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Zoom

Book of Abstracts

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1

“Searches for anomalies in gravitational-wave data as a tool for signal detection and detector characterization

Authors: Filip Morawski[1]; Michał Bejger[2]

[1] *Nicolaus Copernicus Astronomical Center*

[2] *CAMK*

Corresponding Authors: bejger@camk.edu.pl, fmorawski@camk.edu.pl

Detection of the first gravitational wave (GW) in 2015 inaugurated the era of gravitational astronomy. Up to date, more than sixty GW detections has been announced thanks to the observational effort of LIGO and Virgo Collaborations working on Advanced LIGO and Advanced Virgo interferometers. GWs are emitted in violent phenomena, during which time-space changes dynamically. The GW contracts and expands the space through which it passes. However, after travelling over astronomical distances from the source of the emission to the Earth, this effect is little. For example, the deformation of a 400 km object is smaller than 10-19 m. The detection of such a weak signal is further complicated by the noise generated practically through everything: transport, seismic activity, atmospheric conditions or quantum noise from the interferometer. Usual approaches in searching for GW require the knowledge about exact shape of the GW waveform in order to extract the signal from noise dominated data. However, within this project we propose to use an alternative method that focuses on anomalies within the data. The anomaly is any type of signal different from the non-stationary noise from the detector: it might be GW but also detector artifact (called glitch) influencing the quality of data.
During the talk I am going to present preliminary results of anomaly detection searches utilizing deep learning algorithms both on simulated detector data as well as real data from O2 run. Among studied anomalies will be gravitational waves emitted by binary black hole merges as well as sine-gaussian glitches.

Student presentations / **2**

Kinetic numerical simulations of particle acceleration mechanisms in relativistically magnetized jets of blazars

Authors: José Ortuño Macías[1]; Krzysztof Nalewajko[2]

[1] *Nicolaus Copernicus Astronomical Center*

[2] *Nicolaus Copernicus Astronomical Center, PAS, Warsaw, Poland*

Corresponding Authors: knalew@camk.edu.pl, jortuno@camk.edu.pl

High-energy astrophysical phenomena reveal signatures of non-thermal particle energy distributions. Among them stand blazars with very broad photon spectra, from radio up to very high energy ($\sim$ TeV) gamma rays and variability on timescales ranging from decades to minutes. Relativistic magnetic reconnection offers an attractive scenario for the explanation of efficient particle acceleration and multi-scale time variability of the emission. We will present the results of kinetic simulations using the particle-in-cell code Zeltron of relativistic magnetic reconnection that include synchrotron radiation
reaction in a domain with open boundaries.

Recent kinetic simulations of magnetized cylindrical jets demonstrated that kink instability can accelerate particles in two special cases: (1) jets supported by gas pressure, and (2) jets supported by poloidal magnetic field. We implemented in Zeltron a generalized cylindrical jet configuration, and we are currently investigating a broad range of models that bridge those two limits.

Student presentations / **3**

Boosting the heat

Author: Lorenzo Gavassino[1]

[1] *Nicolaus Copernicus Astronomical Center (Warsaw)*

Corresponding Author: lorenzo.gavassino@gmail.com

The search for a relativistic theory of dissipation has lasted for 80 years. In the gravitational-wave era, we need, more than ever, a definitive answer to the question "how do heat and viscosity really work in relativity?". Our interpretation of the data coming from neutron-star mergers crucially depends on this. We need a theory which is formulated as a well-posed initial-value problem, sufficiently simple to be implemented in a numerical simulation, but sufficiently rich to capture all the physical insight we have. I will show that, contrarily to what is usually believed, we do not need a new theory, but a new understanding of the theories which are already available. The solution is already among us, we only need to look at it from the right perspective.

Student presentations / **4**

High metal content of highly accreting quasars

Author: Marzena Sniegowska[1]

[1] *CAMK PAN, CFT PAN*

Corresponding Author: msniegowska@camk.edu.pl

We present an analysis of 23 quasar UV spectra believed to belong to extreme Population A (xA) quasars, aimed at the estimation of the chemical abundances of the broad line emitting gas. Metallicity estimates for the broad line emitting gas of quasars are subject to a number of caveats, although present data suggest the possibility of an increase along the quasar main sequence along with prominence of optical FeII emission. Extreme Population A sources offer several advantages with respect to the quasar general population, as their optical and UV emission lines can be interpreted as the sum of a low-ionization component roughly at quasar rest frame (from virialized gas), plus a blueshifted excess (a disk wind), in different physical conditions. Capitalizing on these results, we analyze the component at rest frame and the blueshifted one, exploiting the dependence on metallicity Z of several intensity line ratios. We find that the validity of intensity line ratios as metallicity indicators depends on the physical conditions. We apply the measured diagnostic ratios to estimate the physical properties of sources (for Broad and Blue components) such as density, ionization, and metallicity of the gas. Our results confirm the existence of two regions in different physical conditions, and suggest metallicity values that are high, and probably the highest along the quasar main sequence, with $Z > 10Z_\odot$.

Student presentations / **5**

X-ray variability studies from GRMHD simulations

Author: Deepika Bolimpalli[1]

Co-authors: Chris Done [2]; Chris Fragile [3]; Chris White [4]; Mahmoud Ra'ad ; Ramesh Narayan [5]; Wlodek Kluzniak [1]

[1] *Nicolaus Copernicus Astronomical Center*

[2] *Durham University*

[3] *College of Charleston*

[4] *KITP Santa Barbara*

[5] *CfA Harvard*

Corresponding Author: deepika@camk.edu.pl

Long term observations of black-hole X-ray binaries show that these systems exhibit extreme, aperiodic variability on time scales of few milliseconds to seconds. The observed light-curves display various characteristic features like log-normal distribution and linear rms-flux relation, which indicates that the underlying variability process is stochastic in nature and is thought to be intrinsic to the accretion process. Theoretical models explain this variability as the inward propagating fluctuations of mass accretion rate on viscous timescales, although confirmations from the numerical simulations of magnetized accretion flows are required for a better understanding of the underlying variability process. Using a set of five exceptionally long general relativistic magnetohydrodynamic (GRMHD) simulations of geometrically thick, optically thin, black hole accretion flows as test-beds, we look for hints of propagating fluctuations of accretion rate in the simulation data. Indeed, our results from these simulations show evidence for the inward propagating fluctuations. Our further findings on how these results compare with the propagating fluctuations model and the observations will be discussed.

Student presentations / 6

The hunt for peculiar Eu and Ba abundances in metal-poor stars using *Gaia* and GALAH surveys

Authors: André Rodrigo da Silva[1]; Rodolfo Henrique Silva Smiljanic[1]

[1] *Centrum Astronomiczne im. Mikołaja Kopernika - PAN*

Corresponding Authors: rsmiljanic@camk.edu.pl, arodrigo@camk.edu.pl

The lanthanide-rich ejecta observed in the spectroscopic follow up of the neutron-star merger and gravitational wave event **GW170817** has shed light on a possible r-process nucleosynthesis site. However, abundances of r-process elements measured in metal-poor stars suggest that neutron-star mergers are not the only site for this kind of nucleosynthesis. Metal-poor stars provide information about the early Galaxy's chemical enrichment. In this regard, the **GALAH** survey is an important source of information: it provides chemical abundances for more than 340 000 stars. In particular it includes abundances of Eu (which is mostly an r-process element) and Ba (mostly an s-process element). Thanks to *Gaia*, an astrometric mission that is obtaining parallaxes and proper motions for more than 10^9 stars, our Galaxy's early merger history has been unfolded in the recent years. Helmi et al. (2018) have shown that the Galactic halo harbours a stellar population with retrograde motion that possibly originated in a major merger event (**of a possible dwarf galaxy now called *Gaia* Enceladus**). In this work, we aim to find metal-poor stars with peculiar Eu and Ba abundances in the cross-match between *Gaia* DR2 and **GALAH** DR2. **Such peculiar stars are important to help in isolating the nucleosynthetic contribution of each neutron-capture process**. Using these data, and limiting the sample to stars with [Fe/H] ≤ -1.0, $\sigma_\pi \leq 20\%$, $T_{\rm eff} \geq$ 4000 K, and $\log\ g$ between 2.0 and 5.0, we identified 18 possibly peculiar stars. We further computed kinematic and orbital parameters to associate the stars to distinct halo components. Five of these stars were initially selected for further investigation and confirmation using the UVES spectrograph. **Four out of these five stars have possible origin in the *Gaia* Enceladus merger**.

Student presentations / 7

Studying the southern Beta Cephei stars using TESS

Author: Sowgata Chowdhury[1]

Co-authors: Gerald Handler ; Filiz Kahraman [1]

[1] *Nicolaus Copernicus Astronomical Center*

Corresponding Authors: gerald@camk.edu.pl, filizkahraman01@gmail.com, sowgata.edu@gmail.com

The TESS satellite provides us with precise high quality time series data for stars including hot O- and B-type stars, which was mostly skipped in other missions. We make use of this photometric data to study variabilities in B type stars. Analysis of HN Aqr (Handler et al. 2019), already showed the prospectives for massive star asteroseismology based on such data, along with realizing the importance of runaway BCEP pulsators. Some of our past works also showed that rotational variability in B type stars are not so uncommon.
Here, the focus will be mainly on our efforts to study pulsation in southern Beta Cephei (BCEP) variables and the promising candidates therein. All stars in our list of candidates were analysed to confirm their pulsations and around 50 new BCEP variables were found. To further confirm their candidature and to place these objects in the HR diagram, 5 weeks of low resolution spectroscopic observations were carried out for more than 450 stars using the SPUPNIC spectrograph of 1.9 m telescope, South African Astronomical Observatory (SAAO). Reduction of the data and parameters extraction are discussed briefly. For the interesting BCEP variables, we will proceed to mode identification and seismic modelling to understand the structure of these stars and try solving some long held problems including the runaway star puzzle.

Student presentations / 8

Magnetic field evolution of neutron stars

Author: Ankan Sur[1]

[1] *CAMK*

Corresponding Author: ankansur@hotmail.com

Neutron stars are incredibly dense compact objects having the strongest magnetic field in the universe known to date. To study the field evolution in real-time, we performed magnetohydrodynamic simulations using the publicly available code PLUTO. The field undergoes a cataclysmic rearrangement in few Alfven timescales which develops a toroidal component with field strength 50% of the poloidal component. This field reaches a pseudo-equilibrium as the instability of the poloidal component leads to the development of turbulence, which in turn gives rise to an inverse helicity cascade determining the final "twisted torus" setup. A complex multipolar structure emerges at the surface while the external field remains dipolar. We are further developing numerical codes for studying the evolution with Hall effect and Ohmic dissipation and for calculating equilibrium models. These studies will help in modeling neutron stars' emission of gravitational waves. We are presently modifying the POLGRAW search codes to analyze LIGO's Observation run 3 (O3) data.

Student presentations / 9

The CaFe Project: Search for the correlation between Fe+ and Ca+ in active galaxies

Author: Swayamtrupta Panda[1]

Co-authors: Mary Loli Martinez-Aldama [2]; Bożena Czerny [2]; Murilo Marinello [3]; Paola Marziani [4]; Deborah Dultzin [5]

[1] *Nicolaus Copernicus Astronomical Center, Warsaw, Poland*

[2] *Center for Theoretical Physics, Warsaw, Poland*

[3] *National Astrophysical Laboratory, Itajuba, Brazil*

[4] *Padova Observatory, INAF, Italy*

[5] *National Autonomous University of Mexico, Mexico*

Corresponding Author: spanda@camk.edu.pl

Resolving the complexity in Fe II species in quasar spectra has been an ongoing work for over 40 years. First identified and reported for the prototypical Narrow-line Seyfert 1 galaxy I Zw 1 (Phillips 1978a), the study has made a niche of its own in the field of AGN research. Seminal works led by Boroson & Green (1992), Verner et al. (1999), Sigut & Pradhan (2003) and others encapsulate the 'yet to be complete' understanding of the physics of the line formation for this first-ionized state of iron (Fe II). A major part of the puzzle is lent by the sheer number of spectral lines in Fe II than spans across a wide energy range (from UV to NIR). This extended emission seen in the spectra mimics a continuum of sorts, thus the telltale term *pseudocontinuum*.

Gaining knowledge from the past studies and of our own, in this study we search for a reliable proxy to Fe II. This proxy, Ca II, is a much simpler ionic species which is characterized by its triplet in the near-infrared part of an AGN spectrum. The analogous line excitation mechanisms (dominated by the Lyα fluorescence and collisional excitation) for the production of these two species is confirmed by the tight correlation between the respective line strengths that we observe from our *up-to-date collection of coincident measurements in the optical and NIR*, and re-affirmed by our photoionization models. Additionally, our models constrain the physical parameters, such as the required level of ionization and the density of the medium (i.e. the broad-line region) that contain these ionic species, hinting also to the cloud's composition and structure (Panda et al. 2020b; Panda 2020). This study reveals the utility of the Ca II as a proxy for Fe II in ways more than one, primarily, **establishing a new radius-luminosity relation** and in **quasar main sequence studies**.

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Scaling of magnetic dissipation and particle acceleration in ABC fields

Authors: Qiang Chen[1]; Krzysztof Nalewajko[2]

[1] *Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences*

[2] *Nicolaus Copernicus Astronomical Center, PAS, Warsaw, Poland*

Corresponding Authors: knalew@camk.edu.pl, chen@camk.edu.pl

Using particle-in-cell (PIC) numerical simulations, we study how the efficiencies of magnetic dissipation and particle acceleration scale with the initial effective wavenumber $k_{\rm eff}$ of the two-dimensional "Arnold-Beltrami-Childress" (ABC) magnetic field configurations.All simulations are run for at least 25 light crossing times in order to achieve a saturation stage.We confirm the existence of topological constraints on the distribution of magnetic helicity specific to the 2D systems, identified earlier in relativistic force-free simulations, which prevent the high-$k_{\rm eff}$ configurations from reaching the Taylor state.Due to the constraints of PIC simulations, the initial magnetization is a decreasing function of increasing $k_{\rm eff}$, hence the high-$k_{\rm eff}$ configurations are inefficient particle accelerators, despite showing magnetic dissipation efficiencies of order $\epsilon_{\rm diss} \simeq 60\%$.Our results are compared with two shorter 3D PIC simulations of ABC fields — in the case of $k_{\rm eff} = 4$ we find that the 3D system is even more efficient in terms of magnetic dissipation, while less efficient in terms of particle acceleration.

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A bright ultraluminous X-ray source in NGC 5055

Authors: Samaresh Mondal[1]; Agata Rozanska[1]; Eleonora Veronica Lai[1]; Barbara De Marco[1]

[1] *Nicolaus Copernicus Astronomical Center*

Corresponding Author: smondal@camk.edu.pl

NGC 5055 X-1 is the brightest ultraluminous X-ray (ULX) source with luminosity 2.3×10^{40} erg/sec, located in the outskirt of the spiral galaxy NGC 5055. We present the first, detailed X-ray spectral analysis of this source. We fit the data with the phenomenological model composed of multi-color disk plus powerlaw and thermal Comptonization model. We found that the disk temperature radial profile has an index of 0.5 which rules out the standard thin disk model. The fitting of the 0.3-10 keV continuum indicates that the source is in the ultraluminous soft state. In all spectral fitting models, the source follows inverse luminosity-temperature relation, which indicates that the emission from the source is geometrically beamed due to optically thick wind outflow.

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Partially accreted crusts of Neutron Stars

Author: Lami SULEIMAN[1]

Co-authors: Julian Leszek Zdunik [2]; Morgane Fortin [3]; Paweł Haensel [4]

[1] *CAMK + Univeristy of Tours*

[2] *Centrum Astronomiczne Mikołaja Kopernika*

[3] *CAMK, PAN*

[4] *Centrum Astronomiczne Mikołaja Kopernika*

Corresponding Authors: lami.suleiman@hotmail.fr, fortin@camk.edu.pl

Neutron stars in binary systems may accrete matter from their companion star ; so far, only the case of a crust fully replaced by accreted matter has been considered in detailed calculations. However if the star has only accreted a small amount of matter, the crust is not fully but only partially accreted. This could be for example the case of IGR J17480−2446. The observed decrease of its temperature after the accretion phase is the slowest of all ˜10 objects for which such a relaxation has been monitored in X-ray and its slow rotation indicates that the accretion of matter from the companion started relatively recently. These could indicate that IGR J17480−2446 has a partially accreted crust which nuclear and thermal properties could be different from the ones of a fully accreted crust.

We propose a model of partially accreted crusts for which we follow the originally catalyzed crust as it undergoes an increase in pressure due to the above accreted material falling at the surface. We study different properties of partially accreted crust, additional energy sources and discuss differences

with respect to calalyzed and fully accreted crust.

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The origin of inequality. Isolated formation of 30 Msun and 10 Msun BH-BH merger.

Authors: Aleksandra Olejak[1]; Krzysztof Belczynski[2]; D. E. Holz[None]; J. P. Lasota[None]; Tomasz Bulik[3]; M. C. Miller[None]

[1] *OA UW*

[2] *Copernicus Center, Polish Academy of Sciences*

[3] *Obserwatorium Astronomiczne UW*

Corresponding Authors: chrisbelczynski@gmail.com, tb@astrouw.edu.pl, aleksandra.olejak@wp.pl

The LIGO/Virgo collaboration has reported the detection of GW190412, a black hole-black hole (BH-BH) merger with the most unequal masses to date: m1 = 24.4−34.7 Msun and m2 = 7.4−10.1 Msun, corresponding to a mass ratio of q = 0.21−0.41 (90% probability range). Additionally, GW190412's effective spin was estimated to be χeff = 0.14−0.34, with the spin of the primary BH in the range aspin = 0.17−0.59. Based on this and prior detections, 10% of BH-BH mergers have q<0.4.
Major BH-BH formation channels (i.e., dynamics in dense stellar systems, classical isolated binary evolution, or chemically homogeneous evolution) tend to produce BH-BH mergers with comparable masses. Here we test whether the classical isolated binary evolution channel can produce mergers resembling GW190412.

Student presentations / **14**

Testing the reliability of AGN torus X-ray spectral models

Author: Tathagata Saha[1]

Co-authors: Alex Markowitz [1]; Johannes Buchner [2]

[1] *Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences*

[2] *Max Planck Institute for Extraterrestrial Physics*

Corresponding Authors: almarkowitz@camk.edu.pl, johannes.buchner.acad@gmx.com, tathagata@camk.edu.pl

Numerous X-ray spectral models have been developed to model emission reprocessed by an AGN torus, e.g., UXCLUMPY, CTORUS, MYTORUS. They span a range of assumed torus geometries and morphologies – some posit smooth gas distributions, others posit distributions of clouds. It is suspected that given the quality of currently available data, certain model parameters (such as photon index and torus column density) may be poorly constrained due to model degeneracies. Moreover, the available data quality might not even be able to robustly distinguish between competing models, thus preventing us from deriving solid conclusions on the geometry and nature of the torus. To investigate these effects, we perform extensive simulations of NUSTAR and XMM data for a range of torus models and use Bayesian methods to compare models and investigate degeneracy between parameters. Preliminary results strongly confirm our initial suspicions; our project thus aims to provide guidance for the X-ray community in terms of the robustness of both torus model fitting and parameter estimation.

Student presentations / **15**

BLR size and R-L relation in realistic FRADO model

Author: Mohammad Naddaf[1]

Co-authors: Bozena Czerny [2]; Ryszard Szczerba [3]

[1] *CFT/CAMK*

[2] *CFT*

[3] *CAMK*

Corresponding Author: naddaf@camk.edu.pl

The effective size of Broad Line Region (BLR), so-called the BLR radius, in galaxies with active galactic nuclei (AGN) scales with the source luminosity. Therefore by determining this location either observationally through reverberation mapping or theoretically, one can use AGNs as an interesting laboratory to test cosmological models. Focusing on the theoretical side of BLR based on the

Failed Radiatively Accelerated Dusty Outflow (FRADO) model and simulating the dynamics of matter in BLR through a realistic model of radiation of accretion disk including the shielding effect, as well as incorporating the proper values of dust opacities, we investigate how the BLR geometry depends on the Eddington ratio and blackhole mass, and modeling of shielding effect. We show that assuming a range of Eddington ratios and shielding we are able to explain the H-beta time-delays in a most recent sample of reverberation-measured AGNs.

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Stellar Pulsation studies

Author: Rathour Rajeev Singh [1]

[1] *Nicolaus Copernicus Astronomical Center, Warsaw*

Corresponding Author: rajeevsr@camk.edu.pl

Pulsating stars offer a window to look into key aspects of stellar evolution and also serve as a tool (especially Cepheids) to distance scale measurements. Their ubiquitous nature can reveal a lot about the structure and evolution of our Galaxy and the Magellanic Clouds. In this talk, I will discuss two important classes of pulsating stars, Cepheids and RR Lyrae, in general, and then dive into a photometric study of pulsations conducted on Cepheids in our galactic disk and bulge using the OGLE-IV survey data. Also, I will discuss how stellar evolution modeling can aid the goals of the research. In the end, I will briefly introduce the long term goals of the doctoral study.

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On the spectral-timing properties of Cygnus X-1 in its hard state.

Author: Eleonora Veronica Lai[1]

[1] *CAMK PAN*

Corresponding Author: eleonorav@camk.edu.pl

During an outburst, Black Hole X-Ray Binaries (BHXRBs) present two main spectral states: the soft and the hard. The geometry of the system is thought to change throughout the outburst but its exact evolution is unknown. In particular, for the hard state, there is still no agreement on its exact geometry. In Cygnus X-1, the spectral components observed in the hard state can be explained in terms of multiple Comptonisation components associated with a non homogeneus Comptonisation region and/or high density disc reflection.
We study the contribution of different spectral components to the observed intrinsic variability at different time scales using spectral-timing techniques. Due to the size of its companion, Cyg X-1 is a High Mass X-ray Binary and it accretes via wind, which plays an important role when determining the intrinsic spectral-timing properties of the source.
I will present the results of the ongoing spectral-timing analysis of the XMM-Newton long monitoring of Cyg X-1 during its hard state covering more than one entire orbit of the binary system (7.22 d).

Student presentations / 18

MOCCA Survey Database: Extra Galactic Globular Clusters. Method and first results

Author: Agostino Leveque[1]

[1] *CAMK*

Corresponding Author: agostino@camk.edu.pl

Over the last few decades, exhaustive surveys of extra Galactic globular clusters (EGGCs) have become feasible. Only recently, kinematical information of globular clusters (GCs) were available through Gaia DR2 spectroscopy and also proper motions. On the other hand, simulations of GCs can provide detailed information about the dynamical evolution of the system. We present a preliminary study of EGGCs' properties for different dynamical evolutionary stages. We apply this study to 12 Gyr-old GCs simulated as part of the MOCCA Survey Database. Mimicking observational limits, we consider only a subssample of the models in the database, showing that it is possible to represent observed Galactic GCs. In order to distinguish between different dynamical states of EGGCs, at least three structural parameters are necessary. The best distinction is achieved by considering the central parameters, those being observational core radius, central surface brightness, ratio between central and half-mass velocity dispersion, or similarly considering the central color, the central V magnitude and the ratio between central and half-mass radius velocity dispersion, although such properties could be prohibitive with current technologies. A similar but less solid result is obtained considering the average properties at the half-light radius, perhaps accessible presently in the Local Group. Additionally, we mention that the color spread in EGGCs due to internal dynamical models, at fixed metallcity, could be just as important due to the spread in metallicity.

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Asteroseismology of pulsating subdwarf B stars using TESS data

Author: Sumanta Kumar Sahoo[1]

Co-authors: Andrzej Baran [2]; Jakub Ostrowski [2]; Sachu Sanjayan [3]

[1] *Nicolaus Copernicus Astronomical Center, Warsaw, Poland*

[2] *Pedagogical University of Cracow*

[3] *PhD Student CAMK*

Corresponding Authors: sachs888@gmail.com, sumanta@camk.edu.pl, andrzej.baran@up.krakow.pl, jakub.ostrowski@up.krakow.pl

Subdwarf B (sdB) stars are extreme horizontal branch stars, consisting of a convective helium burning core, helium shell and a very thin (in mass) hydrogen envelope. Few of these sdBs pulsate (sdBV), which opens the window to study these stars using asteroseismology. From the TESS mission, we have detected a few tens of rich gravity mode sdBVs by analysing their lightcurves and periodograms and identified their pulsation mode geometries. Our mode identifications are based on asymptotic period spacing technique. Along with lightcurve analysis, we have done spectroscopic observations and analysis for few of these stars to determine their physical parameters like effective temperatures and surface gravities. We also compared these asteroseismic and spectroscopic results with our sdB evolutionary models to determine the evolutionary status of these sdBVs.

Student presentations / **20**

General relativistic radiation hydrodynamic simulations of levitating atmospheres

Author: Ruchi Mishra[1]

[1] *CAMK*

Corresponding Author: rmishra@camk.edu.pl

Some accreting neutron stars may produce near-Eddington luminosity. In general relativity, the atmosphere of a sufficiently luminous neutron star is disconnected from and levitates above its surface. The atmosphere is centered at a radius where the gravitational and radiation forces balance each other. We aim to simulate optically thin and thick levitating atmospheres of a near Eddington luminosity neutron star using the KORAL code in order to obtain stationary solutions.

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Stratification of hot accretion flow of MAXI J1820+070

Author: Marta Dziełak[1]

Co-authors: Barbara De Marco [1]; Andrzej Zdziarski [1]

[1] *Nicolaus Copernicus Astronomical Center*

Corresponding Authors: aaz@camk.edu.pl, mdzielak@camk.edu.pl, bdemarco@camk.edu.pl

Spectral and timing results show that the inner accretion flow in the hard state of black hole X-ray binaries (BHXRB) appears more inhomogeneous than assumed in standard spectral fits.
These studies hint at a stratified hot medium, with the inner parts being hotter and emitting a harder spectrum. Such complex structure implies that time-averaged energy spectra cannot be fitted with simple models which assume a single Comptonization region.
We present a study of the recently discovered BHXRB, MAXI J1820+070 during its hard and bright hard state, observed by NICER. We have performed a X-ray spectral-timing analysis which aims at disentangling the spectral components contributing to variability on different timescales, and thus originating at different distances from the BH. The results confirm the stratified structure of the inner hot flow in this source, with the high energy photons contributing to the fastest variability and originating in the innermost regions. We show that this behavior cannot be easily observed from the analysis of time-averaged spectra alone.

Student presentations / 22

Distance determinations using RR Lyrae stars and the new reddening maps of the Magellanic Clouds

Author: Bartłomiej Zgirski[1]

[1] *Nicolaus Copernicus Astronomical Center PAS*

Corresponding Author: bzgirski@camk.edu.pl

During my talk, I will present preliminary results concerning the calibration of the Baade-Wesselink method of distance determinations for RR Lyrae stars.
I will shortly introduce the new reduction - standardization pipeline that I've written for the purpose of the reduction of photometric data.
I will also talk about the new reddening maps of the Magellanic Clouds that were published earlier this year.
Additionally, we will also take a peek at the Cerro Armazones Observatory in Chile which serves the Araucaria project's purposes.

Student presentations / **23**

Pulsating subdwarf B stars in the oldest open cluster NGC6791

Author: Sachu Sanjayan[1]

Co-authors: Andrzej Baran [2]; Jakub Ostrowski [2]; Sumanta Kumar Sahoo [3]

[1] *PhD Student CAMK*

[2] *Pedagogical University of Cracow*

[3] *Nicolaus Copernicus Astronomical Center, Warsaw, Poland*

Corresponding Authors: sachs888@gmail.com, sumanta@camk.edu.pl, andrzej.baran@up.krakow.pl, jakub.ostrowski@up.krakow.pl

NGC6791 is the oldest metal rich ([Fe/H]=0.4) open cluster with an age of 8Gyr. The evolution of this cluster is still an enigma. Subdwarf B stars are extreme horizontal branch core helium burning objects with a very thin hydrogen envelope. We study the evolution of subdwarf B stars in this cluster by means of asteroseismology to derive the parameters of the stars. We have analyzed Kepler super apertures long cadence data of the NGC6791 to search for pulsating sdB stars. We checked all pixels and found only three sdB stars to be pulsating, KIC2569576 (B3), KIC2438324 (B4), and KIC2437937 (B5) in NGC6791. These stars were known before, though we extended the data coverage detecting more frequencies and features in periodograms such as new multiplets, extended period spacing sequences, and candidates for trapped modes. The remaining known sdB stars do not show any light variation, while no new variable sdB is found in NGC6791. We calculated evolutionary tracks and eigenfrequencies of pulsation modes using the new algorithms available in MESA and GYRE modules. We used double optimization algorithms to match the observations and models. Using the asteroseismic interpretations from observed multiplets and spectroscopic observations on the logg and Teff values, we found the optimal models matching in HR diagrams and best fitting periodograms. The best models representing the observed properties of the stars used for determination of fundamental parameters. Hence inferring the parameters like age and metallicity of the clusters they reside in.

Student presentations / **24**

Eclipse Timing of Detached Eclipsing Binaries using SOLARIS network of telescopes

Author: Ayush Moharana[1]

[1] *Nicolaus Copernicus Astronomical Center, Toruń*

Corresponding Author: ayushm@ncac.torun.pl

The multiplicity of stellar systems has a quite high incidence. The presence of multiple bodies around a Detached Eclipsing Binary (DEB) can be observed through the Light Time Effect (LTE). Measuring the precise moments of minima (eclipse timing) takes advantage of the manifestation of LTE due to circumbinary bodies and the periodicity of the DEBs. I talk about the preliminary work to create a pipeline to generate light curves from the SOLARIS long-term (3-5 years) observations and use them for eclipse timing analysis of selected DEBs to look for other stars or exoplanets in those systems.

Student presentations / **25**

Tools for Period Searching in AGN in the Era of "Big Data"

Author: Saikruba Krishnan[1]

Co-authors: Alex Markowitz [1]; Aleksander Schwarzenberg-Czerny [1]

[1] *Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences*

Corresponding Authors: almarkowitz@camk.edu.pl, alex@camk.edu.pl, saikruba@camk.edu.pl

AGN persistently emit across the electromagnetic spectrum; emission is dominated by stochastic, aperiodic variability that overwhelms any periodic/quasi-periodic signal (QPO) if one exists. Pure stochastic red noise processes can spuriously mimic few-cycle sinusoid-like periodicities. Hence, while using different statistical tools one needs to account for red noise which can impact the statistical significance of periodicity detections and calibration of false alarm probabilities (FAP). We have entered the era of "Big Data," with current and near-future large-area monitoring programmes facilitating data trawls for periodicities; developing the proper know-how for period searching is essential. In our project we try to account for red noise using various methods: Auto-correlation Function (ACF), Phase dispersion minimization (PDM), wavelet analysis, & Bayesian CARMA analysis. We test if each method can robustly distinguish between pure red-noise and mixtures of red noise and strictly-/quasi-periodic signals, and check how FAP depends on broadband continuum PSD shape. We determine how QPO detection sensitivity depends on QPO strength and broadband red noise shape for evenly-sampled and for realistically-sampled data (e.g., with data gaps). I will present the results from analysis using the ACF and PDM. We also compare the results on using the PDM and the periodogram. We apply the results to realistic systems, namely gravitational lensing from highly-inclined binary supermassive black hole systems, to check the conditions under which a periodic flux signal can be robustly separated from the red noise using these statistical tools.

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Comparing radio-loud Swift/BAT AGN with their radio-quiet counterparts

Author: Maitrayee Gupta[1]

Co-authors: Marek Sikora [2]; Katarzyna Rusinek [2]

[1] *Nicolaus Copernicus Astonomical Center*

[2] *Nicolaus Copernicus Astronomical Center*

Corresponding Author: mgupta@camk.edu.pl

Some AGN are known to be efficient producers of strong, relativistic jets which power the extended radio sources. Most spectacular in respect of powers and sizes are the radio sources associated with AGN hosted by giant elliptical galaxies. However even among them, the production of powerful jets is a very rare phenomenon and the unanswered question remains why it is so. Since relativistic jets are most likely powered by rotating BHs via the Blandford-Znajek mechanism, one might expect that the parameters deciding about efficient jet production are BH spins and magnetic fluxes. If their values are large, then the innermost portions of accretion flow should be affected by the jet production and this should be imprinted in their radiative properties. In order to verify whether this is the case, we compare the radiative properties of radio-loud and radio-quiet AGN selected from the Swift/BAT catalogue with similar BH masses and Eddington ratios. As we have found the only significant difference concerns the hard X-ray luminosities, which are about two times larger in radio-loud (RL) AGN than in radio-quiet (RQ) AGN. One might speculate that this difference comes from having in RL AGN X-ray contribution not only from the innermost, hot portions of accretion flow, but also from a jet. However, this interpretation is challenged by our following findings: (1) hard X-ray spectra of RL AGN have similar slopes and high-energy breaks to those of RQ AGN; (2) hard X-ray radiation is to be in both RQ and RL AGN quasi-isotropic. Hence we argue that production of hard X-rays in the RL AGN is like in the RQ AGN, dominated by hot, central portions of accretion flows, while larger X-ray production efficiencies in RL AGN can be associated with larger magnetic fields and faster rotating BHs in these objects.

28

Search for Dark Matter with liquid argon detectors

Author: Theo Hugues[1]

[1] *CAMK*

Corresponding Author: theo@camk.edu.pl

Strong evidences from astrophysical observations suggests dark matter, a non-luminous form of matter not described in the Standard Model, accounts for approximately 84% of the matter and 27% of the total density of the universe but dark matter has never been directly detected by terrestrial experiments yet.

DEAP is a direct dark matter search experiment which uses liquid argon as a target material. DEAP utilizes background discrimination based on the characteristic scintillation pulse-shape of argon, it is located at SNOLAB, 2 km below Earth's surface. DEAP-3600 was designed with 3600 kg of active liquid argon mass to achieve sensitivity to WIMP-nucleon scattering cross-sections as low as $10^{-46}cm^2$ for a dark matter particle mass of $100GeV/c^2$.

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Cross-Correlation Study between CMB Lensing and Galaxy Surveys

Author: Chandra Shekhar Saraf[1]

Co-authors: Pawel Bielewicz [2]; Michal Chodorowski [1]

[1] *CAMK PAN*

[2] *NCBJ*

Corresponding Authors: cssaraf@camk.edu.pl, pawel.bielewicz@ncbj.gov.pl, michal@camk.edu.pl

Cosmic Microwave Background (CMB) is a powerful probe to study the early universe and various cosmological models. Weak gravitational lensing affects the CMB by changing its power spectrum, but meanwhile, it also carries information about the distribution of lensing mass and hence, the large scale structure (LSS) of the universe. When studies of CMB is combined with the tracers of LSS, one can constrain cosmological models and test models of structure formation. The main focus of the project is to study cross-correlations between CMB Lensing Potential maps from *Planck* 2018 data release and galaxy distributions from *Herschel* Extra-galactic Legacy Project (HELP) survey to constrain **galaxy linear bias b** and the **amplitude of cross-spectrum A**, to test validity of ΛCDM model. We present our estimation of parameters using Maximum Likelihood Estimation and discuss the results.

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The tools essential for the detection of Near-Earth Asteroids and space debris

Author: Beata Konacka[1]

[1] *Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences*

Corresponding Author: brogowska@camk.edu.pl

The Near-Earth Asteroids (NEAs) and space debris are usually rapid (the angular velocity is equal to a few degrees per day for NEAs, and a few degrees per minute for space debris in low Earth orbit) and dim. Therefore, searching for such objects is a time-consuming process. Nevertheless, detection and cataloging of these objects are of the utmost importance for planetary defense and safety of the vital space-based infrastructure.
One of the most promising methods for searching for fast-moving objects in the sky is a synthetic tracking (ST). It aims to mitigate trailing losses, which are the losses of the signal caused by the smearing object's image on many pixels of the detector, by shortening the exposure time of observation and conducting long sequences of measurements, one after another, without any time gaps in between. The acquired frames are then shifted and integrated. The resulting composite frame simulates a long exposure similar to the one obtained by a telescope that tracks the object. The values of the shift need to be defined by a grid of vectors imitating possible angular velocities of the searched objects.
The superiority of the ST over the traditional methods of asteroid detection relies on sCMOS cameras and usage of wide field-of-view (FOV) telescopes. The sCMOS cameras are the modern alternatives for the CCD detectors commonly used in astronomical applications. Their paramount feature is a negligible read-out time allowing for almost continuous observation without signal losses during the reading out process as it takes place in the CCDs. The telescopes with the wide FOVs are capable of capturing a big piece of the sky in a single exposure, which implies faster survey speed, better sky coverage, and what comes from it, the more numerous discoveries.

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High-Amplitude Delta Scuti stars

Author: Henryka Netzel[1]

[1] *CAMK*

Corresponding Author: henia00@gmail.com

Delta Scuti stars are intermediate-mass pulsating stars of masses around 1.5 - 2.5 solar masses. The majority of them are core hydrogen burning, however, some of them are only evolving towards and off the main sequence. The diversity of evolutionary stages and inner structure among this group makes them interesting objects for asteroseismic modeling. However, most of them pulsate in numerous, low-amplitude, and difficult to identify non-radial modes, which, with some exceptions, hampers usage of asteroseismic methods for most of Delta Scuti stars. In High-Amplitude Delta Scuti stars (HADS) that pulsate in more than two radial modes, the modes can be identified more easily and hence allows the application of asteroseismic modeling to infer physical parameters. I studied the numerous sample of HADS detected during the OGLE observations of the Galactic bulge fields. A comparison to calculated models allowed me to infer the physical parameters for some of them.

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BH Tom – The System for Automatic Observations Scheduling, Photometry and Calibration for Microlensing Events Followups

Author: Mikołaj Kałuszyński[1]

[1] *Nicolaus Copernicus Astronomical Centre, Polish Academy of Sciences, Warsaw, Poland*

Corresponding Author: mkalusz@camk.edu.pl

The followups of not-recurring astronomical events, such as gravitational microlensing events, are crucial in obtaining reliable parameters of the objects involved.
Since they are single-occurrence events, it is very important to quickly start high-quality observations on as many telescopes as possible to obtain accurate light curves with good coverage of the event period.

We developed a system for scheduling observations and data processing accessible by the WEB page and the HTTP API to address these needs.

The scheduling system, and users (astronomers) frontend is based on TOM toolkit: tom-toolkit.readthedocs.io.

The instrumental photometry is performed by the CCDPHOT package exposed via HTTP API.

The photometric calibration is based on CPCS (*Cambridge Photometric Calibration Server*)

We will discuss the goals of the project, the architecture of the system and functionality of its components.

We also present the vision of the CCDPHOT-based universal photometric public service, similar to astrometry.net services for astrometry.

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Modelling of pulsar glitches in Neutron Stars

Author: Vadym Khomenko[None]

Corresponding Author: vadymk@camk.edu.pl

Observations of pulsar glitches have the potential to provide constraints on the dynamics of the high density interior of neutron stars. However, to do so, realistic glitch models must be constructed and compared to the data. We take a step towards this goal by testing non-linear models for the mutual friction force, which is responsible for the exchange of angular momentum between the neutron superfluid and the observable normal component in a glitch. In particular, we consider a non-linear dependence of the drag force on the relative velocity between superfluid vortices and the normal component, in which the contributions of both kelvon and phonon excitations are included.
We find also that for standard mutual friction there are families of unstable inertial and sound waves both in the case of a counter-flow along the superfluid vortex axis and for counterflow perpendicular to the vortex axis and find that entrainment leads to a quantitative difference between instabilities in the crust and core of the star.

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Ammonia in Circumstellar Environment of V Cyg

Author: Bartosz Etmański[1]

Co-authors: Mirosław Schmidt [1]; Ryszard Szczerba [1]

[1] *CAMK Toruń*

The Herschel Space Observatory (HSO) mission has been one of the most successful project that time. From the point of view of molecules detections around stellar objects the most efficient instrument has been Heterodyne Instrument for the Far Infrared (HIFI). This instrument produced big number high-resolution of spectra for different type of object such as massive red supergiants, Asymptotic Giant Branch (AGB) and post-AGB stars, planetary nebulae etc. The observations store in Herschel Science Archive and may be use to find transitions of molecules. One of many molecule which detected by HIFI/Herschel in the Circumstellar Envirmoment (CSE) around AGB stars is NH_3. Ammonia in CSEs around these type of stars has more brightness of lines that it suggested abundant of ammonia determined by the model of atmosphere had predicted. However there are exists two

model which try to explain overabundance of ammonia: formation of ammonia behind the shock front and photochemical processes in the inner part of the envelope partly transparent to UV background radiation due to the clumpy structure of the gas. Here, we present results of the non-LTE radiative transfer modelling of ammonia transitions including a crucial process of radiative pumping via v_2 = 1 vibrational band (at ~ 10 µm) for V Cyg. Only one ammonia transition NH_3 J = 1_0 - 0_0 at 572.5 GHz has been observed by HIFI/Herschel. Therefore, to determine abundance of ammonia we estimate a photodissociation radius of NH_3 using chemical model of the envelope consistent with dust grain properties concluded from the spectral energy distribution. This determination for V Cyg and future calculations for the rest of C-rich AGB stars sample may give us clue which process of ammonia production is more probably.

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Polish SST optical sensor network upgrade as a contribution to EUSST

Author: Chimicz Arkadiusz[1]

[1] *CAMK / POLSA*

Corresponding Author: arkadiusz.chimicz@polsa.gov.pl

During my talk, I will present outlook of results concerning the Polish optical sensor upgrade proposal as part of European Union SST sensors network. This upgrade phase is concentrated on cost effective maximisation of geostationary belt survey capabilities. In this context basic assumptions and preliminary results will be presented.

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Calibrating p-factors of Classical and Type II Cepheids

Author: Piotr Wielgorski[1]

[1] *Nicolaus Copernicus Astronomical Center Warsaw*

Corresponding Author: pwielgor@camk.edu.pl

During my talk I will show our first results from Baade-Wesselink analysis of nearby Classical and Type II Cepheids. The main goal of this project is precision calibration of the p-factor, which is crucial for determining precision extragalactic distances using the Baade-Wesselink method..

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Neutron Star atmospheres and hardness factor

Authors: Bartosz Bełdycki[1]; Agata Różańska[1]

[1] *Nicolaus Copernicus Astronomical Center PAN*

Corresponding Author: beldyckibartosz@gmail.com

We computed a set of model atmospheres and emergent spectra in a plane parallel approximation with inclusion of hydrostatic, radiative, ionization and local thermodynamical equilibrium and equation of state of ideal gas. Moreover, we also included proper Compton scattering description and

free-free, bound-free absorption from all ions of hydrogen, helium and iron. Our models were calculated for four different chemical compositions: pure hydrogen, pure helium and solar models with different abundances of hydrogen, helium and heavy elements. For each chemical composition the models are computed for a dense grid of effective temperatures and surface gravity.
We are going to present the hardness factor as a function of relative luminosity for various metallicities
and effective temperatures.

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Deeping on binary systems: Enigmatic subclass and detached binaries as distance tracer.

Author: Gonzalo Rojas García[1]

[1] *Nicolaus Copernicus Astronomical Centre, PAN*

Corresponding Author: rojas@camk.edu.pl

In this presentation, I will show you my past and current work on binary stars.
On the first part, I going to talk about my results and some basic aspects related with Double Periodic variables (DPV), a very enigmatic subclass of binary stars. On the second part, I will introduce the methodology I expect to apply over a new binary targets set, with the aim of get a physical parametrization for each system, using Wilson-Devinney code and JKTEBOP code, both used in the modeling and analysis of light curves and radial velocity curves for detached binaries.
Finally, as part of the Araucaria project, I will explain how to use detached binary systems in order to determinate distances.

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Swift/BAT AGNs - their radio loudness, jet production efficiency and host galaxies

Author: Katarzyna Rusinek[1]

Co-authors: Marek Sikora [2]; Dorota Kozieł-Wierzbowska [3]; Maitrayee Gupta [4]

[1] *Nicolaus Copernicus Astronomical Center Polish Academy of Sciences*

[2] *Nicolaus Copernicus Astronomical Center*

[3] *Astronomical Observatory, Jagiellonian University*

[4] *Nicolaus Copernicus Astonomical Center*

Corresponding Authors: mgupta@camk.edu.pl, krusinek@camk.edu.pl

The radio loudness of an Active Galactic Nucleus (AGN), defined as the ratio of its radio luminosity to its optical luminosity, is used to classify objects as radio-quiet (RQ) or radio-loud (RL), the latter of which represent about 10\% of sources. However, such a would-be simple division is burdened with many factors, for example, the way the studied sample was chosen, the origin of the radio data and its sensitivity and angular resolution, whether the extended radio emission should included or not, a big and diverse range of redshifts, and finding black hole (BH) masses and thus, Eddington ratios.

Taking all of the above into account we decided to extensively study a well defined sample of *Swift*/BAT AGNs which were selected using the same criteria. For all of the sources in our sample we calculated their BH masses (all of them being $M_{\rm BH} \geq 10^{8.5} M_{\odot}$), bolometric luminosities ($L_{\rm bol}$) and Eddington ratios ($\lambda_{\rm Edd}$). Each AGN has well determined radio properties, and corresponding jet powers (which, in fact, are upper limits for most of the objects). Additionally, we were able to establish the host galaxies for a vast majority of the objects within the sample. During my talk I will present the results of such a study of *Swift*/BAT AGNs and how they imply that some threshold conditions must be satisfied in order to allow the production of strong, relativistic jets in RL AGNs.

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GRRMHD Simulations of Accretion on Neutron Stars

Author: David Abarca[1]

Co-authors: Wlodek Kluzniak [2]; Kyle Parfrey

[1] *CAMK PAN*

[2] *Nicolaus Copernicus Astronomical Center*

Corresponding Author: dantabarca2691@gmail.com

We report on general relativistic radiation magnetohydrodynamic simulations of accretion onto neutron stars. We simulate a super-Eddington accretion flow onto a magnetized neutron star using multiple techniques which allow for proper evolution of the gas in highly magnetized environments. Our results are directly applicable to the study of ultraluminous X-ray sources. We present a model of such a system and show how the high luminosities of these obejcts are dependent on a combination of the magnetic field channeling accretion into columns and the hard surface of the star leading to radiation shocks at the base of the columns.