General Assembly of the Czech Astronomical Society

Student meeting

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Book of abstracts

Karolína Knesplová
Silesian University, Institute of Physics in Opava

Karolína Knesplová: Optical continuum in solar flares
Solar flares are an energetic process that affects all layers of the Sun's atmosphere and causes emission across almost the entire latitude of the electromagnetic spectrum. A substantial part of the emitted energy is in the form of the so-called continuum, however, the origin of this emission is not yet sufficiently clarified. The aim of the work will be to analyze the spectral and image data from the FICUS (Flare Intensity Continuum Ultrawide Spectrograph) instrument, which is intended for the observation of solar eruptions in the entire range of the optical spectrum.

Samuel Amrich
Charles University Faculty of Mathematics and Physics; Department of Space Physics, Institute of Experimental Physics, Slovak Academy of Sciences

Samuel Amrich; Šimon Mackovjak; Silvia Kostárová; Adam Majirský: Vigil-ML: Study toward enhancing reliability and timeliness of Vigil mission predictions through Machine Learning
The space mission Vigil is the first of its kind by the ESA, designed to observe the Sun from the Lagrange point L_5 and provide real-time information about potential space weather events. Its launch is scheduled for the year 2029. Vigil is a specialized probe in a long line of satellites studying the Sun, such as SOHO, SDO, or STEREO. The rationale behind its focus on space weather events is their potential impact on our technological society. During intense events, temporary or permanent damage to communication satellites, power grids, or user microelectronics may occur. Early warning of such events can partially or almost completely minimize negative impacts. Therefore, our work focuses on quantifying the capabilities of the Vigil probe using model data from previous missions and artificial intelligence methods. Our primary objective involves the analysis and find data from existing solar satellites with similar characteristics to data obtained from the future Vigil satellite. Subsequently, we aim to explore the possibilities of using artificial intelligence methods to predict extreme space weather events. We have thus far examined the similarities and differences between the Vigil satellite and previous missions. During the presentation, we will highlight the similarities and distinctions of the Vigil satellite compared to previous missions. Additionally, we will delve into the dynamics of CMEs and their impact on the heliosphere, Earth's magnetosphere, and the surface technology.

Vitalii Kuksenko
Faculty of Mathematics, Physics and Informatics of Comenius University

Vitalii Kuksenko: Fireballs as a probe of the Solar System evolution
Cosmogonic models of the Solar System describe its evolution involving various scenarios that are based on different physical mechanisms. Since there are many models, we need some tool to test them for their accuracy. Here we will present a new approach based on meteor observations. The icy to rocky material ratio of the Oort cloud is a key observational constraint of our interest. Our goal is to calculate the total flux of refractory objects coming from the Oort cloud region. We will introduce our preliminary results of the analysis of the All-Sky Meteor Orbit System (AMOS) database. Our methodology used to search for the extremely dense meteoroids on cometary orbits will be presented. We will present the Tisserand invariant as an orbital characteristic and empirical strength parameters as an indicator of the material of the object. The analysis of potentially extreme cases will be provided.

Łukasz Rogiński
Uniwersytet jm. Adama Mickiewicza v Poznaniu

Łukasz Rogiński: Meteorites of Central and Eastern Europe
In this presentation we will take insight into meteorites in Central and Eastern Europe, with a focus on

specimens from Poland, Czechia and Slovakia. It outlines the classification of meteorites and examines their locations in the region, highlighting both documented finds and those which haven't been found yet. Special attention is given to the largest European iron meteorite Morasko near Poznań and the most famous Czech tektite Moldavite. This presentation offers valuable insights into the historical, geological and astronomical significance of these celestial visitors close to our home.

Dmytro Orikhovskyi

Astronomical Institute of the Slovak Academy of Sciences

Dmytro Orikhovskyi, Theodor Pribulla: Rotational axes of exoplanets

The number of hot Jupiters on misaligned orbits around hot and rapidly rotating stars has been steadily increasing. Fast rotation of exoplanet host stars causes their flattening and in misaligned systems leads to precession of the orbital planes and rotational axes of planets. The orbital plane precession results in transit duration variations due to the changes in the orbital plane inclination angle.

While the Doppler tomography of transiting exoplanets is the most reliable way to determine projected spin-orbit misalignment, gravity darkening in fast rotators can produce asymmetric transit light curves that can constrain the misalignment. This is possible, however, only relatively easy in high-precision satellite data.

The first results of the search for misaligned and precessing systems using the TESS satellite light curves are presented. Preliminary orbital and planetary parameters for the most promising systems are given.

Marco Souza de Joode

Faculty of Mathematics and Physics, Charles University Prague

Marco Souza de Joode: Modeling of protoplanetary disks based on ALMA and VLT measurements

The protoplanetary disk DoAr44 (Haro 1-16, V2062 Oph) is a pre-transitional disk in the Ophiuchus star forming region. A large observational dataset is available, including ALMA complex visibilities, VLTI/GRAVITY continuum squared visibilities, closure phases and triple products, VLT/UVES and VLT/X-shooter H-alpha spectra, and spectral-energy distribution measurements, including observations from ground-based optical observatories, the IRAS satellite and the Spitzer Space Telescope, the Sub-Millimeter Array, the 30-m IRAM radio-telescope, and the Australia Telescope Compact Array.

This work presents a comprehensive physical multi-scale kinematic LTE radiative transfer model, constructed in *Pyshellspec*, describing the inner and the outer disk using 21 free parameters. According to this model, the VLT spectral line profiles are explained by an optically thin spherical inflow/outflow region within the co-rotation radius of the protostar, with velocities around 330 km/s. The VLTI near-infrared interferometric observables can be accounted for by an inner disk region extending from 12 to 35 solar radii. The ALMA visibilities are compatible with a narrow dust ring, extending from 40 to 60 au.

The density profiles in these physical models are discussed, and they are compared to simple analytical mathematical models fitted to the data via Markov chain Monte Carlo techniques, as well as to other observations, such as VLT/SPHERE coronographic images.

David Kománek

Astronomical Institute of the Czech Academy of Sciences

David Kománek, Richard Wünsch: Re-accretion of wind and supernova matter onto a central black hole

I will present simulations of supernovae exploding inside interstellar bubbles formed by fast stellar wind. The bubbles are made up of hot, shocked wind surrounded by thin, dense shells of swept-up interstellar matter. If the shell is sufficiently massive, the supernova ejecta cannot pass through the shell and becomes trapped inside the bubble. Subsequently, a black hole left behind by the supernova may re-accrete some of the supernova ejecta, the wind, or even the swept-up interstellar gas. This mechanism could significantly

increase the mass of the black holes and potentially explain the existence of stellar black holes with masses exceeding 45±5 solar masses detected by LIGO/VIRGO. These black holes fall into an expected mass gap caused by pair instability. Simulations of the entire process will be presented, demonstrating the amount of supernova ejecta, wind, and shell gas that can be reaccreted onto the black hole.

Myank Singhal

Astronomical Institute of Charles University

Myank Singhal: Evolution of Disk-like Structures in the Galactic Centre

In this work, we present an understanding of the complex mechanisms that govern the evolution of orbits in the Galactic Centre. Through N-body simulations, we have gained crucial insights into the evolution of disk-like structures in the Galactic Centre. We see that post-Newtonian corrections and perturbative effects are critical in stabilising these structures. In their absence, these structures would disintegrate due to vector resonance relaxation. Additionally, our research has demonstrated how these disk-like structures can split and create multiple disks with different properties, which could explain both clockwise and counterclockwise disks, as well as the highly debated disk-like structures in the S-star cluster. Our findings shed light on the intricate interplay between gravitational forces from different bodies that shape the dynamics of stars, dusty sources, and compact stellar remnants in the Galactic Centre, providing an important theoretical contribution to the field.

Wathela Alhassan

Nicolaus Copernicus Astronomical Center

Wathela Alhassan, T. Bulik, M. Suchenk: Einstein Telescope: Detection of binary black holes using deep learning

Continuing from our prior work (Alhassan et al. 2022), where a single detector data of the Einstein Telescope (ET) was evaluated for the detection of binary black hole (BBHs) using deep learning (DL). In this work we explored the detection efficiency of BBHs using data combined from all the three proposed detectors of ET, with five different lower frequency cutoff (Flow): 5 Hz, 10 Hz, 15 Hz, 20 Hz and 30 Hz, and the same previously used SNR ranges of: 4–5, 5–6, 6–7, 7–8 and >8. Using ResNet model (which had the best overall performance on single detector data), the detection accuracy has improved from 60%, 60.5%, 84.5%, 94.5% and 98.5% to 78.5%, 84%, 99.5%, 100% and 100% for sources with SNR of 4–5, 5–6, 6–7, 7–8 and >8 respectively. The results show a great improvement in accuracy for lower S NRcoh ranges: 4-5, 5-6 and 6-7 by 18.5%, 24.5%, 13% respectively, and by 5.5% and 1.5% for higher SNR ranges: 7–8 and >8 respectively. In a qualitative evaluation, ResNet model was able to detect sources at 86.601 Gpc, with 3.9 coherent SNR and 13.632 chirp mass at 5 Hz. It was also shown that the use of the three detectors combined data is appropriate for near-real-time detection, and can be significantly improved using more powerful setup.

Kamil Bicz

Astronomical Institute of the University of Wrocław

Kamil Bicz, Robert Falewicz, Małgorzata Pietras: Unveiling the Unseen: Analyzing CD-36 3202's Light Curve and Unprecedented Long-Duration Flare

We would like to present the study of the light curve of the star CD-36 3202, observed by TESS for the presence of stellar spots, and to analyze the longest ever (so far) rotationally modulated white-light flare. The duration of the flare was approximately 27 hours. We modeled the light curve of the CD-36 3202 and estimated that three spots are present on its surface. The mean temperature of the spots was about 4000±765 K, and the total spottedness was on average 11.61%±0.13%. The rotational modulation of the flare's light curve made it possible to estimate the latitude of the flaring region, which was found to be 69^{+2}_{-1}°. Our estimation of the flare's location was the first recreation of the exact position of a flare compared with the spots for a star other than the Sun. The flare is placed 12° from the center of the coolest spot. Removing the effects of rotational modulation from the flare light curve allowed us to correct the estimation of bolometric energy released during the event from $(1.15\pm0.35)\times10^{35}$ erg to $(3.99\pm1.22)\times10^{35}$ erg. Additionally, the flare was covered by the absorbing structure above the flaring region. The structure caused

three occultations during the flare, each with a different shape. These occultations allowed us to recreate the evolution of the shape of this structure and its physical parameters. One of the results is the mean electron density $n_e \sim 7\times10^{13}$ cm^{-3} which is comparable to values reported for some stellar superflares.

Jiří Wollmann

Astronomical Institute of the Czech Academy of Sciences

J. Wollmann, P. Heinzel: Modeling of radiative properties of stellar CMEs

While solar CMEs and related eruptive prominences are routinely observed by space coronagraphs, spectral signatures of stellar CMEs have been discovered only recently. They are interpreted as a Doppler-shifted prominence emission seen in various optical lines, indicating large flow velocities away from the stellar surface. To model such eruptive prominences in the cores of CMEs, we use our 2D non-LTE radiative-transfer code MALI and predict spectral line characteristics of the moving prominence, depending on thermodynamic plasma parameters, altitude in the corona and the flow velocity. As an example we show the modeling of well detected event on the solar-type star EK Dra. The method presented is enough general and allows to simulate the radiation properties of stellar eruptive prominences embedded within CMEs.

Melina Carla Fernandez

Universidad Nacional de La Plata, Argentina

M.C. Fernandez, R.O.J. Venero, L.S. Cidale, I. Araya & M. Curé: Hydrodynamic solutions for radiation-driven winds in transition regions

The standard theory for modeling the radiation-driven winds for hot stars is the m-CAK theory. This theory describes the radiation force between three parameters: α, δ, and k. In particular, δ introduces changes in the ionization of the material and can produce two different types of solutions for the hydrodynamics equations for slow rotating winds. These solutions called “fast” and “δ-slow”, have very different terminal velocities. Furthermore, they are separated with a gap (in the space of δ), where no stationeries solutions can be found. In this work, we use a time-dependent hydrodynamic code, named ZEUS-3D, that solves the equation of motion following the temporal evolution of a given initial solution, to find solutions in the gap. We present here the solutions found, and an important characteristic is a stationary kink they have, at a fixed distance of the star, depending on the value of δ. This discontinuity in the solutions can be related to the Discrete Absorption Components (DACs) in the spectra of massive stars. To evaluate this possibility, we solve the transfer equation in a co-moving frame for Si IV and analyze the synthetic spectra obtained.

Iris Bermejo Lozano

Astronomical Institute of Charles University

Iris Bermejo Lozano, Gregg Wade, Daniela Korcakova: The first magnetic B[e], IRAS17449+2320. Open door to a new interpretation of the origin of FS CMa stars

FS CMa stars are a subgroup of peculiar B-type stars that present the B[e] phenomenon, i.e. forbidden emission lines of low ionization, strong Balmer emission lines, and infrared excess. These characteristics are produced due to the large circumstellar matter and gas surrounding the star. The origin of this material is still unclear, the most accepted scenario to explain is the binarity. The dust and gas are produced due to an interaction between the two components of the binary system and remain around it. However, only a few FS CMa stars have a well-known companion to date. The second scenario was introduced by the discovery of a magnetic field in IRAS17449+2320. Theoretical models point out that magnetic fields can be formed during a merger process of the two members of the binary system and stay stable over time, and a huge amount of material is released around the new object, forming a disk. We analyzed seven spectropolarimetric observations taken during the last 18 years with ESPaDOnS at the CFHT telescope. These data prove the variability of the magnetic field of IRAS17449+2320, and constrain its possible periods. With these stellar parameters, the Oblique Rotator Model is fitted into the data, showing that IRAS17449+2320 presents one of the strongest magnetic fields among main sequence magnetic stars already known, and is the first magnetic B[e] stars detected to date.

Kristián Vitovský
Astronomical Institute of Charles University

Kristián Vitovský, Miroslav Brož: Hydrodynamical models of the β Lyr A circumstellar disc
We present models of dynamics of circumstellar discs, with a focus on the β Lyrae A binary system. This system is an archetype of ongoing mass transfer and has been extensively observed. All these observations were recently interpreted using a radiation-transfer kinematic model (Brož et al. 2021). To our aim, we modified the analytical models by Shakura & Sunayev (1973) for a general opacity prescription, and derived radial profiles of various quantities. The profiles were computed for the accretion rate $\dot{M} = 2\times10^{-5}\ \mathrm{M_\odot\ yr^{-1}}$, inferred from the observed rate of change of the binary period. Informed by the results from the analytical models, we computed time-dependent numerical models, using 1-dimensional radiative hydrodynamics (Chrenko et al. 2017), accounting for viscous, radiative as well as irradiation terms.
Our models show, that to achieve the accretion rate, the surface densities must be much higher (of the order of $10^4\ \mathrm{kg\ m^{-2}}$ for $\alpha = 0.1$) than in the kinematic model. Viscous dissipation and radiative cooling in the optically thick regime lead to a high midplane temperature T (up to 10^5 K). Yet, the disc is still gas pressure dominated. To reconcile temperature profiles, we had to distinguish three different temperatures: midplane, atmospheric and irradiation. The latter two are then comparable to observations (30000 to 12000 K). Due to the high densities and temperatures the aspect ratio H/r of 0.08 can be achieved in a hydrostatic equilibrium.

Aynur Abdulkarimova
Shamakhy Astrophysical Observatory

Olga Maryeva, Sergey Karpov, Alexei Moiseev, Dmitry Oparin: The evolutionary status of J040901.83+329355.6
Every discovered new star with a Wolf–Rayet spectrum necessitates a thorough examination of its evolutionary status before inclusion in the Galactic Wolf–Rayet (WR) star list. One of these objects is a J040901.83+323955.6 was identified as a WR phenomena star in the LAMOST spectroscopic database through machine learning methods a few years ago. Our study focuses on investigating its evolutionary status. Through analyses of spatial and color-magnitude diagrams, photometric variability, and its position on the Hertzsprung–Russell diagram, our findings suggest that J040901.83+323955.6 is a low-mass star in a rare transitional phase towards becoming a central star of a planetary nebula.

Zeťo Xia
Masaryk University, Brno

Xia C., Mikulášek Z., Janík J.: Period analysing of chemically peculiar stars
About 10% of stars on the upper main sequence show an anomalous abundance of at least one chemical element on their surface layers. Due to anomalous chemical abundance, photometric spots may appear on their surface. These photometric spots cause strictly periodic variability in their light curves. We determined the rotational period of several chemically peculiar stars using data from TESS mission.

Pavol Mártonfi
Prírodovedecká fakulta Univerzity Pavla Jozefa Šafárika v Košiciach

P. Mártonfi, R. Gális, J. Merc: Radial velocities of the emission lines in the spectra of the symbiotic system AX Persei
Symbiotic stars are interacting binaries in which mass is transferred from the cool component to the hot one that is responsible for the manifestation of their activity – outbursts causing significant changes in their light curves and spectra. One of the first known variable star from this category is the classical symbiotic system AX Persei. Although this system is studied for decades, new results from its research can still surprise. In our previous research, we studied the photometric activity and orbital period of this binary. In this contribution, we present the investigation of the radial velocities of prominent emission lines in the system's spectra. Observations from the ARAS database were adopted and four methods of radial velocity measurements were employed. In the case of the lines composed from multiple components, they were split into individual profiles and the radial velocity values were measured separately for each of them. Finally, we performed

period and correlation analysis of the radial velocity curves. The occurrence of the period near the orbital one (681.2 ± 8.3 days) and high mutual correlation coefficients were expected.

Jakub Kolář

Masaryk University, Brno

Jakub Kolář: Squadra: observing group of multiply eclipsing stars

Doubly eclipsing systems represent a new and rapidly developing scientific field in variable stars astrophysics. New precise and long-term photometric and spectroscopic data make studying these systems more detailed and understanding their nature, numbers, and properties possible. We will present our observing group, show methods to find new quadruple stars and summarize our recent general results.

Alžběta Oplištilová

Astronomical Institute of Charles University

Alžběta Oplištilová, Miroslav Brož, Petr Harmanec, Christian Hummel: The VLTI/GRAVITY observations of the brightest stars in the Orion belt

Massive stars have relatively short lifetimes (millions of years), however, they are crucial cosmic engines with influence on cosmic evolution that outlasts their lives. They exert strong feedback on their environment and are not only essential sources of energy, ionising photons, and heavy chemical elements – through stellar winds or core-collapse supernova explosions – but also precursors of neutron stars, black holes, and consequently gravitational wave sources. The very characteristic of massive stars is multiplicity. More than 90% massive hot OB stars possess or have possessed at least one massive stellar companion, which influences their evolution throughout their entire lives. Massive star's evolution still remains poorly constrained by observations. The primary kind of observation constraining diameters is the long-baseline interferometry. While the most massive stars in the LMC are too distant (50 kpc) for interferometric measurements, the Orion OB association in our Galactic vicinity hosts several massive stars, e.g., Delta, Epsilon, Zeta, and Sigma Ori. We have already constructed a model (Oplištilová et al. 2023) of a triple star Delta Ori A based on various kinds of observations (photometry, astrometry, radial velocities, eclipse timings, eclipse duration, spectral line profiles, and spectral energy distribution), except for interferometry; VLTI/AMBER data was not useable. The conclusions were that the compact binary of Delta Ori is a pre-mass-transfer object, while the tertiary seems to be unusually inflated (according to the HR diagram). We also noticed that Delta Ori could be related to other bright stars in Orion, in particular, Zeta Ori, which has a surprisingly similar architecture, or Epsilon Ori, which is a single supergiant and possibly a post-mass-transfer object. Therefore, we applied for and successfully obtained VLTI/GRAVITY interferometric observations to accurately determine angular diameters of the stars in the Orion belt. With this constraint, we are going to discuss their evolutionary stage.

David Korda

Astronomical Institute of the Czech Academy of Sciences

David Korda: Foundations of Artificial Intelligence: Exploring Neural Networks

This lecture offers a comprehensive exploration of neural networks, focusing on practical methodologies for model development and application, complemented by interactive examples. Beginning with a clear definition and overview of neural networks, the presentation transitions into practical aspects, detailing the step-by-step process of designing, training, and deploying neural network models for real-world problems. Attendees will gain practical insights into data preprocessing, model architecture selection, hyperparameter tuning, and evaluation techniques, essential for effective neural network development. The interactive demonstrations and code snippets showcasing the usage of popular tools and frameworks that simplifies the implementation and experimentation process.