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CAMK PAN

Book of Abstracts

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Eleonora Veronica Lai - An X-ray spectral-timing analysis of Cygnus X-1 during its hard state.

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The X-ray spectrum of a black hole binary is very complex and even if there is a relative consensus regarding the nature of the soft state, there is an ongoing dispute concerning the hard state. In Cygnus X-1, the hard state spectrum cannot be described only by the well known "disk plus power law" model. The observed spectral complexity can be explained in terms of multiple comptonisation components associated with a non homogeneus comptonization region and/or high density disc reflection.
I will present the ongoing analysis of new XMM-Newton observations of Cygnus X-1 in the hard state using X-ray spectral-timing techniques. This approach can be used to break spectral degeneracies and better costrain the physical origin of spectral components, by studying their contribution to the variability observed at different time scales.

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Lorenzo Gavassino - The role of General Relativity in the Glitch Theory

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Neutron stars are the hottest laboratory of ultracold matter in the universe and pulsar glitches, sudden spin-up events observed in many pulsars, may constitute the most energetic manifestations of fermionic superfluidity. As these are very compact systems, however, it is necessary to account for general relativity when modelling such events and interpreting astronomical data. In this talk, I will discuss how to do this, and present a fully general relativistic hydrodynamical model for pulsar glitches, based on the formalism developed by Carter and collaborators to describe relativistic superfluids. In particular, I will focus on the effects of time-dilation and frame dragging and show that they can significantly affect calculations of the glitch rise time. Such effects should thus be included in theoretical models to accurately constrain neutron star parameters and the equation of state from glitch observations.

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Magdalena Sieniawska - Rotating neutron stars: dense-matter interiors and gravitational-wave searches using the time-domain F-statistic method

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Gravitational waves astronomy is one of the youngest and dynamically progressing field in modern astronomy. Existence of gravitational waves was predicted by Einstein, more than hundred years ago, but was confirmed observationally only in 2015. Until then we could observe astrophysical bodies and events only by telescopes that register electromagnetic waves (like radio waves, gamma waves, X-rays etc.), and neutrinos, hence a lot of fascinating phenomena, like the mergers of black holes, were practically invisible. So far, several signals from the compact objects coalescences were detected in LIGO and Virgo detectors. As the interferometers improve their sensitivity, we expect other, more subtle, types of signals to be registered. One of the promising scenario is the detection of continuously-emitted, periodic and almost-monochromatic gravitational waves, originating inside rotating neutron stars (NS). Discovery and research on such types of signals can provide interesting information about the properties of neutron stars, their structure and environment around them.

The reason why gravitational signatures from NS are so thoroughly and eagerly wanted, is that the interior of a NS is still a mystery today. The extremely large densities and pressures present inside NS can not be reproduced in terrestrial laboratories. We also do not have a credible theoretical description of how matter behaves above the nuclear saturation density. By measurements of the NS masses and radii one can, in principle, determine the properties of matter inside NS. Since the measurements of NS parameters from the electromagnetic emission are in most cases charged with large observational errors, an analysis based on gravitational waves emission can be an alternative to determining the NS properties and their equation of state.

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Daniel Pieńkowski - Characterization of evolved giants in symbiotic binaries

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Symbiotic stars are binary systems composed of a red giant, and a hot, compact companion, usually white dwarf or neutron star, surrounded by ionized nebula. Despite of their long periods, which reach up to dozens of years they strongly interact via wind or Roche-lobe overflow, which places symbiotic stars among the most variable stars. Moreover, in the past, when the present compact object was going through AGB phase mass flowed in opposite direction which left a mark in the chemical composition of its companion –the present red giant. Study of chemical composition of symbiotic giants are essential to fully understand their evolution as well as many others related objects involving red giant stars at any phase of their life.
To study chemical properties of the symbiotic giants, we collected many low-resolution near infrared spectra for objects from northern and southern hemisphere. By measuring equivalent widths of Na, Ca and CO features in K-band region of spectra and by comparing them with synthetic ones, we tried to find the effective temperatures, metallicities and chemical composition of these giants.

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Marta Dziełak - Analysis of GX 339-4 during its hard state

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We probed models of disc truncation in the hard spectral state of the black hole X-ray binary GX 339-4. We tested a large number of different spectral models of disc reflection and its relativistic broadening. Our statistically best-fit model requires the disc to be truncated at a radius larger than or equal to about two ISCO radii.
Finally, I will present preliminary results from the study of the X-ray spectral-timing properties of GX 339-4 at the end of the outburst. Our aim is to constrain the origin of the soft component observed in the hard state of the source.

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José Ortuño Macías - Relativistic Radiative Magnetic Reconnection

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We will present the results of kinetic simulations of relativistic magnetic reconnection including synchrotron radiation reaction in a domain with open boundaries. In such configuration, reconnection produces steady relativistic outflows that involve chains of plasmoids with well-defined statistical characteristics (Sironi et al. 2016). Due to the stochasticity of plasmoids chains, the plasmoid reconnection offers an attractive scenario for the multi-timescale and multi-wavelength variability of high-energy non-thermal sources, in particular those associated with relativistic magnetized jets, e.g., blazars (Christie et al. 2019). However, the effects of radiative cooling on the evolution of plasmoid properties have not been investigated yet. By means of particle-in-cell (PIC) simulations using the Zeltron code that includes synchrotron radiation reaction, a strong cooling efficiency regime is achieved, with typical synchrotron cooling length scales of the order of the physical size of our computational domain. As has been noted before, the evolution of individual plasmoids depends fundamentally on their size, e.g. the bulk acceleration length scale is shorter for small plasmoids, and small plasmoids are responsible for the most rapid variability of the emitted radiation. We find that small plasmoids are able to radiate away a large fraction of their thermal energy within the domain boundaries, and hence their contribution to the observed light curves can be accurately described by the results of our simulations.
- Christie, I.M., Petropoulou, M., Sironi, L. & Giannios, D., 2019, MNRAS, 482, 65
- Sironi, L., Giannios, D. & Petropoulou, M. 2016, MNRAS, 462, 48

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Ruchi Mishra - Numerical Simulation of Backflow in thin Accretion disk

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Analytical solution for a thin accretion disk shows that, for some values of the viscosity parameter, part of the accretion flow in the disk, is not towards the star, but in the opposite direction. We study such thin disks by preforming hydrodynamic simulations using the PLUTO code, comparing the numerical with analytical results. We confirm that, for viscosity smaller than some critical value, there is a backflow in the mid-plane of the disk. The distance from the star to the starting point of

backflow is increasing with viscosity, as predicted by the analytical solution. When the viscosity reaches some critical value, there is no backflow in the disk. We extend this study to the cases with magnetic field.

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

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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 (RL) and radio-quiet (RQ) AGN selected from the Swift/BAT catalog 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 RL AGN than in 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.

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Agostino Leveque - MOCCA survey database I: preliminary results on Extra Galactic Globular Clusters

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The dynamical state of Globular Cluster (GC) strongly depends on the initial cluster conditions and evolution on stars and binaries. Moreover, the observed properties of Galactic and Extra Galactic Globular Cluster (EGGC) can be effected by their dynamical histories. In order to discrimate those effects, numerical simulation of Globular Clusters evolution is needed. In my studies, the MOnte Carlo Cluster simulAtor (MOCCA) code has been used.

I will present preliminary results from the dynamical evolution of Globular Cluster providing four prescription based on different mechanisms for neutron star (NS) and black hole (BH) supernovae

kicks. In fact, a different kick velocity distribution of NS and BH would imply a different number of compact objects retained into the system, and strongly influence the long-term evolution of GC.

Finally, I will present how the dynamical state of an observed EGGC could change its colors. In this study, I simulated mock observations, in different photometric bands, of GCs from selected simulations in "MOCCA survey database I", for distances greater than 1 Mpc. I expect that the obtained results contribute substantially to the observed bi-modality color distribution of EGGC.

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Przemysław Mikołajczyk - Beta Cephei stars from multi-source photometry

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In my presentation I will briefly outline possibilities of detecting new pulsation modes in Beta Cephei stars utilizing SMEI (Solar Mass Ejection Instrument) photometry.
Although reduction process of this kind of data is very complicated, it can be done quickly and efficiently and the final product are single band photometric measurements spanning over the period of over 8 years.
I will show some examples of data already prepared and decorrelated, focusing on B-type pulsators, but I will also present capabilities of such data for other spectral types of stars, including known binary systems, A- and F-type pulsators as well as long-term variables.

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Swayamtrupta Panda - Understanding the general scheme of FeII emission in active galaxies

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Quasar main sequence, analogous to the stellar main sequence , explains the connection between the wide variety of active galactic sources and their evolution. Based on *Principal Component Analysis* (PCA), the sequence can be explained by correlations between the observed spectral properties (Boroson & Green, 1992). Among those quantities, it was observed that the bulk of the correlation is driven by anti-correlation between two dominant terms - the measure of the Keplerian velocity of the Hβ profile (the full-width at half maximum) and the parameter $\mathbf{R}_{\rm FeII}$ (which is the FeII emission in the optical band between 4434-4684 Å, normalised to the broad Hβ emission). Due to its complexity resulting in numerous emission lines that span from the infrared to the ultraviolet regime, this resemblance to a continuum makes FeII difficult to extract useful information lest the spectra have a sufficiently high signal-to-noise. We utilize the current state of the art photoionisation modelling code, **CLOUDY** (Ferland et al. 2017), to estimate the net optical FeII emission (incorporating a 371 level FeII model with 68,535 transitions) emanating from the dense, ionized broad-line region (BLR) clouds. (a) With the two main physical observables - the black hole mass and accretion rate, and

incorporating the distribution of viewing angle, we explain the dependence of the R_{FeII} sequence on Eddington ratio (L_{bol}/L_{Edd}) and on the related observational trends. This dependence is shown as a function of the SED shape, cloud density and composition, verified from prior observations; and (b) We explain the high accretors from the theoretical relation between ionization parameter (U), the mean cloud density (n_H) and R_{FeII}. We incorporate the departure coefficient in standard radius-luminosity relation (Martínez-Aldama et al. 2019) and the fundamental plane relation (which is a bivariate relation between the Eddington ratio, R_{FeII} and $D_{H\beta}$ i.e., the shape of the broad emission profile for $H\beta$) for the BLR (Du et al. 2016) in this relation to constrain the physical parameter space for these high-Eddington sources.

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Ankan Sur - Magnetic field instabilities in Neutron stars

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Neutron stars are incredibly dense compact objects having the strongest magnetic field in the universe known to date. The exact configuration of the field is not known and the simplest model that is often considered is that of a dipole. Such a dipolar poloidal field is however known to be unstable and the equilibrium configuration is an open problem of great astrophysical relevance. We perform magnetohydrodynamic simulations using the publicly available code PLUTO. The field evolution undergoes a 'kink instability' and a cataclysmic rearrangement in few Alfven timescales. This develops a toroidal component with a field strength of the same order of magnitude as that of the poloidal component. In this process, the star gets deformed which causes it to produce a non-zero ellipticity. Such objects emit continuous gravitational waves which can be target sources for the advanced LIGO-Virgo detectors.

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Sowgata Chowdhury - Studying Massive star Variability with the TESS Mission

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BCEP stars are unique pulsators among all well-known variables, that end up in massive type-II supernovae. To study the connection between the progenitors and the supernovae remnants, it is crucial to do asteroseismic modelling of the progenitors and study its rotational activities. Rotational activities in hot stars also challenges the convection theory apart from deepening our understanding of how hot star rotation affect the pulsations and its asteroseismology. We are using highly precise space photometry obtained with NASA's TESS mission for this purpose. 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. BCEP stars as runaway pulsators or in EB systems, both provide additional constraints to improve our understanding of their past, present and future evolutionary states. In this project, we are systematically searching for interesting BCEP targets in the TESS fields, and following them through ground-based spectroscopy. Along with thorough studies of the known pulsators, we expect many new variables, especially in the galactic disc fields. Having attained a good understanding about the structure of these stars through detailed mode identification and efficient seismic modelling among others, we shall search

for the missing pieces that are hindering our deeper understanding of massive star evolution and their end states - violent Type II Supernovae.

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Beata Rogowska - Detection of fast moving objects using a synthetic tracking technique and astrographs equipped with sCMOS cameras

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I present a new technology in the sky surveys in order to look for fast moving and faint objects like unknown Near-Earth Objects (NEOs) or space debris. NEOs are chunks of the interplanetary matter located in orbits that allow them to enter the Earth's neighborhood. It is believed that they are relatively unchanged leftovers from a Solar System forming process. In result, they are of profound importance in understanding the structure, dynamics and evolution of the Solar System. Space debris are artificial objects left in orbit after space missions, non-operating satellites or products of in-space collisions or fragmentations of space vehicles e.g. rockets stages, paint flakes, astronauts'tools. They are potentially dangerous to operating satellites and human-in-space missions, as a single impact could produce a tremendous number of pieces and then an avalanche of collisions. Due to that detection, tracking and cataloguing of space debris are necessary to ensure safety in our cosmic neighborhood. Many of natural and artificial objects which are close to Earth are also intrinsically faint and move rapidly in the sky (even a few degrees per day for NEO, degrees per second for LEO debris), therefore their detection is complex.

I present the concept of modern observational technique for their detection. The technique is called synthetic tracking (ST) and its main goal is to mitigate the trailing loss caused by smearing an object' s image through the field of view (FOV) during a long exposure. The idea is to acquire a large number of short exposure frames, then shift and add them to simulate telescope tracking of the object. The powerfulness of this method depends on modern technologies like sCMOS detectors and wide FOV telescopes called astrographs. The sCMOS cameras are a new generation of CMOS technology called scientific CMOS. They are characterized by high-speed and low noise read-out. Astrographs are capable of capturing a bigger piece of the sky during a single exposure and so allow covering a large area of the sky during one night.

22

Qiang Chen - Numerical study of magnetized GRB afterglow shocks: dynamics and radiation emission

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The observation of GRB afterglow is an important means to locate the central emission counterpart and limit the physical parameters. We proposed a generic forward and reverse shock model to study the magnetization of the ejecta. The model is based on total energy conservation of each region in the whole shock system, hence can efficiently describe the dynamics evolution with an overall scope, and is found governed by the magnetic field corrected shock jump conditions. Principally the

new model can deal with arbitrarily magnetization degree, however with high degrees the reverse shock is suppressed even if it actually exists. We explored both ISM and wind type circum-burst medium. The light curve of wind type is flatter and more luminous by nearly an order compared to the ISM type. The synchrotron radiation light curves of both ISM and wind profile show the peak flux emission occurs when $\sigma \sim 0.1 - 1$. The numerical dynamics results helped in the interpretation of this perplexed trend. In a case of high σ, the magnetized plasma is radiatively inefficient, hence if the magnetic power is limited by total energy which is typically $\sim 10^{52}$ erg, the resulting luminosity must be very low due to the suppression of the ejecta density and the total particle number. This happens while magnetic energy dominates over kinetic energy once $\sigma > 1$.

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Marzena Sniegowska - CL AGN - the spectral (r)evolution

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I will present a detailed analysis of SDSS J123359.12+084211.5 –source classified by MacLeod et al. (2018) as a
CL AGN. However, this object is an exception in CL AGN population, because of large Eddington ratio and strong changes in FeII emission.
The changes in the FeII strength affects the position of the object in the optical FWHM Hbeta vs. RFe plane, where RFe is a ratio of EW FeII and EW Hbeta.
A broad component of Hbeta line changes dramatically as well, which disrupts known correlations in the proposed Quasar Main Sequence.
Moreover, I have found more objects with similar spectral evolution, which may indicate that CL AGN are not a homogenous sample.
Lastly, we propose a simple explanation of the mechanism of the Changing Look phenomenon in AGN. This model gives quantitative predictions and works well for
multiple outbursts of NGC 1566.

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Bartosz Etmański - Ammonia in circumstellar envelopes of carbon rich stars

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The HIFI instrument on board of the Herschel Space Observatory (HSO) has been very successful in detecting molecular lines from circumstellar envelopes around evolved stars, like massive red supergiants, Asymptotic Giant Branch (AGB) and post-AGB stars, as well as planetary nebulae. Among others, ammonia has been found in circumstellar envelopes of C-rich AGB stars in amounts that significantly exceeded theoretical predictions for C-rich stars. Few models have been proposed to resolve this problem: formation of ammonia behind the shock front, photochemical processes in the inner part of the envelope partly transparent to UV background radiation due to the clumpy structure of the gas, and formation of ammonia on dust grains. Careful analysis of observations may help to put constraints on one or another mechanism of formation of ammonia. Here, we present details of the non-LTE radiative transfer modeling of ammonia transitions including a crucial process of radiative pumping via v_2 = 1 vibrational band (10 μm) for selected stars from the sample of C rich

stars observed with the HIFI instrument. These sample of C-rich stars include mostly ground transition of ammonia J = 1_0–0_0 at 572.5 GHz. The photodissociation radius (and distribution molecule) of ammonia has been obtained from calculation of the simplified chemical model of the circumstellar envelope including only proces of photodissociation (Glassgold et al. 1987). The dust properties were obtained from modelling of the spectral energy distribution (SED) (MRT, R. Szczerba, 1993). In some cases observed SED was reproduced by assuming inverse power law dependence of dust opacity with wavelength, fixed optical depth at selected wavelength, and power law distribution of dust temperature in the envelope (e.g. Schönberg et al. 1987).

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Bartłomiej Zgirski - Calibration of RR Lyrae stars as distance indicators. New reddening maps of the Magellanic Clouds.

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In my talk, I will present preliminary results obtained using optical and near-infrared telescopes from Cerro Armazones and different spectrographs from observatories located in Chile. Results concern calibration of the Baade-Wesselink method (infrared surface-brightness method) and Galactic period-luminosity relation for RR Lyrae stars in the proximity of the Sun. These calibrations are crucial for future precision measurements to different groups containing old (type II) stellar population such as globular clusters, dwarf galaxies, galactic haloes, etc.

In the second part of the talk, I will present new reddening maps of the Magellanic Clouds. Such maps are crucial for measuring energetics of any phenomenon that occurs in the MCs and thus for precision calibration of distance indicators.

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Chandra Shekhar Saraf - Cross-Correlation Study between CMB Lensing and Galaxy Surveys

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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 the CMB is combined with the tracers of LSS, one can constrain cosmological models, models of LSS development and astrophysical parameters simultaneously. The main focus of this project is to study the cross-correlations between CMB lensing and the galaxy matter density to constrain the galaxy bias b and the amplitude scaling parameter A, to test the validity of ΛCDM model. We test our approach for simulations of the Planck CMB convergence field and galaxy density field, which mimics the density field of the Herschel-ATLAS (H-Atlas) galaxy survey. We use maximum likelihood method to constrain the parameters.

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Marcin Semczuk - Tidally induced warps of spiral galaxies in IllustrisTNG

Author: Marcin Semczuk[None]

Warps are a very common feature of spiral galaxies. According to first Bosma's law (Bosma 1991), at least half of observed spirals have warps present in HI observations. All three massive spirals of the Local Group have warped disks. The frequent occurrence of this feature implies that warps are either long-lived or continuously generated. There are several theories aiming to explain the origin of warps in galactic disks. They often refer to the misalignment between dark halo's and disk's angular momenta, asymmetric gas accretion or tidal interactions.
During my talk, I will present early results of my project in which I am investigating tidally induced gaseous warps of galaxies from IllustrisTNG simulations. IllustrisTNG is a state-of-the-art magnetohydrodynamical cosmological suite of simulations that follows the formation and evolution of galaxies. I found that around 190 galaxies from one of the IllustrisTNG simulations have S-shaped warped disks and the most common formation mechanisms of these warps are tidal interactions and accretion of satellite galaxies.

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Mohammad Naddaf - Realistic Numerical Approach to the Dynamics of BLR Clouds and Determination of BLR location in FRADO Model

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I will present my simulation results of the motion of the dusty clumps under the gravity of black hole and the effect of radiation pressure from a realistic extended accretion disk. I will show how this radiation accelerates the dusty clumps and forms dust-driven winds in AGN, and having included the change in dust opacity, i.e. dust sublimation, I discuss how and where it may lead to a failed outflow (Czerny et al. 2017). These simulation results for different parameters such as BlackHole mass, accretion rate, accretion efficiency, and dust species, can give us a 3-D picture of the matter distribution and its dynamics and location of BLR, from which one then can calculate the expected time delay distribution, and can obtain the shapes of emission lines.

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Vadym Khomenko - Hydrodynamical instabilities in superfluid neutron stars with background flows between the components

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The interiors of mature neutron stars are expected to be superfluid. Superfluidity of matter on the microscopic scale can have a number of large scale, potentially observable consequences, as the superfluid component of the star can now flow relative to the 'normal'component that is tracked by electromagnetic emission.
The most spectacular of such phenomena are pulsar glitches, sudden spin-ups of the neutron star, observed in many pulsars. A background flow of the normal-fluid part of the star with respect to the superfluid is also known to lead to a number of instabilities in laboratory superfluids, possibly leading to turbulence and modifying the nature of the mutual friction coupling between the two fluids.
We consider modes of oscillation in the crust and core of a superfluid neutron star, by conducting a plane-wave analysis. We explicitly account for a background flow between the two components (as would be expected in the presence of pinning) and perturbations of the entrainment, and we consider both standard (Hall-Vinen) and isotropic (Gorter-Mellink) forms of the mutual friction. We find 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. For isotropic mutual friction we find no unstable modes, and speculate that instabilities in a straight vortex array may be linked to glitching behaviour, which then ceases until the turbulence has decayed.

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Syed Naqvi - Gravitational wave Memory Effect

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Gravitational waves offer a unique window to study the strong-field regime of general relativity. In 1916-18, Einstein showed their existence in linearized approximation which was followed by a period of confusion. Finally cemented theoretically by Bondi, Sachs, Trautman gravitational waves are an important tool to discover new information about fundamental gravity effects.

One of the persistent gravitational wave effect called memory effect forms an interesting proposition theoretically and astrophysically. It is essentially a permanent displacement between particles after GW passes. It's linear and non-linear form will be important for the future GW detections from compact binary sources. This effect gives information about the asymptotic nature of spacetime and is relevant for a large number of detections by LIGO/VIRGO. The linear part discovered by Zel'dovich & Polnarev and the nonlinear part discovered by Christodoulou help us understand the nature of spacetime and explore further the nonlinear part of general relativity.

We plan to study the linear memory effect for different wave profiles under the exact plane wave solution of Einstein's vacuum equations. The displacement and velocity memory effects are studied by analyzing the geodesic equation for test masses under exact plane wave spacetime.

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Samaresh Mondal - The connection between ultra-luminous X-ray sources and double compact objects.

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We explore the different formation channels of merging double compact objects (DCOs: BH-BH/BH-NS/NS-NS) that went through an ULX phase (X-ray sources with luminosity exceeding the Eddington luminosity of a 10 $M_\odot$ black hole). There are two major formation channels which can naturally explain the formation of DCO systems: isolated binary evolution and dynamical evolution inside dense clusters. It is not clear which channel is responsible for (majority/all) LIGO/Virgo sources. Finding connections between ULXs and DCOs can potentially point to the origin of merging DCOs as more and more ULX are being discovered.
We use the StarTrack population synthesis code to show how many of the observed ULXs may form merging DCOs in the framework of binary evolution. We find that in the local universe as many as ~50% of merging DCO progenitor binaries have evolved through an ULX phase. This shows that ULXs can be used to study the origin of LIGO/Virgo sources.

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Sumanta Kumar Sahoo - On a mode geometry in a sample of subdwarf B stars observed by TESS

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Hot subdwarf B (sdB) are the extreme horizontal branch stars, which had lost most of their hydrogen envelope and will go directly to the white dwarf cooling track. A complete evolution process of such stars is still a puzzle. Pulsating sdB stars (sdBV) may support our effort. A detailed asteroseismic study and modelling along with spectroscopic analysis over a large sample of these stars will surely help us to understand the internal structure and their evolution. In this project, we are using the relatively precise short and long cadence data obtained during TESS mission, in order to collect a large sample of pulsating sdB stars. Thus far, we have detected more than 15 rich g-mode sdB pulsators from nine months of data. By using fourier transform technique, we detect pulsation frequencies in these stars. Then, we have to identify the pulsation modes, which would describe pulsation geometry, to better constrain theoretical pulsation models of sdB stars. For this purpose, we use a selection of features such as rotationally split multiplets and/or asymptotic period spacing along with some statistical analysis.

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Sachu Sanjayan - Musical Orchestra of sub dwarf B stars in NGC6791

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We analyzed Kepler super apertures LC data of the open cluster NGC6791 to search for new pulsating sdB stars. We found a sample of many pulsating and binary stars, among which three of them are sdBV stars KIC2569576 (B3), KIC2437937 (B5) and KIC2438324 (B4). These stars were known before, though we extended the data coverage detecting more frequencies and features in periodograms, like new multiplets, extended period spacing sequences and candidates for trapped modes. We will show our results using the usual tools, like the KS test, echelle diagrams and reduce period diagrams. Our result will surely help calculating well constrained evolutionary models of these stars.

34

Saikruba Krishnan - Tools for Period Searching in AGN in the Era of ”Big Data”

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Active Galactic Nuclei persistently emit across the electromagnetic spectrum and are dominated by stochastic, aperiodic emission that is variable on timescales from hours to decades. The stochastic variability tends to overwhelm any possible periodic signal, preventing us from robustly confirming if periodic signals are present in AGN. It has also been seen that pure stochastic red noise signals spuriously mimic few-cycle periods. We have already entered the era of “Big Data” with current and near-future large-area monitoring programmes such as LSST facilitating data trawls for periodicities; developing the proper know-how for period searching is thus essential. Hence in our project we try to account for the red noise properly using different methods (ACF, epoch folding, wavelet analysis and Bayesian analysis) and test if each method can robustly distinguish between pure red-noise processes and mixtures of a strictly- or quasi-periodic signal (QPO) plus red noise, while pursuing the following questions: When the variability process is pure red noise (no QPO present), what is the false-alarm probability and how does it depend on broadband continuum PSD shape? When there is intrinsically a mixture of red noise and a QPO, is there a range in detection sensitivity between the various methods? How many observed cycles are needed for confirmation of a detection?. Here we present some of the results and inferences drawn from analysis in progress. We compare our results to models of binary SMBH systems to constrain the regions of parameter space where detection of periodicities against AGN red noise is feasible.

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Krystian Iłkiewicz - Population synthesis of classical novae population

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Cataclysmic variables (CVs) are interacting binary stars that consists of a degenerate white dwarf accreting mass from a normal star donor. Our understanding of evolution of such systems have been challenged by properties of their known population, such as white dwarf mass distribution, orbital period distribution and their space density. With the recent developments of population synthesis codes we are able to reproduce the CV population characteristics. However, there are still unsolved problems posed by the population of classical novae among the CVs, such as for example why there is only one system known to have both dwarf nova and classical nova outbursts. In my talk I will discuss the recent developments of population synthesis codes as well as my work on understanding of classical novae population using population synthesis.

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Piotr Wielgórski - Type II Cepheids as precise distance indicators

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The goal of my PhD project is calibration of two methods of measuring distances with Type II Cepheids as indicators. These old population stars are less luminous and not so stable as their famous young population counterpart- Classical Cepheids, however they can be used to determine distances of dwarf galaxies and globular clusters, where Classical Cepheids are not observed. I am going to use parallaxes of a sample of 40 nearby Type II Cepheids determined by the Gaia mission and photometric and spectroscopic observations performed in the Cerro Armazones and La Silla Observatories to calibrate period-luminosity relation and p-factor from the Baade-Wesselink method for these stars. In my talk I will present preliminary results.

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David Abarca - Radiative GRMHD simulations of accretion onto neutron stars

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We simulate accretion at super-critical rates onto magnetized and non-magnetized neutron stars to investigate the properties of matter flow in the vicinity of ULX pulsars. We show first results of a newly implemented method to simulate a well behaved magnetosphere. We explore the case of channeled accretion along magnetic field lines leading to the formation of accretion columns and the radiative luminosity from the magnetically confined plasma. We also demonstrate that high rates of accretion alone onto a non-magnetized neutron star are insufficient to produce super-Eddington luminosity.

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Konrad Kobuszewski - Dynamics of quantized vortices in sipn-imbalanced Fermi superfluids.

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Behaviour of interacting fermions at low temperutres is not fully understood despite over the six decades of theoretical and experimental studies in the systems like liquid He-3, heavy nuclei, neutron stars and more recently in cold atoms. In this regime all these systems undergo a superfluid phase transition which can be indicated by appearance of quantized vortices.
In my talk I would like to briefly describe crucial differences between bosonic and fermionic superfluidity to justify that the second case is far more demanding at the fundamental level, because a satisfactory description requires inclusion of many mechanisms for superfluid relaxation like various phonon processes or Cooper pair breaking. Moreover the spin-imbalnce introduces new complication, because implies coexistance of both superfluid and normal components even at zero temperature limit. I will show that time-dependent superfluid density functional theory (TDSLDA) in a natural manner incorporates all these necessary ingredients. I will also present some numerical simulations of quantized vortices within TDSLDA in the so-called unitary Fermi gas. In comparison to the spin-balanced case, a suprising feature of a vortex in the spin-polarized system will be revealed. Finally I will discuss how my research can influence understanding of quantum turbulence and modeling of the neutron star crust.

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Henryka Netzel - Non-radial modes in classical Cepheids - what to look for in spectroscopy?

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Recent photometric observations of classical Cepheids and RR Lyrae stars led to discoveries of additional signals, which are suggested to be due to excitation of non-radial modes with degrees 7, 8 and 9 (Cepheids) or 8 and 9 (RR Lyrae stars). These modes in photometric data have usually low amplitudes. This fact, combined with a high degree of these modes would make it very difficult to detect these signals in spectroscopic data. I present a survey of simulated spectra for first-overtone Cepheids to investigate what can we learn from spectroscopy about these mysterious modes.

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Filip Morawski - Deep learning classification of the continuous gravitational-wave signal candidates from the time-domain F-statistic search

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There are many potential sources of gravitational waves (GW) still awaiting detection. Among them, particular attention is given to the non-axisymmetric neutron star (NS). The emitted, almost

monochromatic signal is expected to be detected in the near future by LIGO and Virgo detectors. Although the GW waveform is well known, its small amplitude makes it extremely hard to detect.
The accepted approach in searching for continuous GWs is a matched filter technique known as the F-statistic method. The method generates large number of GW candidate signals that have to be further analyzed.
In our work we present the application of deep learning in the analysis of F-statistic signal candidates. To model the continuous GW we use the spinning triaxial NS ellipsoid signal injected in the Gaussian noise. Our dataset contains also stationary lines mimicking local artifacts in the detector frame. In the first part of our research we study the application of convolutional neural networks for the classification of the GW. Second part of the talk is focused on various unsupervised deep learning algorithms in order to clusterize the dataset.
Our research shows the benefits of using deep learning in the context of the classification of continuous GWs. It also gives limits to the signal-to-noise ratio of the signal our method is able to correctly identify.

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Ananda Deepika Bollimpalli - X-ray variability in compact objects

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Compact objects like neutron stars and black holes exhibit X-ray variability on different time scales and the key processes responsible for this variability differ depending on the type of the compact object and the time scale of the variability. Spectral-timing analysis of X-ray bursts in accreting neutron star systems shows periodic intensity variations which are termed as burst oscillations. We explore a new possibility of understanding these burst oscillation frequencies in the context of the radial oscillations of "levitating atmospheres". There is plenty of observational evidence that some neutron star systems reach super-Eddington luminosities, either through the accretion of matter onto the stellar surface or by thermonuclear burning. Stars with such high luminosities are shown to harbor levitating atmospheres, supported by the radiation pressure from the star at a certain height above the stellar surface. We study the oscillations of these radiation-supported atmospheres to find a family of relativistic eigenmodes and eigenfrequencies of the radial oscillations. The frequency of these oscillations depends on the stellar parameters and varies with the stellar luminosity/ flux. We also find that damping due to radiation drag limits the frequency of these oscillations introducing a characteristic maximum in the frequencies. Both the maximum frequency and the frequency variation with the flux can be used to determine the mass and radius of the neutron star. In addition to the stellar parameters, observation of the variation of the oscillation frequencies with flux would allow us to estimate the stellar luminosity and therefore the distance to the source with an accuracy of a few per cent.

Extensive studies of X-ray timing analysis have shown that black-hole X-ray binaries exhibit extreme variability in X-rays on short time scales in the so-called hard state. Various characteristics of these X-ray variability are well interpreted by inward propagating fluctuations in mass accretion rate. In this work, we try to compare the accretion rate profiles from GRMHD simulations of a geometrically thick and optically thin advection dominated flow (ADAF) to those predicted by the phenomenological model of Mahmoud, Done & De Marco (2019) to better understand the underlying physical process in the accretion disks. We find the power-spectra and the time lags generated from GRMHD accretion rate curves to be inconsistent with the model-fitted data. We speculate that the GRMHD case shows a rather different phenomenon, perhaps related to the B-field fluctuations, whereas the model-fitted data are instead dominated by the propagating small fluctuations.

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Monica Taormina - Towards an accurate distance determination: physical parameters of early-type eclipsing binaries in the LMC

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Late-type eclipsing binaries provide very good means for distance determination, but we can observe them no farther than in the Magellanic Clouds. Although early-type binaries were discovered in other galaxies in the Local Group, they cannot be used because of a lack of a firm calibration of the surface brightness - color relation. Our goal is to establish this relation for early-type stars based on high quality spectroscopic and infrared observations of B and O-type detached eclipsing systems in the LMC. It will allow distance determinations accurate to about 2.5% to a single object located well beyond the Magellanic Clouds. Apart from this, we will obtain precise physical parameters of about 20 early-type stars, which can be used for a detailed study of their evolution. This is particularly important for the massive stars for which not many good measurements of the fundamental parameters are available. Here we will present our solution for one O and one B-type massive detached SB2 system. The masses of their components are about 20 Msun and 14 Msun, respectively.

44

Katarzyna Rusinek - Radio bimodality of Swift/BAT AGNs and SDSS quasars

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The radio-loudness of an Active Galactic Nucleus (AGN), defined as the ratio of its radio luminosity to its optical luminosity, indicates the existence of radio-quiet (RQ) and radio-loud (RL) objects, the latter of which represent 10% of sources. However, there is a clear division in the field - some studies push for a strong bimodality in the distribution of radio-loudness while others claim a smooth distribution of this quantity. The lack of consensus on this topic may result from selection methods such as limits in the optical magnitude and radio flux and/or the estimation of the radio luminosity - should we account for the extended radio structure or stick to the core emission only?

Taking all of the above into account we decided to study the radio bimodality in two samples with well defined black hole masses ($M_{\rm BH}$) and Eddington ratios ($\lambda_{\rm Edd}$), and by having all the objects selected using the same criteria. Our preliminary results indicate that: (1) there is an explicit bimodality in the radio-loudness distributions in both populations; (2) the RL fraction of AGNs accreting at moderate rates is larger than of quasars. In my presentation I will focus on finding the main features and mean properties of radio-loud, radio-intermediate and radio-quiet sources. In addition to that, I will discuss the physical sizes and radio morphologies of each of the samples by including the distinction between compact and extended radio morphologies as a parameter.

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Mikołaj Kałuszyński - The Araucaria Project: Using Graph Databases for Astronomical Data on the Example of the "fits-warhouse"System

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These days, observational astronomy collects enormous volume of data. Most of this volume is made of broadly defined measurements and products of those measurements processing. Along with this measurement data, big amount of structured metadata has to be processed and maintained. Also, the research results has usually the form of structured data. The examples of such kind of data are respectively: FITS files headers and derived properties of astronomical objects.
We present how the problem of storing, analyzing and maintaining relationships between structured data can be addressed using graph databases, which is relatively novel approach to database management systems. The demonstration is based on the current implementation of fits-warehouse –a database of metadata of the Aruacaria project's FITS files library, along with parameters of observed objects. The fits-warehouse uses the neo4j graph database engine and stores around 10 milion of records.

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Dominik Gronkiewicz - Thermal instability of warm and optically thick corona

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Warm, optically thick corona in slab geometry is a plausible explanation for Soft X-ray Excess observed commonly in AGNs and in some Black Hole Binaries. We have shown that this coronal layer can be formed by dissipation of energy carried by magnetic field from the disk midplane.

However, the energy supply does not guarantee the existence of the corona, as in some situations it appears to be severely impacted by local thermal instability when even basic radiative transfer is included. The instability is caused by steep dependence of free-free opacity with temperature. The extent and magnitude of deviation from stability is dependent mostly on temperature of the disk-corona boundary, however slight dependence on magnetic field strength is also observed. For this reason, it impacts mostly outer parts of the disk, where the gas is cooler and free-free opacity contribution is significant.

We discuss the strength and limitations of used approach and effects of different opacity models. We also consider the possible interesting consequences and outcome scenarios of this result for coronal models as well possibility for disk winds or outflows.

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Bartosz Bełdycki - Ray-traced spectra from the matter moving around compact objects

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Accreting systems, i.e. consisting of an accretion disk around compact object, are well visible on the X-ray range. To be able to theoretically explain the broadband spectrum of there object in accordance with observations, we need several emission components.
In a previous years, we showed that there is possibility of modeling the emission of such sources, if we sum up emission from the source, taking into account the fact that these objects are not spherically symmetrical and the emission depends on the observer's inclination. In addition, we showed that it is possible to use such counted models to estimate the distance to the source, which coincided with the values obtained by observation methods.
Our main goal is to answer the question whether it is possible to explain the shape of the spectrum observed in the X-ray range, using a model that will reconstruct the emission from a source with non-spherical symmetry including the effects associated with a strong gravitational field near compact objects together with accurate modeling of the accretion disk's atmosphere.
In this talk, I will discuss how the reconstruction proceeds and at what stage of development we are currently.

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Arkadiusz Chimicz - National Space Situational Awareness Operation Centre setup and requirements

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One of the aims of Polish Space Strategy is it set up and enhance capabilities of National Space Situational Awareness (SSA) Centre. The centre is planned to encompass three basic elements of SSA that is Space Surveillance and Tracking (SST), Near-Earth Objects (NEO) and Space Weather (SWE). Each of the element has it own specificities and there I am concentrating on the SST which is a priority.

The SST functionality is to gather measurements through radar, optical and laser observations of Earth surroundings through survey and tracking in order to process this information into actionable services aiming in general to mitigate unwanted and harmful actions in the space.

In the scope of the presentation the general functional structure of the Centre will be discussed and proposed. In particular the basic SST services such as conjunction assessment, re-entry analysis, fragmentation analysis and mission characterisation will be elaborated and the technical requirements presented.

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