M.[1], Švanda M.[1], Heinzel P.[1], Denker C.[2], and Koza J.[3],

[1] *Astronomical Institute of theCzech Academy of Sciences, Ondřejov, Czech Republic*
[2] *Leibniz-InstitutfürAstrophysik Potsdam, Potsdam, Germany*
[3] *Astronomical Institute, Slovak Academy of Sciences, TatranskáLomnica, Slovakia*

The nature of heating the middle and upper chromosphere by acoustic and magnetoacoustic waves is investigated by comparing a deposited acoustic energy flux with total integrated radiative losses. The comparison is based on a consistent set of high-resolution observations of weak-plage and quiet-Sun regions acquired inthe Ca II 854.2 nm and Hαlinesby the Fast Imaging Solar Spectrograph at the Goode Solar Telescope on 2019 October 3 and in the Hα and Hβ lines by the echelle spectrograph attached to the Vacuum Tower Telescope on 2018 December 11 and 2019 June 6. The deposited acoustic-energy flux is derived from Doppler velocities observed in the line centers and wings. Radiative losses are computed by means of a set of scaled non-LTE 1D hydrostatic semi-empirical models. In the middle chromosphere (Ca II 854.2 nm formation), the radiative losses can be fully balanced by the deposited acoustic energy flux in a quiet-Sun region. In the upper chromosphere (Hα and Hβ formation), the deposited acoustic flux is small compared to the radiative losses in quiet as well as in plage regions, so that other heating mechanisms have to act to balance the radiative cooling. The crucial parameter determining the amount of deposited acoustic flux is the gas density at a given height in the atmosphere.

Advances in (not solely solar) radio astronomy

Bárta M.[1,2] & the Czech EU ARC Team[2]

[1] *Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic*
[2] *European ALMA Regional Center - Czech node (EU ARC.CZ), Czechia*

Radio astronomy, albeit being still relatively young discipline, witnesses a new blossom in the last few years. This has been enabled by recent technological break-though, namely in digital technologies and ICT. The giant single-dish instruments, like Chinese FAST (currently the biggest in the world), are what especially attracts attention of media. Nevertheless, much significant advance in astrophysics has been reached in domain of interferometry and aperture synthesis with large arrays composed of much smaller antennas. Namely, an extension of this method to the high-frequency millimeter (sub-THz) band together with growth of the antenna baselines up to the global Earth scale, have led to a series of impressive scientific successes. The first ever image of the back-hole horizon vicinity in the M87 galaxy center, published in April 2019, represents undoubtedly the most prominent example.

Therefore, after the introductory overview, we focus on the topical method of radio (including mm/sub-mm) interferometry, its physical foundations, and new/planned instruments working on that principle. A bit longer we stay discussing the Atacama Large Millimeter/sub-millimeter Array (ALMA), which has played a key role also in the above mentioned Event Horizon Telescope for imaging of the black hole. Solar research using radio astronomy methods does not stay behind: Since 2017 ALMA observes - also thanks to the contribution of astronomers from Ondrejov - our Sun, too. As the broad-band digitizers used in modern radio instruments (software-defined radio) become affordable, the new wave of development appeared recently also in smaller and mid-size instruments.

The fully digital solar radio spectrographs AMATERAS (Japan), SSRT (Russia) or recently reconstructed Ondrejov spectrograph RT5/OSCARS, can serve as illustrative examples.

News in solar research with ALMA

Bárta M.[1,2] & the Czech EU ARC Team[2]

[1] *Astronomical Institute of theCzech Academy of Sciences, Ondřejov, Czech Republic*
[2]*European ALMA Regional Center - Czech node (EU ARC.CZ), Czechia*

Since 2017, when the Solar Observing Mode has been commissioned, ALMA contributes by its unique capabilities also to the research of the Sun and its activity. Nevertheless, unlike the standard regimes, the Solar ObsMode suffers by a couple of so far unresolved drawbacks. The Czech node of the EU ARC has been recently focusing at two of them: Automation of the solar ALMA data processing (calibration & imaging), and enabling the solar ALMA observations with high spatial resolution. The solar data are so far processed purely manually - the analyst has to prepare the scripts for calibration and imaging specially tailored to every dataset. Not only this is demanding on the manpower but also it brings a risk of human-introduced mistakes and omissions. The EU-ARC.CZ is therefore developing the Solar Script Generator - the program, which analyzes the dataset and generates the set of the processing scripts automatically. The processing of solar data will thus become much faster and robust and shall approach us towards the universal ALMA pipeline, used for the processing of data acquired in the standard observing modes. The second drawback of the Solar ObsMode is rooted in the fact that for technical reasons the solar observations are so far possible only with the compact configurations of antenna array. This limits our spatial resolution in synthesized images up to 0.6 arcsec. In order to overcome this limitation, we have suggested two ways how to resolve this issue. Should we succeed, the world-wide community of solar physicists will benefit from the unique ALMA spatial resolution, which is normally possible in non-solar modes. Detailed feasibility study on this topic is a subject of our project proposed to the ESO's programme ALMA Development Studies.

Study of turbulent flow around a circular cross-section obstacle

Belov S., Jelínek P., *University of South Bohemia in České Budějovice, Faculty of Science, Institute of Physics, Branišovská 1760, 370 05 České Budějovice, Czech Republic*

During fluid flow around bodies, especially of a cylindrical shape, at a certain range of Reynolds number occurs a phenomenon called Kármán vortex street, when vortices with opposite vorticity regularly shed behind the body alternately from both sides. This phenomenon is important in various areas such as meteorology or construction, for example, it occurs when air flows around isolated mountains or high structures. In a magnetic field environment, this phenomenon is less understood and its investigation is important for many applications in astrophysics, for example, it can explain some oscillations in coronal loops or in cometary plasma tails. In this paper, the process is studied numerically in two dimensions using the numerical code Lare2d. A parametric study was performed for different flow velocities and sizes of the circular obstacle, then the numerical model was extended by addition of a magnetic field. The flow velocity and size of the obstacle affected the time when vortex shedding was observed, the frequency of this process, the size of the vortices themselves and the structure of the drag. The addition of a magnetic field slightly reduced the frequency of vortex shedding. The future extension of this model into three dimensions may have application in a more detailed determination of the influence of magnetic field on vortex shedding.

Dynamics and magnetism of selected phenomena in the atmosphere of the Sun

Benko M.[1], Gömöry P.[1], Kuckein C.[2], Balthasar H.[2], Asensio Ramos A.[3], González Manrigue S.J.[1]

[1] *Astronomical Institute, Slovak Academy of Sciences, TatranskáLomnica, Slovakia*
[2]*Leibnizov Inštitút pre Astrofyziku Potsdam, Nemecko*
[3]*Instituto de Astrofisica de Canarias, IAC, La Laguna, Spain*

The aim of this work is investigation of the dynamics and magnetic field in a sunspot. For this purpose, the spectro-polarimetric observation obtained with the GREGOR telescope using the GRIS spectropolarimeter on June 20, 2016 was analyzed. The active region of AR12553 was observed in the spectral region of 1 μm. The basic physical parameters of the magnetic field of the studied spot (absolute size, inclination and azimuth of the magnetic field) in the photosphere and chromosphere were determined from the obtained Stokes profiles using the software tools SIR (Stokes Inversion based on Response functions) and HAZEL (Hanle and ZEeman Light). Based on these quantities, it is possible to determine the individual components of the magnetic field vector in the x, y and z axes. The dynamic properties of the sunspot were studied using Doppler velocities derived from the observed spectral lines forming in the photosphere and chromosphere.

On average rotational velocity of the solar corona

Dorotovič I., Rybanský M., *Slovak Central Observatory Hurbanovo*

The average rate of coronal rotation is determined from the results of various authors, while the main source of data is the work of Dorotovič and Rybanský (2019). The calculation must take into account the differential rotation, the reduction of the area towards the pole and the distribution of the tracers depending on the heliographic width. The resulting values of the mean synodic period of coronal rotation are compared with the mean period of occurence of geomagnetic disturbances, *i.e.* with the period of occurence of hypothetical M - regions on the Sun. Bartels (1932) set this period at 27.0 days. It seems that the period of coronal rotation determined by the movement of coronal structures (determined using a contrast method) agrees in the best way with this period and not with the period determined by the movement of coronal bright points. It follows from this that the bright points and the M - regions do not have common origin.

Drift of footpoints of the eruptive magnetic flux rope

Dudík J.[1], Lörinčík J.[1], Aulanier G.[2], Zemanová A.[1]

[1] *Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic*
[2] *Observatoire de Paris, LESIA, UMR8109 (CNRS), 92195, Meudon Principal Cedex, France*

The three-dimensional magnetohydrodynamic model of solar flares leads to new predictions regarding the behavior of the erupting magnetic flux rope. We found that its chromospheric footpoints drift during the flare. This phenomenon is linked to the development of flare ribbons, in particular their hook-shaped ends, which first expand and then contract. This phenomenon is accompanied by the reconnection of the erupting flux rope with the surrounding coronal loops, while the original anchors of the flux rope change into flare loops. In doing so, some magnetic induction lines reconnect several times. These predictions were confirmed by the observation of several solar flares. In some of them, a drift of the footpoints of the eruptive filament by more than tens of arc seconds was found, alongside other manifestations of three-dimensional reconnection.

Diagnostics of the kappa-distribution from EUV solar spectra

Dzifčáková E., Dudík J., Lorinčík J., Zemanová A.

Astronomical Institute of theCzech Academy of Sciences, Ondřejov, Czech Republic

Non-Maxwellian electron distributions with a high-energy tail can originate in the solar corona and transition region due to a strong gradient temperature or density or as result of some kinds of heating. This group of distributions exhibiting high-energy tails is well represented a kappa-distribution.The shape ofdistributions influences individual ionization, recombination and collisionalexcitation rateswhat changesthe relative spectral line intensities. This enables diagnostics of non-Maxwellian distributions from observations. Theoretical spectra for different kappa-distributions, temperatures and electron densities can becalculated using KAPPA package to propose distribution diagnostics for individual purposes. The proposed diagnostics of plasma parameters canbe applied on spectra of different structures and phenomena in the solar corona and transition region.We showed that the spectra of some solar features are strongly non-Maxwellian, including TR line profiles as well as line ratios in active region loops or in solar flares.

Vertical magnetic fields on evolving pores

García Rivas M.[1], Jurčák J.[1], Bello González N.[2]

[1]*Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic*
[2]*Kiepenheuer-Institut für Sonnenphysik, 79104 Freiburg, Germany*

Recent studies of sunspots have shown that there is a critical value (B_{crit}) of the vertical component of the magnetic field (B_{ver}) that triggers umbral mode of convection, i.e., only umbral convection is allowed in regions with $B_{ver} > B_{crit}$ .We study the existence of a B_{crit} in other magnetic structures, such as pores. The evolution of B_{ver} on the pore boundary during its lifetime shows the role of B_{ver} on the stability of pores.

Arch Filament Systems and their evolution through the layers of the solar atmosphere

González Manrique S.J.[1,2,3], Kuckein C.[4], Pastor Yabar A.[5], Diercke A.[4,6], Collados M.[1,2], Gömöry P.[3], Zhong S.[7,8], Hou Y.[7,8], Denker C.[4]

[1]*Instituto de Astrofísica de Canarias (IAC),*
[2]*Universidad de La Laguna (ULL),*
[3] *Astronomical Institute, Slovak Academy of Sciences, Tatranska Lomnica,Slovakia*
[4]*Leibniz-Institut für Astrophysik Potsdam (AIP),*
[5]*Stockholm University, Albanova University Centre,*
[6]*Universität Potsdam (UP),*
[7]*National Astronomical Observatories, Chinese Academy of Sciences,*
[8]*University of Chinese Academy of Sciences*

Emerging flux regions (EFRs) are seen as magnetic concentrations in the photosphere of the Sun. From a theoretical point of view, the EFRs are formed in the convection zone and then emerge because of magnetic buoyancy (Parker instability) to the solar surface. During the formation process of EFRs, merging and cancellation of different polarities occur, leading to various configurations of the magnetic field. Often, EFRs are visible in the chromosphere in form of magnetic loops loaded with plasma, which are often called “cool loops” when seen in the chromosphere along with dark fibrils and they can reach up to the corona. Nowadays, we refer to them as an arch filament system (AFS) which connects two different polarities. The AFSs are commonly observed in several chromospheric spectral lines. A suitable spectral line to investigate chromospheric features and particularly AFSs is the He I 10830 Å triplet. The new generation of solar telescopes and instruments such EST and DKIST, will allow us to record very high spectral, spatial, and temporal resolution observations necessary to investigate the dynamics, magnetic field, and characteristics of AFSs. These observations will help us to answer many open questions related to flux emergence such: (1) What are the observational consequences of the emerging flux? (2) How do EFRs evolve with time in the different layers of the solar atmosphere and how are these layers linked? (3) Is it possible to measure the height difference between the photosphere and the chromosphere connected by the legs of the AFSs?

Spectroscopy and Differential Emission Measure Diagnostics of a Coronal Dimming Associated with a Fast Halo CME

Gömöry P.[1], Veronig A.[2,3], Dissauer K.[2], Temmer M.[2], Vanninathan K.[2]

[1] *Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovakia*
[2]*Institute of Physics, University of Graz, A-8010 Graz, Rakúsko*
[2]*Kanzelhöhe Observatory for Solar and Environmental Research, University of Graz, A-9521 Treffen, Rakúsko*

We present analysis of the coronal dimming area related to the fast halo CME which was associated withthe C3.7 two-ribbon flare observed on 2012 September 27. We use Hinode/EIS spectroscopy and SDO/AIA imaging to study physical parameters of the event. Spectroscopic data revealed double-componentshapes of coronal emission line profiles which indicate velocities up to 130 km s^{-1} in the area of impulsive dimming onset.The electron densities estimated from the ratio of "upflowing" components of spectral lines at log T [K] = 6.2 reach 2×10^{9} cm^{-3}. The DEM analysis based on SDO/AIA data revealsimpulsive reduction of density by 40%–50% within ~10 minutes. The density values remain reduced in the dimming regionfor several hours.

SolarOrbiter – European mission to wards the Sun

Heinzel P., *Astronomical Institute of theCzech Academy of Sciences, Ondřejov, Czech Republic*

On February 10, American NASA launched from Florida ESA's Solar Orbiter probe towards the Sun. The payload contains 10 scientific instruments, 6 of them are "remote sensing" (telescopes) and 4 are "in situ" instruments to detect plasmas, waves and magnetic fields. Czech Academy of Sciences participated in the development and construction of three instruments. In this talk we will focus mainly on the space coronagraph Metis, which will study the solar corona, solar wind and coronal mass ejections (CME). We will show the satellite orbits in the interplanetary space a its periodical approaches to the Sun. Solar Orbiter will gradually change orbit inclination up to 30 degrees with respect to the ecliptic plane which will enable us, for the first time, to observe the solar poles. The principal goal of the project is a complex study of processes in the solar atmosphere and their influence on the surrounding heliosphere, including the Earth (the so-called space weather).

Influence of solar wind on the electric field in the Earth's ionosphere and atmosphere

Chum J., *Institute of Atmospheric Physics of the Czech Academy of Sciences, Czech Republic*

Solar wind, stream of charged particle from the Sun with frozen in interplanetary magnetic field, interacts with the Earth's magnetosphere, ionosphere and upper atmosphere by a complicated way via a number of mechanisms. Using our own measurements, we will focus on two effects.
a) prompt penetration electric fields observed globally during sudden commencements of geomagnetic storms. We will present observation of these electric fields (impulses) in the ionosphere from our network of continuous Doppler sounders. It will be shown that polarity of these fields is opposite on the day and night side.
b) influence of polarity of interplanetary magnetic field (IMF), namely its By component, on atmospheric electrostatic field (electric field between the ionosphere and ground surface). This effect is known from polar regions. At middle latitudes, it cannot be observed directly as it is covered by influence of local weather, fluctuations of aerosol concentration etc. It will be shown that the influence of the IMF polarity on electrostatic field might be detected using proper cross-correlation analysis of data also in middle latitudes.

The nature of sunspots

Jurčák J.[1], Bello González N.[2], Schlichenmaier R.[2], Rezaei R.[3], Schmassmann M.[2], García Rivas M.[1]

[1] *Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic*
[2] *Kiepenheuer-Institut für Sonnenphysik, 79104 Freiburg, Germany*
[3] *Instituto de Astrofisica de Canarias, Spain*

We summarise the recent observational results that show the importance of the vertical magnetic field component (B_{ver}) as the crucial parameter to inhibit convection in the solar photosphere. These studies show that sunspot umbrae are stable if and only if B_{ver} is stronger than a critical value of approximately 1.9 kG (0.19 Tesla). In areas with B_{ver} lower than the critical value, sunspot umbrae are unstable and prone to be occupied by a more vigorous modes of magneto-convection that will heat up and brighten these areas. This behaviour confirms the theoretical models of convection in the presence of magnetic fields that also predict the dependence only on B_{ver}.

Analysis of the first two principal components of the solar magnetic field

Kalenda P., *CoalExp, Pražmo 129, (Corresponding)*

The subject of the research are possible physical mechanisms, underlying the excitation of two major components of independent magnetic background fields detected by Principal Component Analysis (PCA) Zharkova et al. (2015).

It has been found that the optimal physically consistent approximation of the blue curve (= 1.PC) is the mutual impact of all planets with the greatest moment, that is planets, which shift the Sun from the barycentre of the entire Solar System, i.e. Jupiter, Saturn, Uranus, Neptune and especially Planet Nine, which is well detectable at all of approximations. The beat pulses have the character of pulses, well approximated by the fourth power of harmonic functions, which also has its physical explanation (integral of the magnetic and gravitational forces when the Sun moves in a changing gravitational and magnetic field).

The optimal approximation of the red curve (2.PC) is the sum of the harmonic functions of beats of the planets of large gravitational, magnetic and tidal influences with the whole Solar System and especially with the internal tidal planets (Mercury - Venus - Earth).

A survey and development of optical solar observations in Ondřejov

Kotrč P., *Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic*

Sporadic observations af the Sun began at the begining of the 20th century. A systematic study of solar activity started in 40ties when first steps to regular solar patrol appeared. It continues both at the traditional and higher technological level up to present. In 50ties observations with the spectrographs of original constructions, spectrohelioscops, chrompospheric telescopes, later on magnetographs and prominence telescopes were regularly performed. In 80ies observations with the new horizontal spectrographs HSFA began. In the recent ten years the solar robotic telescope is developed. Since 2014 the first experiments with a wide range solar spectrograph registrating spectral flux from an isolated flaring region are performed. Solar department also participates at the development of EST and using of GREGOR telescope.

Spectral break and spectral bump in two successive type II solar radio bursts

Koval A.[(1)], **Karlický M.**[(1)], **Bárta M.**[(1)], **Stanislavsky A.** [(2)], **Dorovskyy V.**[(2)],

[1]*Astronomical Institute of the Czech Academy of Sciences, Ondrejov, Czech Republic*
[2]*Institute of Radio Astronomy of NASU, Kharkiv, Ukraine*

Type II solar radio bursts are prominent radio signatures of coronal shocks and shock acceleration processes. It is generally accepted that these bursts are generated by energetic electrons accelerated at propagating shock waves driven by solar eruptions (i.e., flares or coronal mass ejections (CMEs)) via the plasma emission mechanism. They are usually observed within the metric-kilometric wavelength range. On the solar spectrograms type II bursts drift from high frequency to low frequency as bright narrow bands of fundamental and higher harmonic plasma radio emission. Although the type II band as a whole demonstrates a gradual drift on the solar dynamic spectrum, it exhibits intermittent structure. Evidently, the spectral shape of the type II burst depends on the properties of coronal plasma through which the shock wave propagates. Particularly, among different morphological features of type II bursts, spectral breaks and spectral bumps are of current interest. Recently, these spectral features have been interpreted as a result of the CME-streamer interaction (Kong *et al.*, 2012; Feng *et al.*, 2013).

In the present work, we report about two subsequent type II bursts in the Nançay Decametric Array (NDA) records, where the first event has a spectral break and the second one has a spectral bump (see Figure 1). For the first time, the both features observed in two successive type II bursts, most likely, generated by the same shock. We support the conception of origin of these morphological features based on the CME (shock) movement through a streamer. We attempt to obtain the parameters (magnetic field and electron density) of corona medium, including the streamer structure, along the shock path from analysis of the observed type II bursts. The possible scenarios of the CME-streamer interaction are considered.

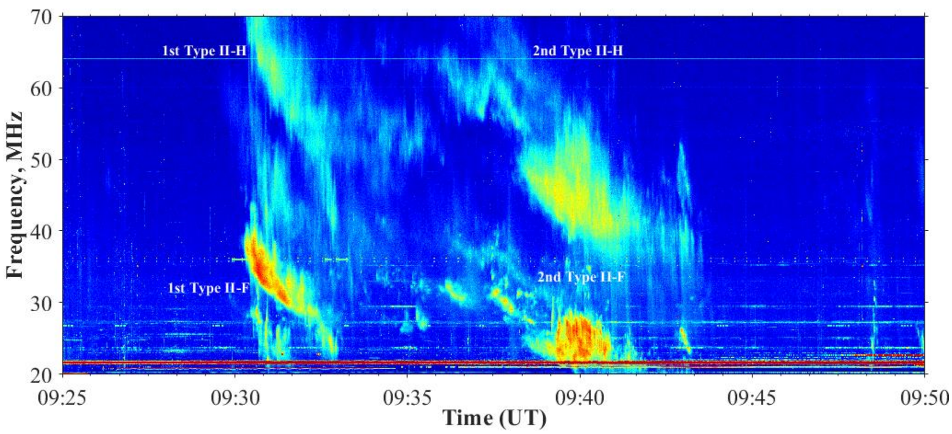

Figure 1. The NDA solar dynamic spectrum with two successive type II radio bursts recorded on March 17, 2004. The fundamental and harmonic components are labeled for both events.

New control system for radiotelescopes RT2 and RT5 in Ondřejov

Koval A., Krejcar J., Jiřička K., Bárta M., *Astronomical Institute of the Czech Academy of Sciences, Ondrejov, Czech Republic*

Radiotelescopes RT2 (7.5m dish) and RT5 (10m dish), located at the observatory of the Astronomical Institute of Czech Academy of Sciences in Ondřejov, are being used for radioastronomical research of the Sun already for decades. For the technical reasons (quite a massive construction), they are mounted on the azimuthal mount, which brings additional demands on their pointing to the celestial target - in our case the center of the solar disc: motions in azimuthal and elevation axes are irregular when tracking the Sun. Before the era of computers this problem has been solved by a specifically designed mechanical converter (in fact, a kind of mechanical calculator), which carried out the transformation of regular rotation of the clock machine to the irregular motions in the azimuth-elevation (Az/El) coordinates. The procedure relied on the accuracy of the entire mechanical system and did not contain any feedback for checks, whether the antenna is actually pointing to the Sun. In early 1990's it was therefore replaced by a simple computer-controlled system. From the known solar ephemeris it calculates the Az/El coordinates of the Sun and compares them (in regular 1-second intervals) with the antenna position as determined by the incremental rotation sensors connected to the azimuth and elevation axes. In case of difference, a current impulse is sent to the electromotive drive in the appropriate axis. This way a correction of the antenna position is done every second. The interfaces between the wires of the incremental rotation sensors (5V logics) and the PC, as well as that between the PC and electronic switch of the motors, have been implemented by means of specifically tailored cards inserted in slots of the ISA bus at the mainboard of the controlling PC. Although this system has been successfully working for years, in 2020 we have decided for its essential reconstruction. It was motivated namely by highly risky obsolescence of the HW with practical impossibility to acquire the spare parts for replacement (e.g., old PCs with the ISA-bus slots) in case of their failure. During the reconstruction the incremental rotation sensors has been replaced by their absolute counterparts, both interfaces (sensors to PC, and PC to electronic motor switch) were completely newly implemented on the popular programmable "Arduino" platform, and the entire controlling system has been connected to the new PC (which at the same moment serves as a primary data storage for the also recently newly reconstructed radiospectrograph) via the USB port. In addition to getting rid of the risky dependence on the highly obsolete HW, the new system has also other advantages. It allows - in line with the modern trends - for automatic calibration of the antenna-position sensors by searching for the maximum of signal (similar to, e.g., ALMA antenna "pointing calibration" performed before each execution block). Furthermore, it checks the elevation of the Sun above the local horizon and ensures soft start/stop of the entire system according to its value (so far we have used hard start/stop managed by the timer-controlled power socket). And last but not least: the new system allows for easy tracking of the other celestial bodies (besides the Sun), too. This can be utilized for flux calibration of the receiver or for a prospective night observing programme of the radiotelescope. Prototype of the new control system has been recently finished and currently it runs in a test regime in the RT2 dish. After the test completion (Fall 2020) it shall be replicated and its copy will drive also the radiotelescope RT5.

Re-analysis of physical parameters in the stratosphere

Kozubek M., *Institute of Atmospheric Physics of the Czech Academy of Sciences, Czech Republic*

During last years several new global reanalyses has been released (MERRA2, ERA5 or CFS v2). We compare behaviour of several parameters which are very important in the stratospheric dynamics and climatology. We analyze and compare temperature, wind and ozone climatology with existing observations. We analyze important stratospheric phenomena like SSW, QBO or ENSO and their interpretation in these new reanalyses. We analyze whole available periods for each reanalysis.
The trend analysis needs homogenous datasets without any artificial breakpoints. We also study is a detection of breakpoints in the temperature time series from the MERRA -2 and ERA 5 reanalyses with the help of the Pettit homogeneity test for all pressure layers above 500 hPa for each month of the year. We are looking for grid points where these breakpoints occur and also for years when they occur (geographical and time distribution. It is expected the results will be better for the Northern Hemisphere due to the denser data. We are interested in the spatial and vertical distribution of breakpoints as well. These results give us the knowledge about the suitability of both reanalyses temperature data for trend analysis in the future. Finally we computed trends of basic parameters for comparison.

Solar activity and climate change

Kučera A., *Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovakia*

Global warming, i.e. the increase of the average temperature on Earth in recent decades, is a fact that is based on measurements and no one doubts this phenomenon. However, there is no such consensus on why warming occurs. Basically, two groups are "fighting" against each other. One is of the opinion that human activity is predominantly involved in global warming (anthropogenic influence) and the other minimizes this human influence and places the main emphasis on the influence of natural phenomena, including mainly solar activity, cosmic radiation, volcanic activity and other influences.

The aim of this contribution is to explain the relationship between solar activity and temperature changes on Earth in the short and long term and to answer the question of whether solar activity is mainly responsible for the current warming of the Earth.

Is the relationship between ionospheric parameters and indices of solar activity stable?

Laštovička J., *Institute of Atmospheric Physics of the Czech Academy of Sciences, Czech Republic*

Stability of the relationship between ionospheric parameters and indices of solar activity is important for the study of climatology and long-term trends of ionospheric parameters as well as for modeling, because long-term series of homogeneous measurements of relevant parts of the solar spectrum are not available. We used annual values of ionospheric parameters foF2 and foE for four European stations with long-term data of high quality for the period 1976 - 2014 and indices of solar activity F10.7 and solar Lyman-alpha radiation Fα. This relationship was generally assumed to be stable, but it is shown here that this is not to be the case. Compared to the past, the dependence of ionospheric parameters on solar activity indices is stronger/steeper than before, with a break around 1996 for foF2 and 2000 for foE. The relationship between solar activity indices has also somewhat changed, indicating a possible solar cause of these changes.

Which solar index is best for long-term study of the ionosphere?

Laštovička J., *Institute of Atmospheric Physics of the Czech Academy of Sciences, Czech Republic*

Problem of the optimal index of solar activity is important for the study of climatology and long-term trends of ionospheric parameters as well as for modeling, because long-term series of homogeneous measurements of the relevant parts of the solar spectrum are not available. Here we choose from four indices F10.7, Mg II, solar Lyman-alpha flux Fα and relative number of sunspots R, which we apply to annual values of ionospheric parameters foF2 and foE for four European stations with long-term data of high quality for the period 1976 - 2014. For foF2 the Mg II seems to be optimal followed by F10.7, for foE, on the contrary, F10.7 is better than Mg II. Thus, it follows that for different ionospheric parameters there may be a different optimal index of solar activity. The Fα and R-number are a little worse, but no index is bad. The new recalibrated and homogenized R-numbers are clearly better than the original R-numbers in relation to ionospheric parameters.

A study of Kelvin-Helmholtz instability in solar partially ionised magnetised jets

Lomineishvili S.[1,3], Zaqarashvili T.[2,3,4], Gömöry P.[1], Kuridze D.[3,5,6], Tsiklauri D.[7].

[1] *Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovak Republic*
[2] *Space Research Institute, Austrian Academy of Sciences, Schmiedlstraße 6, 8042 Graz,*
[3] *Abastumani Astrophysical Observatory at Ilia State University, 3/5 Cholokashvili Avenue, 0162 Tbilisi,Georgia*
[4] *IGAM-Kanzelhöhe Observatory, Institute of Physics, University of Graz, Universitätsplatz 5, 8010 Graz, Austria*
[5] *Institute of Mathematics, Physics and Computer Science, Aberystwyth University, Ceredigion, Cymru, SY23 3BZ, UK*
[6] *Astrophysics Research Centre, School of Mathematics and Physics, Queen's University Belfast, Belfast BT7 1NN, UK*
[7] *School of Physics and Astronomy, Queen Mary University of London, London, E1 4NS, UK*

Kelvin-Helmholtz Instability (KHI) in solar, partially ionised, magnetised jets is studied. The jets are modelled as two magnetic slabs in a relative motion at an arbitrary angle. Using MHD equations of partially ionised plasmas, an analytical dispersion relation is obtained, which further is solved analytically and numerically for various settings pertaining to the solar chromospheric jets and prominences. The relative importance of partial ionisation and perpendicular magnetic field component on the onset and growth rate of KHI is quantified and discussed.

Research, engineering, and educational activities at the Department of Space Physics, Institute of Experimental Physics, Slovak Academy of Sciences

Mackovjak Š.[1], Baláž J.[1], Bobík P.[1], Langer R.[1], Kolárik M.[1], Pastirčák B.[1], Putiš M.[1], Strhárský I.[1], Štefánik S.[1], Štetiarová J.[1], Amrich S.[2], Harman M.[3], Varga M.[3]

[1] *Department of Space Physics, Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovak Republic*
[2] *Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic*
[3] *Department of Cybernetics and Artificial Intelligence, Faculty of Electrical Engineering and Informatics, Technical Universit, Košice, Slovak Republic*

The space program in Košice has more than 50 years-long tradition. It has started with the research of cosmic rays on Lomnický štít and participation in the Intercosmos program. At present, the research activities of the department focus on the modeling of cosmic rays in the heliosphere, studying airglow and participating in the scientific projects of international collaborations (JEM-EUSO, POEMMA, Baikal). Regarding engineering activities, we are preparing the ADM module for the ESA JUICE mission, the ASPECT-L device for the Luna-26 lunar mission, and AMON detectors for the EUSO-SPB2 mission. We also provide continuous measurements of secondary cosmic rays at the Lomnický štít Observatory and measurements of the thermosphere and ionosphere parameters at the Astronomical Observatory at Kolonický saddle within the AMON-net project. The educational activities of SPACE::LAB project consist of regular lectures for the public, summer schools, and competitions for students. During the overview presentation, all these current activities will be presented together with the achieved results. Possible cooperation with the community of Slovak and Czech solar physicists will be suggested, especially in the field of space weather research and the use of machine learning techniques.

Wavelet Separation Method (WASEM) and its use in solar research.

Mészárosová H., *Astronomical Institute of theCzech Academy of Sciences, Ondřejov, Czech Republic*

The Wavelet Separation Method (WASEM), based on the wavelet analysis techniques, isuseful for analysis of observational data maps consisting of two or more individual (quasi-)periodic physical phenomena. Such a data map mayalso contain a non-periodic emission(s). Thus,the WASEM is suitable when the original data maps (e.g., imaging data, space-time diagrams,dynamic spectra) consist of different physical structures that are observed, for example, at thesame observation site during the same time interval. In such a case, an interesting physical phenomenon but with a weaker emission may coincide in time with a strong emission. This strong component is usually well detectable (directly observable), while the weaker component remains hidden (overexposed). The possibilities of WASEM analysis for the detection of the hidden physical structures are presented using illustrative numerical simulations. The limits of using of this method and examples of its use in solar atmosphere research are discussed.

Spatial distribution of energy partitioning in a cold solar flare

Motorina G.G., *Researcher, Astronomical Institute ASCR; Pulkovo Observatory; Russia*
Fleishman G.D.,*New Jersey Institute of Technology, USA*
Kontar E.P., *School of Physics and Astronomy, University of Glasgow,UK*

Solar flares are the most energetic manifestation of solar activity. Although flare energy release is initiated by magnetic reconnection in the corona, a large part of observational evidence of their course is based on emission of lower layers, where electron beams penetrate to the chromosphere leading to ambient plasma heating. Thus it is important to look for the temporal relationship between non-thermal emissions of accelerated particles and thermal emissions, produced by plasma heated during a flare. In this way so-called ‘cold’ flares may be a rather clean case for studying thermal plasma heating in response to non-thermal electron acceleration in flares. These events are recognized by an absence of pre-flare heating, weak thermal response, prominent non-thermal emission, and compact structures with a strong magnetic field.

Here, we analyze a 'cold' solar flare 2013-Nov-05, which was well-observed by SDO/AIA and RHESSI. We conduct a detailed DEM analysis of SDO/AIA data to estimate the moderately heated component. We use the RHESSI data to quantify the hot component of the flaring plasma and the non-thermal component. To complement our study, we build a 3D model using the GX Simulator tool, photospheric magnetic measurements, microwave (NoRP, RSTN, SRS) and X-ray imaging and spectroscopy data. We show that morphologically the flare consisted of two reasonably compact flux tubes, where a single episode of electron acceleration happened, and that the non-thermal energy deposition over the impulsive flare phase matches the sum of the thermal energies of the two flaring flux tubes. We discuss physical implications of the obtained results.

Study of the white-light emission during the X9.3 flare on 6 September 2017

Mravcová L., *Astronomical Institute of the Czech Academy of Sciences, Prag, Czech Republic*

The X9.3 solar flare (SOL2017-09-06T11:53) was one of the strongest solar flares in the solar cycle. In our study, we focused on the emission in the white light continuum known as the white-light flares. We used data provided by SDO/HMI to detect the emission. These observations show reconstructed pseudo-continuum that should correspond to the Paschen continuum. The flare region was also scanned by Hinode/Solar Optical Telescope, which we used for checking the quality of the SDO/HMI data. The flare was also detected by the instrument LYRA where we can observe an emission in the Balmer continuum. There is a supposed relationship between the emission in the Balmer and in the Paschen continuum. The aim of this study is to compare these two emission types and test the assumption that one can be easily computed by using the other.

Great minima and maxima of the solar activity

Pastorek L., *Slovak Central Observatory,Hurbanovo*

A summary of the basic long-term periods and Maunder minimum like long-term extremes found in the solar activity. These long-term variations in solar activity have been reported both on the basis of direct long-term observations of sunspots with the naked eye and telescopes, and indirectly using cosmogenic radionuclides of ^{14}C and ^{10}Be.

Observations of the Sun in Ondřejov before 1956

Pavelková M., *Astronomical Institute of the CAS, Ondřejov, Czech Republic*

The first mentions of the observation of the Sun at the observatory in Ondřejov can be found in the astronomical magazine Říše hvězd from the year 1917. The data itself, we will probably never find anymore. In the archives of the Astronomical Institute of the ASCR, however, are hidden other treasures with original drawings of observations, including descriptions of the current weather, the shape of prominences, their coordinates and Ondřejov own classification or telegrams intended for prof. Kiepenheuer to determine suitable radio frequencies for communication. In addition to such material resources, we have also memories of still living witnesses and their children. All the data show that the Sun was regularly observed at the observatory before the Solar Laboratory building was built in 1956 or even before the spectrohelioscope was built in 1942.

Geomagnetic Dst index and its significance for geomagnetic activity modeling

Revallo M., *Earth Science Institute of the Slovak Academy of Sciences, Dúbravská cesta 9, 840 05 Bratislava, Slovak Republic*
Valach F., *Geomagnetic Observatory, Earth Science Institute of the Slovak Academy of Sciences, Komárňanská 108, 947 01 Hurbanovo, Slovak Republic*
Hejda P., *Institute of Geophysics of the Czech Academy of Sciences, v.v.i., Boční II/1401, 141 31 Praha 4, Czech Republic*

The geomagnetic Dst index plays an important role not only as a quantitative measure of geomagnetic disturbances but can also, for example, serve to obtain a physical insight to the processes of solar wind energy transfer to the magnetosphere. In this contribution, we focus on magnetic storms in different phases of the solar cycle in terms of their causes (CME and CIR). Based on the solar wind data, we will analyze the geomagnetic response described by the Dst index. The simulated series of the Dst index obtained on the basis of an empirical model of the interaction of the solar wind and the magnetosphere will be compared with real data. We will examine empirical models for producing the time series of the Dst index and suggest possible approaches for further parametrization and refinement of these models.

Non-LTE modelling of a small-scale arch filament located in the active region

Schwartz P.[1], Heinzel P.[2], Balthasar H.[3] , Kuckein C.[3], Verma M.[3], Denker C.[3], González Manrique S.J.[1]

[1]*Astronomical Institute of Slovak Academy of Sciences, 05960 Tatranská Lomnica, Slovak Republic*
[2]*Astronomical Institute, Academy of Sciences of the Czech Republic, 25165 Ondřejov, Czech Republic*
[3]*Leibniz-Institut fürAstrophysik Potsdam,14482 Potsdam, Germany*

We present reset sof the non-LTE modelling of the small-scalearc filament located in the aktive region AR12597observed spectroscopically in the Hαline on 28 September 2016 with the Echelle spectrographat the VTT telescope. Itisassumed in the model that filament of such a type iscomposedof flux-tubeslocated in the transitiv region and/or corona and relative lycool plasma canflowalong these flux-tubes with variol velocities. The flux-tube
Systém is approximated in the model by the 2D horizontal slab where its finite dimensions formits crosssection and the in finite dimension is parallel to the solar surface. The is o thermal and isobaric slabisir radiated from the bottom and the sides and the non-LTEradiative transfer in the 2D geometry is solvedusing the MALI numerice technique. Assuming that flux-tubes are oriente dalos the magnetic field, orientation of plasma flow in the slabis defined by the azimuth and inclination an glesof the magnetic field. Moreover, all unresolved plasma motions in the slab are characterized by the velocity of micro-turbulence asanad ditionalinput parameter of the model. Simultaneously with the Hα observations the full-Stokes spectro polarimetric data in the in frared HeI triplet werealso obtained with the GRIS polarimeter locate dat the GREGOR telescope. These
Spectro polarimetric data providedus with the posibility of estimation of the magnetic field vector usingt he HAZEL in vision code. Thus, azimuth and in clination anglesof the plasma-flow velocity are fixed in the model and the absolute magnitude of the velocity can beobtained. Fur ther on we are applying in the model also fine structure using more 2D slabs with different physical propertiese speciály velocities and also variations of temperature and pressure which shoul dresem blebetter the systém of flux-tubes. Results of the modelling whe nusing suchimproved model are then compared with those obtained with the simple single-slab model and iti sevaluated whether reset softhe improved model resemble observations better thant hosegot from the simple model.

Chromospheric heating by acoustic waves I – Models

Sobotka M., Abbasvand V., Heinzel P., Švanda M., and Jurčák J., *Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic*

Acoustic and magnetoacoustic waves are considered to be possible agents of chromospheric heating. We present a comparison of deposited acoustic energy flux with total integrated radiative losses in the middle chromosphere of the quiet Sun and a weak plage. The comparison is based on a consistent set of observations in the Ca II 854.2 nm line acquired by the IBIS instrument attached to the Dunn Solar Telescope. The deposited acoustic-flux energy is derived from Doppler velocities observed in the line core and a set of 1737 non-LTE semi-empirical models, which also provide the radiative losses. The models are obtained by scaling the temperature and column mass of five standard non-LTE models VAL B – F (Vernazza et al. 1981) to get the best fit of synthetic to observed profiles. We find that the deposited acoustic-flux energy in the quiet-Sun chromosphere contributes by 30% - 50% to the energy released by radiation. However, this contribution is probably reduced by a "magnetic shadow" of the plage nearby. In the plage with magnetic field, it balances 50% - 90% of the radiative losses.

How the historical observatory Clementinum recorded magnetic storms?

Valach F., Geomagnetic *Observatory of the Earth Science Institute, Slovak Academy of Sciences, Hurbanovo*
Hejda P., *Geophysical Institute of the Czech Academy of Sciences, Prague*
Revallo M., *Earth Science Institute of the Slovak Academy of Sciences, Bratislava*

Besides the astronomical and meteorological observations, between years 1839 and 1917 the historical observatory of Prague also carried out regular geomagnetic observations. These observations belong to the oldest systematic observations of their kind. In doing so, some very unique magnetic storms were recorded; on one of them, which was observed on 17 November 1848, we reported during the last Solar Physics Meeting. In the present talk, we focus the then techniques of the geomagnetic field observations, especially the technique that was used for the measurements of the horizontal intensity (so called *H*-component). In Clementinum, the measurements of the *H*-component started at the very beginning of the regular geomagnetic observations and continued until the end of 1914. Like the nowadays routine, the measurements consisted of recording the geomagnetic field variations and the absolute measurements. The variation instrument was a bifilar magnetometer and the absolute measurements were done by means of classical Gauss's absolute method. At the present time, challenging re-processing of the records from this unique observatory are in progress. In our talk we also indicate some difficulties that we have hitherto faced when dealing with the records and we show our solutions.

Doppler velocity drift in solar prominences

Zapiór M., *Astronomický ústav AV ČR, Ondřejov, Česká republika*

Solar prominence plasma consists of different chemical elements, which can be in neutral or in ionized state. In the presence of prominence oscillations, caused by MHD waves, neutrals and ions should behave differently, because perturbation of the magnetic field directly affects ions only. I will present the latest results of prominence oscillations collected with HSFA-2 spectrograph located in Ondrejov Observatory. The discrepancy between Doppler velocity, called drift, observed in different spectral lines of neutrals and ions will be analyzed.

A Remarkable Confined Flare Accompanied by Rarely Observed Slowly Positively Drifting Bursts in Radio Frequencies 0.8-2.0 GHz

Zemanová A., Karlický M., Kašparová J. and Dudík J., *Astronomical Institute of the Czech Academy of Sciences, Ondřejov, Czech Republic*

We will present an observation of very interesting confined flare which started within active region, and then it expanded into huge magnetic rope with embedded cold filament, lying outside the active region. During this expansion we observed a cusp structure and several slowly positively drifting burst within the radio frequencies of 0.8-2.0 GHz. So far this type of bursts is rarely observed and their origin is not known. As our radio spectrum does not provide us with any spatial information, we analyzed the multi-spectral data (H-alpha, UV/EUV, hard X-rays. radio) and carefully followed the flare evolution to investigate the circumstances which may lead to generation of such bursts.