

XXI SERBIAN ASTRONOMICAL CONFERENCE

October 5 - 8, 2026, Belgrade, Serbia

BOOK OF ABSTRACTS

Eds. Milica Andjelić and Dragana Ilić



Belgrade 2026

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SUPERMASSIVE BLACK HOLES AT COSMIC DAWN

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Supermassive black holes are ubiquitous in the nearby Universe. Their lifecycle appears to be closely connected to the evolution of galaxies. How and when did these mysterious objects form? What was the first generation of black hole seeds? How did they grow quickly enough to power the most distant quasars? And how do black holes co-evolve with galaxies? I will summarize the demographics of central black holes in the local Universe and recent discoveries made with the James Webb Space Telescope that offer surprising, new insights into the earliest phases of black hole and galaxy formation during the first billion years of cosmic history. I will outline what we know and the much else that still remains uncertain.

RUBIN OBSERVATORY'S LSST: STATUS REPORT

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The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST), the most comprehensive optical astronomical sky survey ever undertaken, started obtaining panoramic images of the night sky this year and will continue doing so for ten years. The resulting 30 petabytes of imaging data, essentially a digital color movie of the night sky, will include about 20 billion galaxies and a similar number of stars, and will be used for investigations ranging from cataloging potentially dangerous near-Earth asteroids to fundamental physics, such as the characterization of dark matter and dark energy. I will briefly showcase Rubin's early data and the upcoming Data Preview 2, which is equivalent to about 1% of LSST dataset and will enable many early science projects.

**ASTEROID SYNTHETIC PROPER ELEMENTS: COMPUTATIONAL
COMPLEXITY, FAILURES, COMPARISON OF THE CATALOG
CONTENTS AND DATA ACCURACY**

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Asteroid synthetic proper elements are computed by means of the well known and amply tested routines, with a firmly established standard theory, practices and the software used for the purpose. For the sake of the proper elements users we present here an overview of the complexities encountered in their computation for asteroids with very different orbits, from fairly regular to highly chaotic, and in various dynamical circumstances. We discuss comparatively seldom failures of the procedure - occurrence of hyperbolic osculating elements in the course of numerical integration, very large errors of the resulting proper values, problems in computation of chaos indicators, and similar, and by considering several typical examples, we point out the dynamical or computational causes of the failures, e.g. resonances or close approaches to perturbing planets.

The proper element catalogs nowadays typically contain data sets for well over a million asteroids, and are available from three different sources (AstDyS, Asteroid Families Portal, PDS A&D subnode). We compare the contents of these catalogs and discuss the accuracy of the data in terms of the most common applications of proper elements: classification of asteroids into families and study of the asteroid long term dynamics.

USING AI TO ADVANCE UNDERSTANDING OF OUR UNIVERSE

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AI has revolutionized many aspects of life, and impacted scientific research in different areas, including understanding of our universe. AI can advance how we do research in cosmology, how we analyze the data, and how we interpret the observations. I will present a few examples ranging from galaxy clustering to weak lensing that demonstrate the power of AI in cosmology.

RADIO EVOLUTION OF SUPERNOVA REMNANTS

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Supernova remnants (SNRs) are a particular class of emission nebulae characterized by strong shocks propagating through the interstellar medium (ISM). These shocks accelerate particles and compress and amplify the interstellar magnetic field, making SNRs powerful synchrotron radio emitters. Although synchrotron emissivity depends on several variables, it is determined primarily by the number density of cosmic-ray (CR) electrons, their injection momentum, and the strength of the magnetic field in the emission region downstream of the shock. As SNRs dynamically evolve in time, these variables change and we also expect some radio evolution of SNRs. We model this evolution based on our current understanding of particle acceleration processes and magnetic field compression and amplification. In the presented test-particle model, we include electron heating, as well as resonant and non-resonant magnetic-field instabilities. Using this model, we calculate evolutionary tracks in the in the so-called radio surface-brightness – diameter ($\Sigma - D$) plane.

MAPPING THE MULTI-PHASE BARYON CYCLE IN COOL-CORE BCGS WITH JWST/MIRI

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Brightest Cluster Galaxies (BCGs) reside in the deepest gravitational potential wells in the Universe, making them ideal systems for studying the interplay between the interstellar medium and active galactic nucleus (AGN) feedback. In cool-core clusters, these galaxies are immersed in complex, multiphase environments featuring extended filamentary structures whose origin and excitation remain poorly understood. While Spitzer spectroscopy previously revealed strong rotational H₂ emission, its lack of spatial resolution prevented a clear identification of the physical drivers behind this gas. In this talk, I will present the first spatially resolved mid-infrared imaging and spectroscopy of five representative cool-core BCGs obtained with JWST/MIRI. By combining high-resolution F560W, F770W, and F1000W imaging with MIRI Medium Resolution Spectroscopy (MRS), we resolve these filaments and their physical conditions on 100 pc scales. I will introduce a new color-color diagnostic (F770W/F560W vs. F1000W/F770W) that effectively disentangles PAH-rich star-forming regions from H₂-dominated gas. Crucially, we have developed a method to quantify the line contribution to the broadband MIRI filters, allowing us to map the molecular gas mass fraction and confirm that these filaments are indeed reservoirs rich in warm molecular hydrogen. By anchoring these MIRI findings with multi-wavelength data from ALMA and MUSE, we are quantifying the circulation of the baryon reservoir across the central 50 kpc. Our results confirm that these H₂ filaments are dominant structures in the circumgalactic environment, providing a direct observational constraint on AGN-driven processes. This work establishes a high-resolution framework for investigating the interplay of multiphase gas in the most massive galaxies in the local Universe, revealing filamentary structures previously inaccessible to direct study.

PLATO: TERRESTRIAL PLANET HUNTER

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The European Space Agency's PLATO mission is scheduled for launch in spring 2027. The PLATO satellite is a unique space observatory equipped with 26 cameras working together to continuously monitor the brightness of more than a hundred thousand stars for several years. By combining observations from space and ground-based telescopes, the mission will provide an unprecedented census of planetary systems in our Galaxy and help us understand how planets form and evolve. The instrument, observing strategy and data reduction pipelines are optimised for the detection of small, Earth-sized planets orbiting Sun-like stars, including planets located in the habitable zone. PLATO's instruments have now been completed, the first observing field has been selected, and extensive testing and mission preparations are underway. This talk will provide an overview of the mission, its scientific objectives, and the status of its preparations for launch. I will also give information about the guest observer program, and the data products that will be released to the community.

**SERBIAN DIRECTABLE SOFTWARE IN-KIND CONTRIBUTION
FOR AGN SCIENCE IN THE VERA C. RUBIN OBSERVATORY
LEGACY SURVEY OF SPACE AND TIME**

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The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) is opening a new regime for time-domain astrophysics, in which extracting science from massive, irregularly sampled, multi-band light-curve datasets requires scalable and robust analysis tools. Within the international Rubin In-Kind Program, the Serbian SER-SAG-S1 team contributes directable software development focused on variability analysis of active galactic nuclei (AGN) and transient and variable sources. The contribution has resulted in the development of Quasar harmonic eXplorer (QhX), designed for detection and characterization of periodic and quasi-periodic signals in irregular multi-band time series (Kovačević et al. 2026a), together with Quasar neural attentive latent process (QNPY-Latte), a machine-learning framework for photometric reverberation mapping (Raju et al. 2026). Both developments have been accompanied by validation, documentation, community testing and training activities within the Rubin Science Collaborations. We present the development of the Serbian contribution from its initial scientific requirements to science-ready software, its application to precursor and Rubin Data Preview datasets (Kovačević et al. 2026b), and its role in enabling AGN variability studies in the LSST era. This contribution reflects the growing integration of astronomy, informatics, and statistical methodology, providing scalable tools for extracting robust scientific information from the increasingly large and complex time-domain datasets of the Rubin LSST era.

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BEYOND THE GALACTIC HABITABLE ZONE: A CONTEMPORARY VIEW OF GALACTIC HABITABILITY

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The Galactic Habitable Zone (GHZ) was originally conceived as a static, metallicity- and hazard-defined annulus within a galaxy, a valuable first approximation for linking galactic properties to the conditions necessary for life. Over the past two decades, however, advances in cosmological simulations, stellar surveys, and exoplanet science have fundamentally changed our view of galaxies, revealing that habitability is governed by a complex interplay of chemical evolution, stellar dynamics, star formation history, and astrophysical hazards that evolve over cosmic time. Here, I discuss how these developments challenge the classical GHZ picture and motivate a more dynamic framework for galactic habitability. Stellar orbits are not fixed: radial migration redistributes stars across galactocentric distances throughout the lifetime of the galaxy, blurring any sharply defined habitable ring into a broader, time-dependent region. Chemical evolution is not fixed either: massive galaxies going through mergers or gas accretion can become chemically decoupled, with a metal-rich stellar population coexisting with a diluted gas reservoir. This transitional state turns out to reshape habitability estimates in a counterintuitive way: the very processes that suppress future terrestrial planet formation can also suppress the radiation hazards for already existing planetary systems. These examples illustrate the need to move beyond the static habitable zone concept toward a physically motivated, time-dependent description of galactic habitability. I aim to offer both a synthesis of where the field currently stands and a perspective on how much of the classical GHZ picture can be expected to survive closer scrutiny when the reality of complex galaxy evolution is accounted for.

RADIATIVE SHOCKS IN SNRS: MAGNETIC FIELDS AND COSMIC RAYS

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Most studies of radiative shock waves aim to derive the shock speed and perhaps elemental abundances. If proper motion velocities and high resolution spectra are available, it is possible to obtain the ram pressure, preshock density and compression ratio and to estimate the non-thermal radio and gamma-ray emissivities. We will discuss the techniques for finding the ram pressure in particular.

MOLECULAR OUTFLOWS AT HIGH REDSHIFT PROBED BY ABSORPTION LINES

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Gas outflows are believed to play an important role in galaxy evolution as they regulate star formation, limit fueling of the central supermassive black hole, and enrich the halo and intergalactic medium with metals. Since molecular gas, which is the coldest and densest phase of the interstellar medium, is the primary fuel for star formation, molecular outflows are often seen as evidence of negative feedback, i.e., suppression of star formation that may facilitate the transition from a star-forming to a quiescent galaxy. Observations suggest that the molecular phase often dominates the mass budget of the outflows. Therefore, if the outflow velocity exceeds the escape velocity, the loss of gas can permanently affect star formation and transport substantial metal-enriched material to the intergalactic medium. However, studies of molecular outflows at high redshift are still limited due to observational challenges. Their driving engine and impact on host galaxies are thus not fully understood. In this talk, I will first outline the efforts to search for such outflows in star-forming galaxies and quasars from the local universe to the Epoch of Reionization (redshift $z \sim 6$ and beyond) using far-infrared absorption lines. This epoch was marked by galaxy formation accompanied by high star formation activity and rapid supermassive black hole growth that culminated at cosmic noon ($z \sim 2$), when outflow feedback may have played a prominent role. Then, I will focus on recent observations targeting the OH (hydroxyl radical) molecule via its rotational line at the rest wavelength of $119 \mu\text{m}$ using the Atacama Large Millimeter/submillimeter Array. The P-Cygni line profile of OH $119 \mu\text{m}$ provides robust evidence of molecular outflows even when they are undetected in emission lines of other tracers of cold gas, such as the CO rotational lines and [C II] $\mu 158 \text{ m}$. Specifically, I will present our recent observations of OH toward quasars that reveal powerful molecular winds blowing at velocities up to $\sim 1500 \text{ km/s}$ driven by the nuclear activity, and discuss their impact on the evolution of host galaxies.

BLUE EXCESS HOT DOGS AND THEIR LINK TO LOCAL AGN

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Hot dust-obscured galaxies (hot DOGs) are a population of hyperluminous, highly obscured active galactic nuclei (AGN) found at high redshifts. Their spectral energy distributions are characterized by extremely red thermal dust continua in the infrared and typical galaxy features at shorter wavelengths. However, about 25% of hot DOGs exhibit blue UV/optical continua, consistent with either unobscured AGN emission or extreme star formation. By combining optical polarimetry with VLT/FORS2 and radiative transfer simulations, we demonstrated that the blue continuum is in fact light from the obscured AGN scattered by dust in the polar region, coincident with a massive outflow. Meanwhile, it has recently become clear that dust is ubiquitously present in the polar regions of local AGN, where it is tentatively associated with radiation pressure-driven winds. Using multi-wavelength observations and radiative transfer simulations, we constrained the geometry and dust properties of the archetype 1 AGN in the nearby Circinus galaxy. Remarkably, the dust in this nearby, low-luminosity Seyfert galaxy exhibits properties similar to those found in the high-redshift, hyperluminous AGN hosted by blue hot DOGs.

PEERING INTO SUPERNOVA EXPLOSIONS WITH JWST

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Supernovae are among the most energetic events in the universe and play a key role in shaping the energy balance, structure, and chemical content of galaxies. They are responsible for the formation and distribution of heavy elements and dust grains that enrich the interstellar medium in which they evolve. The explosions leave behind compact objects whose high densities and magnetic field strengths represent matter under some of the most extreme conditions known, while some serve as standard candles with a crucial role in determining cosmological parameters. Despite their great importance in astrophysics, key questions remain about the nature of supernova progenitors and their precise explosion mechanisms. The role of supernovae in the dust enrichment of galaxies is also a major open question. In recent years, JWST has provided an unprecedented view of young supernova remnants, allowing us to peer into the deepest ejecta layers, probe dust formation, and reveal remarkable, never-before-seen details in the structure of the interior ejecta and surrounding circumstellar material. I will review some of these recent JWST observations of supernova remnants and what they tell us about supernova explosions and their progenitors.

BEYOND THE SURVEY: COMPLEMENTARY ACTIVITIES IN THE RUBIN OBSERVATORY FRAMEWORK

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This talk examines the broader framework of activities surrounding the Vera C. Rubin Observatory and the Legacy Survey of Space and Time (LSST). While the primary mission of Rubin Observatory is an unprecedented wide-field, time-domain survey of the sky, a diverse and rapidly evolving set of complementary initiatives has emerged to support, amplify and disseminate its scientific impact. These include Community forum, Rubin Science Assemblies (webinar series), LINCC (LSST Interdisciplinary Network for Collaboration and Computing), Project and Community workshops, and a wide range of education and public outreach (EPO) programs. Such "secondary" activities are in fact integral to the success of modern large-scale scientific infrastructures, transforming them from data-producing facilities into dynamic, inclusive research ecosystem. The findings have broader implications for the design and operation of future large scientific collaborations beyond astronomy.

**UNRAVELING THE SECRETS OF STAR CLUSTERS:
A METHODOICAL APPROACH TO TRANSFORMING
GAIA DR3 DATA ARCHIVES INTO
CLASSROOM EXPERIMENTS**

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We present a teaching exercise intended for secondary-school and university physics and astronomy teachers, aimed at demonstrating how standard, widely available tools - Python and Microsoft Excel or LibreOffice Calc - can be used to independently process real astronomical data and produce authentic research results in the classroom. As a case study, the age determination of open star clusters (the Pleiades, the Hyades, M67, NGC 2516, NGC 752) is carried out using the color-magnitude diagram (CMD) method. With a help of prepared Python script, students can download photometric and astrometric data from the Gaia DR3 archive (ADQL query, kinematic selection of cluster members) together with theoretical PARSEC isochrones, and then independently construct the CMD in Excel, overlay the isochrones, and visually fit the cluster age by identifying the main-sequence turn-off point. The result is further verified through an independent estimate based on the mass–luminosity relation. The emphasis of the poster is not on astrophysical results itself, but on transferability of the methodology: the laboratory exercise shows how user can access genuine scientific databases. It also presents how basic programming and spreadsheet analysis can be combined into one low-budget, easy reproducible laboratory exercise that develops students’ digital and research literacy, with minimal technical prerequisites (only Python and Excel/LibreOffice are required).

GALAXY MORPHOLOGY CLASSIFICATION: WHERE SHOULD WE DRAW THE LINE?

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Cosmological simulations like IllustrisTNG require efficient morphological classification, as detailed multi-component kinematic analyses are computationally expensive and limited to small samples. Previous approaches often relied on an ad hoc kinematic threshold (e.g., $F_{\text{disk}} = 0.4$) to separate early- and late-type galaxies, which frequently misclassifies moderately prominent disks. Using precomputed stellar circularity catalogs for TNG100 galaxies at $z = 0$, we derived a new, data-motivated threshold of $F_{\text{disk}} = 0.25$. This lower limit effectively captures the diversity of disk-dominated systems and allows for the identification of a third class of morphologically complex, irregular galaxies. We demonstrated the reliability of this approach by successfully recovering the morphology-density relation across field, group, and cluster environments. Thus, stellar circularity should be utilized as a robust, computationally cheap morphological proxy, providing a valuable baseline for large statistical studies and machine learning applications.

**DEPARTMENT OF ASTRONOMY AT PETNICA SCIENCE CENTER:
2024-2026**

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Petnica Science Center (PSC) is an educational center where extracurricular science programs are provided. In this presentation, the work of the PSC Astronomy Department for high school students between 2024 and 2026 is summarized. The core educational principle of PSC is recognized as 'education of students by other students,' wherein high school participants are primarily taught and mentored by undergraduate students, with the support of expert associates. The full educational cycle is organized as a two-year program. In the first year, foundational mathematical and physical methodologies, as well as the basics of astronomy, are introduced to the students, and by the end of the second year, their own research projects are completed. Accordingly, this presentation will outline the current structure of the department, the research topics, other activities from the mentioned period, and future plans.

DARK MATTER IN THE CLASSROOM: A SPARC-BASED ROTATION CURVE EXERCISE FOR TEACHERS

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This work presents an educational module in which astrophysical phenomena are not merely interpreted, but actively applied through a teaching activity that integrates programming, data analysis, and theoretical physics. We use the SPARC database (Spitzer Photometry & Accurate Rotation Curves) to extract data, and through further processing in Python, obtain the derived quantities. These results are then displayed in Excel in graphical form and represent galaxy rotation curves. It is clear that these activities merge astrophysics with practical, hands-on exercises, as noted above. The exercise's central goal is to quantify the dark matter fraction as a function of galactocentric radius, thereby making the growing discrepancy between observed and baryonic rotation curves directly measurable. The key pedagogical value of the exercise lies in combining three types of skills that are rarely linked in teaching: 1. automatic extraction of information from a database, 2. manual, transparent processing in a spreadsheet program, where the student follows each step of the formula, 3. comparison of the obtained results with the literature through discussion. The exercise is primarily intended for teachers, equipping them with a ready-to-use, adaptable material that they can transfer to their students, thereby lowering the barrier for introducing observational astrophysics into secondary and undergraduate classrooms.

IMPACT OF CLOUDINESS ON THE DEGENERACY OF EXOPLANETARY SPECTRA

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Different regions of an exoplanet atmosphere are probed during ingress, mid-transit, and egress, potentially producing distinct spectral signatures. To investigate this effect, we generated a grid of atmospheric models for the transiting exoplanet WASP-17b spanning a range of temperature structures and cloud distributions. Transmission spectra were simulated using the NASA Planetary Spectrum Generator (PSG) over the wavelength range $0.8\text{--}2.2\ \mu\text{m}$ for ingress, mid-transit, and egress phases. An automated analysis framework was developed to compare the resulting spectra and quantify phase-dependent spectral variability associated with atmospheric asymmetries. The results show that increasing atmospheric asymmetry leads to progressively larger differences between ingress and egress spectra, while the mid-transit spectrum remains comparatively stable. Several wavelength regions exhibit enhanced sensitivity to atmospheric asymmetries, indicating that some spectral features are more strongly affected by three-dimensional atmospheric structure than others. The analysis further demonstrates that the detectability of these asymmetries depends on both the atmospheric configuration and the assumed observational noise level.

PREDICTING THE GRAVITATIONAL FIELDS OF LOW-SURFACE-BRIGHTNESS SPHEROIDS

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The radial acceleration relation allows predicting the gravitational field in most galaxies just based on the distribution of the visible matter. Its existence was first predicted by the MOND theory of modified gravity. The relation however often fails in dwarf spheroidals and the dark-matter free ultra-diffuse galaxies, which is a recently discovered rare class of galaxies whose formation mechanism is not understood well. The problematic galaxies can be described as low-surface-brightness (LSB) spheroids. In my talk, I will describe my efforts to find a MOND-like framework that would work for the LSB spheroids. The found equation allows predicting their gravitational fields just on the basis of their visible properties, like the radial acceleration relation. If the found relation is interpreted in the framework of dark matter and the standard gravity, it hints that the dark-matter free galaxies form through the standard processes acting at unusual intensities rather than by exotic mechanisms. In addition, the relation implies that dark-matter free galaxies should have very specific photometric properties, which facilitates finding more representatives of this class of rare and puzzling galaxies. I will present a few concrete ultra-diffuse galaxies predicted to have little-to-no dark matter.

VALIDATION OF VIIRS NIGHTTIME LIGHTS USING SQM MEASUREMENTS AT BELGRADE AND VIDOJEVICA - A PRELIMINARY STUDY

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Rapid urbanization and the ongoing need for public lighting are contributing to light pollution, one of the fastest-growing environmental pollutants. Beyond environmental implications, light pollution is increasingly affecting the quality of life of urban inhabitants, degrading sleep, impairing traffic safety, and undermining other aspects of urban life. While research on Artificial Light at Night (ALAN) has gained momentum worldwide in recent decades, the Balkan region remains largely under-researched in systematic monitoring and assessment of light pollution. This preliminary study presents one of the first systematic attempts to validate VIIRS Day/Night Band (Visible Infrared Imaging Radiometer Suite) data using SQM-L measurements on the ground at three locations in Serbia. Research is carried out in a highly urbanized area in Belgrade at Kalemegdan (44.825°N, 20.451°E), an urban green area at the Astronomical Observatory of Belgrade - AOB (44.802°N, 20.513°E), and a rural mountainous area at the Astronomical Station Vidojevica - ASV (43.141°N, 21.556°E). The data have been collected over 14 months, from March 2024 to June 2026, and filtered using standard methodology to retain cloudless-sky data, resulting in 2.5-7.4% of valid data, consistent with other SQM networks. VIIRS monthly average radiance data (nW/cm²/sr) were obtained from Google Earth Engine. The analysis revealed varying degrees of correlation between satellite and ground-based measurements. At Kalemegdan, a significant logarithmic correlation was identified (Pearson's $r = -0.700$, $p = 0.016$, $n = 11$), indicating a stronger relationship between VIIRS radiance and SQM measurements under higher levels of artificial illumination. At AOB, statistical correlation has been negligible ($r = 0.021$, $p = 0.951$, $n = 11$), probably due to the limited SQM value range (18.27-18.64 mag/arcsec²), while statistical correlation at ASV is slightly higher ($r = -0.268$, $p = 0.376$, $n = 13$) owing to significantly low VIIRS values that are typical for rural areas (0.29-0.63 nW/cm²/sr). This preliminary study confirms the viability of SQM-VIIRS validation in Serbia and establishes ASV as a documented dark-sky site suitable for astronomical observations; however, to provide more robust and detailed conclusions, the SQM network should

include more measurement points across different urban quarters and longer observation periods (at least 3 to 5 years). This research was supported by the Science Fund of the Republic of Serbia, no. 6775, Urban Observatory of Belgrade.

LONG-TERM LIGHT CURVE OF V425 CAS

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Several studies and astronomical databases like Wenzel (1987), AAVSO, ASAS - SN, ZTF, TESS provide photometric data for V425 Cas. We use these databases together with our own data collected at NAO Rozhen, AO Belogradchik and AS Vidojevica to present complete light curve from 1965 to 2026. There are almost no published data from 2006 to 2015 and our observations show none missed low brightness states in the period 2003 - 2025.

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**PROBING BROAD LINE REGION PHYSICS ACTIVE
GALACTIC NUCLEI**

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We present a framework designed to constrain the physical properties of the Broad Line Region (BLR) in the extremely variable Active Galactic Nuclei (AGN). By mapping the non-linear relationship between the optical continuum luminosity (L_{cont}) and the integrated broad Balmer emission line fluxes (e.g., $H\beta$) across highly variable epochs, we model the transition between regular reverberation and line flux saturation.

LISTENING TO THE OLDEST LIGHT: A SOUND INTERFACE FOR COMMUNICATING COSMOLOGY

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The Cosmic Microwave Background Radiation (CMBR) provides one of the primary observational foundations of modern cosmology, preserving information about primordial density fluctuations and baryon acoustic oscillations (BAO) that seeded the large-scale structure of the Universe. We present interactive sound sculptures inspired by the horn antenna used in the discovery of the CMBR, designed as a science communication interface. These sculptures receive microwave radiation from the sky and convert electromagnetic fluctuations into audible sound through a directional horn receiver and acoustic resonator. The audience can listen to the sound rendered from the received signal of the CMBR. It serves as an analogy to the primordial acoustic oscillations (the first sound waves in the universe) that propagated through the baryon-photon plasma before recombination. The project explores how cosmological knowledge emerges from weak fluctuations embedded within noisy observational data. By allowing visitors to interact physically with the receiver and experience changes in the electromagnetic environment as audible variations, the installation communicates fundamental concepts including CMBR, cosmology, origins of structures, and the relationship between noise and cosmological information. We will also discuss the project's relevance in the context of current challenges to the standard cosmological model, including the Hubble tension, recent JWST observations of unexpectedly massive galaxies and black holes at high redshift, and constraints on dark energy from the DESI survey. These developments motivate new perspectives on the interpretation of cosmological observations and the communication of contemporary astrophysics to broader audiences.

MILKY-WAY-LIKE POPULATIONS IN ILLUSTRISTNG AND IMPLICATIONS FOR GALACTIC HABITABILITY

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Current investigations of galaxy evolution increasingly combine cosmological simulations, multi-wavelength surveys, and astrobiological perspectives to understand how galaxies build the environments in which planetary systems form and persist. In this work, we explore the evolution of galaxy populations in the IllustrisTNG simulations across representative redshifts (0-3), examining how stellar mass and star formation activity evolve. The analysis compares internally derived IllustrisTNG star-forming main sequence (SFMS) relations with empirical COSMOS-based references, providing a framework for tracing galaxy evolutionary state. Particular attention is given to whether simulated populations show continuous or partially separated active and suppressed star-formation regimes, and how Milky-Way-like analog populations occupy different regions of the SFMS across cosmic time. Preliminary analysis suggests that Milky-Way-like analog populations remain associated with active star-forming environments across the investigated redshift range. From an astrobiological perspective, this framework connects galaxy-scale evolution with long-term conditions relevant for planetary system formation and persistence, including sustained star formation, chemical enrichment, and the development of dynamically stable galactic environments. This provides a basis for our future studies connecting Milky-Way-like analog populations with metallicity growth, merger history, and the evolving galactic environments that shape the formation and long-term persistence of planetary systems.

THE NATURE OF SPIRAL STRUCTURE IN NGC 783 INFERRED FROM COLOUR GRADIENTS IN ARMS

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The origin and nature of spiral arms in galaxies are still debated and most likely not described by a single universal mechanism. A few observational indicators are expected to represent the formation mechanism of spirals in observed galaxy. Some techniques to measure them are proposed, however it is still unclear how robust they are. We focus on the idea that galaxy rotation curve and pattern speed difference at given radius (dependent on the nature of spiral arms) should manifest itself in azimuthal age (and therefore colour) gradients across the spiral arm. We develop a method to measure them using multiple filters and apply it to NGC 783, a prominently grand-design yet not well-studied spiral galaxy. Additionally, we test the method on several model galaxies from TNG50 simulation to ensure plausibility of results. Our results indicate that NGC 783 possesses a density wave in its disc with corotation radius located at 10-15 arcsec from the centre, and the spiral nature in TNG50 galaxies is diverse.

SUPERNOVA EXPLOSIONS OF RUNAWAY STARS AND YOUNG NEUTRON STARS ABOVE THE GALACTIC PLANE

MSc thesis presentation

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Several supernova remnants and young neutron stars were recently discovered relatively high above the Galactic plane. Understanding their origin will provide key insights into the properties of the Galactic halo. One possibility is that they originated from runaway OB stars born in the Galactic disk. We aim to determine the spatial distribution of supernova explosions from runaway OB stars and to assess whether this model can explain certain observed neutron stars. Therefore, we mapped the distribution of supernova events produced by runaway OB stars by incorporating their birth rate, initial spatial distribution, lifetime, ejection mechanisms, and velocity distributions. By tracking their motion in the Galactic potential, we determined their final distribution right before the explosion. We show that the neutron star Calvera, which is found at $z \approx 2.2$ kpc, could have originated from a runaway OB star. In addition, we compared the probabilities of finding a supernova remnant origin ating from Type Ia and core-collapse supernovae high above the Galactic plane, finding that supernova remnants related to core-collapse supernovae outnumber those related to Type Ia supernovae.

**SANU-BAN PROJECT GAIA ASTROMETRY AND FAST VARIABLE
ASTRONOMICAL OBJECTS (FROM 2023 TO 2025)**

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At the end of 2025 we finished our SANU-BAN bilateral joint research project "Gaia astrometry and fast variable astronomical objects" (2023-2025). Also, it is in line with our local cooperation the Serbian-Bulgarian mini-network telescopes (which we established at 2013); there are 8 instruments: 5 in Bulgaria (at Rozhen and Belogradchik sites) and 3 in Serbia (at Astronomical Station Vidojevica - ASV site). We observed 15 Gaia Alerts objects during 2025: AT2021aeuk (1 time), AT2024kwu (1), TCrB (20), ZTF18aarippg (2), SN2015ap (1), Gaia22dwj (1), Gaia23crp (4), Gaia24acn (5), Gaia24aup (8), Gaia24azc (4), Gaia23cer (6), Gaia24bux (1), Gaia24bnd (1), Gaia24axc (1) and Gaia23axx (1). Also, we did some objects in line with the international Whole Earth Blazar Telescope (WEBT) project: 0235+164, 0735+178, 0716+714, 1553+113, 1641+399, 1652+398, 1807+698, 2200+420, 2230+114, 2251+158, 2344+514, etc. Some results of our activities are presented, here.

MULTI-HEAD ALNP: AN ATTENTIVE LATENT NEURAL PROCESS FOR AGN LIGHT CURVE RECONSTRUCTION AND PARAMETERS INFERENCE

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Historically, to study the geometry of the innermost region of an Active Galactic Nucleus (AGN), we used a technique known as Reverberation Mapping (RM). Recent observational evidence suggests that the classical models of the AGN accretion disk are incomplete, indicating that the disk is systematically larger than predicted by the classical Shakura-Sunyaev model, a discrepancy commonly referred to as the "disk size problem".

Traditional RM techniques have been one of the tools for probing the AGN disk structure, but they perform poorly on the sparse and irregularly sampled light curves typical of astronomical observations. Furthermore, the number of sources with dedicated RM campaigns is small.

The advent of next-generation surveys, such as the Legacy Survey of Space and Time (LSST), will provide higher-cadence observations for millions of AGNs. While this will dramatically increase the available data, it also demands scalable and computationally efficient analysis techniques capable of processing the unprecedented data volume.

In this context, we present a Multi-Head ALNP, a Latent Attentive Neural Process designed to simultaneously reconstruct AGN light curves and infer their underlying physical parameters. By combining these tasks within a single framework, the model addresses both the challenges posed by sparse, irregularly sampled observations and the computational demands of the LSST era.

**BULGARIAN ANTARCTIC ASTRONOMICAL OBSERVATORY.
EXPARIMENTS AND RESULTS**

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This study outlines the inaugural Bulgarian polar astronomy project (2024-2025) conducted at Livingston Island, Antarctica, focused on the impact of solar activity on ionospheric dynamics and high-energy particle fluxes. The research investigates solar-terrestrial interactions, specifically solar flares and coronal mass ejections, and their effects on ionospheric disturbances, geomagnetic field variations, and radiation levels. The experimental framework comprises four synchronized components: HF radio spectrography (50-1000 MHz) for solar burst observations, VLF monitoring of ionospheric D-layer disturbances, magnetometric measurements of local geomagnetic variations, and passive radiation dosimetry. Preliminary results and ongoing data analysis aim to enhance space weather forecasting and mitigate risks to satellite communications. This initiative establishes Bulgaria's research capacity in polar astrophysics through multi-institutional and international collaboration.

LIGHTNING ON THE EXOPLANET K2-18B

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Recent JWST observations have enabled detailed modelling of hydrogen-rich sub-Neptune atmospheres, including Hycean worlds such as K2 18b. Using photochemical profiles derived from JWST data as inputs to a validated plasma fluid code, we investigate the physical conditions required for lightning initiation on this exoplanet. We compute the breakdown electric field (E_k) for three atmospheric scenarios proposed for K2 18b: (a) an uninhabited Hycean atmosphere with trace CH_4 (b) an inhabited Hycean atmosphere with elevated H_2O content, and (c) a mini-Neptune chemical equilibrium composition. All scenarios yield E_k between 1.6 and 1.7 MV/m, roughly half of Earth's value of 3.2 MV/m. This reduction arises from the high H_2 content, which limits excitation energy losses and facilitates electron avalanches, indicating that significantly weaker thunderstorm fields are sufficient to trigger electrical breakdown in K2 18b's atmosphere. Streamer inception and propagation, as precursors to lightning discharges, are simulated using an axially symmetric classical fluid model implemented in the AMReX adaptive mesh refinement framework for large-scale parallel computations. The model is formulated as a first-order fluid system under the local field approximation, with second-order Runge-Kutta time integration and finite-volume spatial discretisation. Crucially, the model employs electron transport coefficients obtained from numerical multi-term solutions of the Boltzmann equation, providing physically accurate input data for ionisation, attachment, mobility, and diffusion. Photoionisation is included via a non-local Helmholtz formulation with the Bourdon three-term parametrisation, thereby enabling consistent positive streamer dynamics. Simulations show that positive and negative streamers incept and propagate in all atmospheric scenarios, demonstrating that lightning initiation via the avalanche-streamer mechanism is viable on K2 18b. Combined with climate model predictions of strong convection and CAPE values exceeding 3 kJ/kg, these results suggest that lightning on K2 18b is not only possible but likely frequent, with important implications for atmospheric chemistry and potential prebiotic pathways in Hycean environments, a topic of evident astrobiological importance.

MULTIWAVELENGTH DETECTION PROSPECTS FOR ANNIHILATING HEAVY WIMP DARK MATTER AROUND M31*

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Weakly Interacting Massive Particles (WIMPs) represent still the most popular candidate for the role of dark matter (DM), which is a mysterious hidden mass in our Universe. So far indirect astrophysical searches of DM have tested and excluded only relatively light thermal WIMPs with masses up to ~ 0.1 TeV by looking for DM annihilation signatures. However, theoretically, WIMP mass can be as high as 100 TeV. A difficulty to constrain heavy WIMPs is caused by quite rapid annihilation signal decrease with the mass increase. And supermassive black holes (SMBHs) provide a unique possibility to probe heavy WIMPs by forming very dense DM spikes, where the annihilation rate can be high enough for the detection of such signal. Andromeda galaxy M31 hosts massive and nearby SMBH, which is very promising for WIMP detection. However, it was unfairly missed and not studied before. My work analyzes in details both prompt gamma and secondary synchrotron possible signals from annihilating DM in M31* and their detectability by CTA and ALMA telescopes. I show that the thermal WIMPs with masses up to 1-10 TeV are realistically accessible by this methodology.

BINARY COMPANIONS FROM SDSS DR17

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We present an ongoing search for Doppler signals consistent with stellar or brown dwarf companions among a promising sample of target stars. The primary objective of this work is to produce a comprehensive catalog of both known and previously unpublished binary systems within our broader planet-search sample.

To identify and characterize these systems, we utilize combined radial velocity (RV) measurements, leveraging visit-level RVs from APOGEE-1 and APOGEE-2 in SDSS DR17. Target confirmation and extensive cross-referencing of the literature are performed using the SIMBAD database to ensure a robust sample selection. For our radial velocity and orbital analysis, we employ the Data Analysis Center for Exoplanets (DACE) platform to conduct extensive period searches and Keplerian orbital modeling of the observed RV variations. Furthermore, to break observational degeneracies and further constrain the systems, we integrate astrometric data from the Gaia mission whenever available.

Currently, our sample includes approximately 30 of the most promising RV-variable systems, including systems with supporting Gaia DR3 non-single-star (NSS) solutions. We will discuss our preliminary Keplerian analysis, the integration of Gaia DR3 NSS astrometry, and the current status of our binary star catalog.

TITAN SUBMARINES: A STATE-OF-THE-ART REVIEW OF THEIR DEVELOPMENT

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Since the investigations of the Cassini-Huygens mission, the presence of methane-ethane lakes in the polar geographical latitudes has become the next focus point of future missions on Titan. While the Cassini probe has significantly contributed to our understanding of the physical-chemical processes involved in creating the compounds that comprise the lakes, as well as maintain them, they cannot be investigated thoroughly through the means employed and the data gained so far. Among the missions proposed to investigate Titan further, one of the primary modes of probing the lakes would involve submarines. Unmanned submarines are a common way of investigating the depths of large bodies of liquid and the case of Titan, while no different in concept, has numerous specificities which need to be addressed. An adequate thermal regulation system would be required. The buoyancy system would need to utilize a compound with little to no condensation in Titan's low temperature environment. Any control system would have to be autonomous, despite the submarine being able to exchange data with Earth on a near constant basis. These are merely a few issues which need to be considered in creating such a unique probe. The following presentation presents a summary of the development of a successful Titan submarine design. While the project itself hasn't progressed beyond Phase I of development, the pieces of such an innovation are still being assembled, ultimately bringing about a pioneering endeavour of astronautics, just like the Cassini-Huygens mission was.

MODELING THE YARKOVSKY EFFECT FOR TUMBLING ASTEROIDS

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The Yarkovsky effect is the primary non-gravitational force driving the long-term orbital evolution of small bodies and is therefore essential for accurate orbit determination and impact hazard assessment. While the effect has been extensively investigated for principal-axis rotators, its modeling remains considerably more complex for asteroids in non-principal-axis (tumbling) rotation. We present a generalized numerical model that computes the Yarkovsky acceleration for tumbling asteroids by simultaneously integrating their heliocentric orbital motion and rotational evolution. The rotational dynamics are described by the two characteristic periods of non-principal-axis rotation, the precession of the principal inertia axis around the angular momentum vector and the rotation about the principal axis, without requiring these periods to be commensurate. The model is applicable to arbitrary asteroid shapes, thermophysical properties, and rotational states. Acknowledgements: This research is supported by The Science Fund of the Republic of Serbia through Project No. 7453 Demystifying enigmatic visitors of the near-Earth region (ENIGMA).

THE SEARCH FOR OPTICAL COUNTERPARTS TO ISOLATED FASHI HI SOURCES

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The standard Λ CDM cosmological model successfully describes the universe on large scales but faces challenges on smaller scales, notably the "missing satellite problem" where simulations predict significantly more low-mass dark matter halos than we actually observe (Klypin et al. 1999; Moore et al. 1999). A widely discussed solution to this discrepancy is the existence of "dark galaxies", dark matter halos that contain neutral hydrogen (HI) gas but have either failed to form a visible stellar population or have very few stars (Simon & Geha 2007; Sawala et al. 2016). Consequently, deep HI surveys have become the primary method for detecting these starless gas clouds (Haynes et al. 2018). However, many initial dark galaxy candidates identified in these surveys are reclassified after detailed follow-up observations. Some candidates are eventually shown to be tidal debris rather than self-gravitating halos (Davies et al. 2004; Haynes et al. 2007). Others, initially thought to be entirely dark, are later revealed to harbor extremely faint stellar components when observed with deeper optical imaging, reclassifying them as extreme low-surface-brightness (LSB) dwarf galaxies (e.g., Leisman et al. 2021; Du et al. 2024). A prime example of this is the recently discovered HI cloud FAST J0139+4328, which was initially proposed as the first isolated dark galaxy in the local universe. However, our recent deep optical observations unambiguously revealed an LSB optical counterpart, demonstrating that its stellar component was simply below the detection limit of previous medium-depth surveys like Pan-STARRS1 (Mitrašinović, Grozdanović, et al. 2026). To minimize the likelihood of observing tidal debris, the most promising candidates for true dark galaxies are highly isolated HI clouds located far from dense environments or massive galaxies. Nevertheless, verifying their "dark" nature requires optical imaging capable of surpassing the limits of standard wide-field surveys (which typically reach $\sim 24\text{--}25$ mag arcsec⁻²), in order to definitively rule out ultra-faint stellar populations (O'Beirne et al. 2025; Sola et al. 2022).

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SOLAR CORONAL HOLES: DYNAMICS, THERMAL AND MAGNETIC FIELD STRUCTURE

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Coronal holes, with unipolar magnetic field structures are the lowest density plasma activity features that are mainly detected in either UV or X-ray radiations of the sun's atmosphere. These activity features are associated with rapidly expanding magnetic field structure and the acceleration of the high-speed solar wind in the heliosphere and beyond. Possible link of sunspot activity on the Earth's atmosphere and climate are well recorded in the literature. Recently, evidences are building up that coronal holes also trigger responses in the Earth's upper atmosphere, ionosphere and magnetosphere. In one of our studies (Hiremath et.al. 2015, New Astronomy, 35, 8), we find that, in addition to influence of sunspots, radiative emission of coronal holes also trigger and maintain Indian Monsoon rainfall. For this purpose, estimation of radiative flux and energy of the coronal holes at 1 AU during their evolution passage on the solar disk are necessary. Eight years of full-disk SOHO/EIT 195 Å calibrated images that are used to measure latitudinal and day to day variations of thermal and magnetic field structures of near equatorial coronal holes on the sun and at Lagrange point L1 are estimated. Detailed analysis, estimated coronal hole positional measurements, thermal and magnetic field structure physical parameters will be presented. These estimated physical parameters are not only useful for the instruments (such as SOHO and Aditya) stationed at Lagrange point L1 but also models of space weather effects in the heliosphere and beyond. In this presentation, latitudinal variation of rotation rates, temperature and magnetic field structures of near equatorial coronal holes will be presented. Lastly, genesis of coronal holes will also be discussed.

**THE FOUNDERS OF THE SCIENCE OF ASTRONOMY AT
THE ASTRONOMICAL AND METEOROLOGICAL
OBSERVATORY IN BELGRADE**

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The Astronomical and meteorological observatory began its activity in 1887. Since inception, the work focused primarily on meteorology, with a lesser emphasis placed on astronomy. This was not due to the lack of professional staff, as the observatory employed those with a focus on astronomy, such as Milan Nedeljković, Djordje Stanojević, Wenceslas Jardetzky (Vjačeslav Žardecki) and Jelenko Mihailović, but rather it was that the Observatory decided that a focus on meteorology would be more valuable for Serbia. The lesser cost of meteorological instruments when compared to those needed for astronomy impacted this decision, as well. The founder, first director, and builder of the Vračar Observatory in Belgrade was Milan Nedeljković (1857 – 1950), who studied astronomy and meteorology in France, at the Paris Observatory, where he gained friends and the respect of fellow astronomers. The director of the Astronomical and Meteorological Observatory in 1899/1900 was physicist and astronomer, Djordje Stanojević (1858 – 1921) who also studied and worked in the most famous observatories, including Potsdam, Meudon, Greenwich, Pulkov, and several others. Jelenko Mihailović (1869 – 1956), professor of physics and mathematics, voluntary part-time assistant at the Astronomical and Meteorological Observatory in 1893, 1896 and 1897, permanent assistant from 1898 to 1906, and deputy director to Milan Nedeljković from 1896 – 1906, also contributed to astronomy. Wenceslas Jardetzky (1896 – 1962) graduated from the Faculty of Physics and Mathematics in Odessa and specialized in astrophysics. He worked at the Odessa Observatory and the Pulkovo Observatory in St. Petersburg, for a short time. Jardetzky arrived in Belgrade in January 1920, and his value as a promising scientist was quickly noticed. In March 1920, Milan Nedeljković employed Jardetzky as an assistant at the Astronomical and Meteorological Observatory. After a year, Jardetzky was appointed to work at the University in Belgrade. To fill the newly vacant position at the Observatory, Nedeljković 1921. contacted astronomer Vojislav Mišković (1892 – 1976). Mišković completed his studies in Marseille in 1919, and he worked at both the observatories in Marseille and Nice. However, Mišković decided to stay in France until he received his doctorate, which was in 1924.

PROPERTIES OF EXTRASOLAR PLANETESIMAL BELTS FROM ARKS

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The Solar system contains two planetesimal belts: the main asteroid belt and the Kuiper belt. These bodies collide and their collisions produce smaller bodies, including lots of dust particles. In the Solar system, we can individually detect and study the large asteroids and the Kuiper belt objects. Around other stars all we can see are belts of dust. Nevertheless, from the radial and the vertical structure of the dusty belts we can learn about the collisional and dynamical processes affecting the extrasolar planetesimals, and we can even infer how large extrasolar planetesimals are and the masses of the belts. We will present the latest results on this topic from a major international observational and theoretical research program, the ALMA Survey to Resolve exoKuiper Belt Substructures (ARKS).

THE MULTIPHASE INTERSTELLAR MEDIUM OBSERVED AT LOW-RADIO FREQUENCIES

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The interstellar medium (ISM) of the Milky Way, although accounting for only a few percent of the Galaxy's mass, plays a crucial role in star formation and galactic evolution. Composed of ionized, atomic, and molecular gas, dust, and cosmic rays, the ISM undergoes complex transformations driven by gravity, phase transitions, and magnetohydrodynamic turbulence. Despite its importance, the detailed role of magnetic fields, closely coupled to the ISM, remains poorly understood. In this talk, I will present how low-frequency polarimetric radio observations and Faraday tomography are used to investigate the magneto-ionic medium. I will also highlight recent results and demonstrate how a multi-frequency approach provides a more comprehensive view of different ISM components and structures, including the Local Bubble, through their distinct emission mechanisms.

**LINKING GAIA CRF WITH ICRF BY MEANS OF V AND R
MAGNITUDES OF SELECTED QUASARS**

PhD thesis presentation

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One of the main objectives of the Gaia mission of the European Space Agency is to construct a new celestial reference frame - Gaia CRF. This frame should be linked to the International Celestial Reference Frame – ICRF which is fixed with respect to distant objects (quasars). A set of 47 objects visible in both domains (optical and radio, and without detected extended emission in the radio domain) has been proposed for this link. The mentioned objects are active galactic nuclei (AGNs) the brightness of which varies over the whole electromagnetic spectrum. The brightness change may be due to activity in different AGN regions, but also to external factors. Such variations can lead to changes in the photocentre position and, consequently, to changes of the object coordinates. In order to establish which objects are suitable for linking these two frames we have examined the brightness, colour and spectral index (α) variation in the optical domain. The objects have been observed from 2013 in the V and R bands. The brightness of most objects was found to be variable, or possibly variable. Almost 15% of all objects have brightness changes greater than 1 magnitude, only $\sim 10\%$ are stable with smaller brightness changes of ~ 0.3 magnitude. Based on the analysis of brightness, color, and α changes, 17 objects were selected as suitable for linking the ICRF to the Gaia CRF.

**SUPERCOMPUTER BURA AS PART OF THE CROATIAN IN-KIND
CONTRIBUTION TO RUBIN/LSST: SUPPORTING DATA-INTENSIVE
ASTRONOMY AND SCIENTIFIC COLLABORATION**

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Rubin/LSST is a large-scale, long-term survey expected to generate petabyte-scale data volumes, requiring substantial computational resources for data processing and analysis. Consequently, high-performance computing (HPC) infrastructure plays an important role in enabling Rubin/LSST science operations and supporting the broader scientific community. With the commencement of the Rubin/LSST continuous survey, together with the availability of alert streams and Data Preview 2 products, astronomers are gaining access to real, large-scale observational datasets, providing new opportunities for data-intensive astronomical research. As part of the Croatian Rubin in-kind contribution, the HPC system 'Bura' serves as a dedicated software processing center for LSST-related activities. In this talk, I will present the main features of 'Bura', recent updates, training and user-support activities, and outline its role in supporting Rubin science. I will also outline opportunities for establishing collaborations within and beyond the Rubin science collaborations with particular emphasis on potential applications of 'Bura' within the Rubin scientific community, primarily (but not exclusively) across the Solar System, Transients and Variable Stars, and Stars, Local Volume and Milky Way science collaborations. Several scientific use cases and ongoing collaborations involving 'Bura' will also be presented, such as our efforts to develop a stellar classification framework based on LSST ugrizy photometry, employing dimension reduction techniques and advanced clustering and machine learning methods.

ON THE MODELLING OF GAMMA RAY BURST SPECTRA WITHIN NONHOMOGENEOUS ASTROPHYSICAL RADIATORS PARADIGM

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Prompt emission spectra of gamma-ray bursts (GRBs) often display low-energy spectral features with hard photon indices ($\alpha \approx -0.7$ to 0.0) that challenge all existing uniform-field synchrotron models. While a decaying magnetic field scenario can only harden synchrotron spectra up to $\alpha = -2/3$, magnetic reconnection and photospheric models do not readily produce the same spectral features and require additional physical assumptions. To examine the previously unaddressed role of the magnetic field's non-homogeneous structure, we present the Non-homogeneous Astrophysical Radiator (NAR) model. In the NAR model, the non-homogeneous structure of the shock-generated magnetic field is addressed both along the surface of the shock front, using a probabilistic power-law description, and along its depth, using an exponential decay profile. By solving the synchrotron radiation transport equation for different emitting zones, we show that their superposition can easily recreate the observed hard photon indices of GRB prompt emission (e.g., $\alpha = -0.5$, -1.0 , and -1.8), which are inaccessible to uniform magnetic field models, without invoking photospheric dissipation or magnetic reconnection. NAR model simulations are then validated against the GECAM data of GRB 230307A prompt emission. Finally, we discuss some existing challenges and limitations in the development of the NAR model.

**HI FLOWS INSIDE AND AROUND NEARBY
LATE-TYPE GALAXIES**
MSc thesis presentation

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Star-forming disk galaxies consume their gas reservoirs on timescales of a few gigayears, yet they sustained roughly constant star formation for several billions of years. While this indicates that galaxies receive a continuous supply of gas that replaces the material used in star formation processes, the channels of this gas replenishment remain poorly constrained. This Thesis investigates two of the proposed mechanisms by searching for their kinematics signatures in the neutral hydrogen (HI) of nearby disk galaxies: radial inflow from the circumgalactic medium (CGM), and fountain-driven accretion, in which cool gas ejected from the disk by stellar feedback interacts with the surrounding corona and falls back as an inflowing, lagging layer of extraplanar gas (EPG). We analyzed deep HI observations of a sample of seven nearby late-type galaxies from the MHONGOOSE survey, whose combination of depth and spatial resolution makes it well suited for detecting faint, low-column-density gas both at the disk periphery and in the halo. Radial motions were measured through tilted-ring modeling of the HI disk kinematics with 3DBarolo software. The extraplanar gas was separated from the regularly rotating disk based on its anomalous kinematics and modeled with EPGfit, a dedicated Bayesian fitting pipeline. We find no evidence for large-scale, coherent radial inflows in the outskirts of the HI disks in our sample, in agreement with previous results for larger samples of local spiral galaxies. The EPG masses are consistent with the predictions of a stellar-feedback-driven galactic fountain. However, the recovered radial and vertical velocities span both inflow and outflow across the sample, rather than the systematic inflow predicted by the fountain-accretion model, so a direct association with this scenario is not immediate and would require dedicated dynamical modeling of the fountain cycle. While our results indicate that fountain-driven accretion might be a viable channel of gas accretion in galaxies, a larger galaxy sample and multi-wavelength observations are required to provide stronger constraints on such mechanism.

A CANDIDATE VERY YOUNG PAIR OF SMALL NEAR-EARTH ASTEROID

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Asteroid pairs provide constraints on recent disruption, rotational fission, and the evolution of binary asteroids among small Solar System bodies. Near-Earth asteroid pairs are particularly difficult to confirm because planetary encounters rapidly modify their trajectories and erase evidence of a common origin. We investigate the possible relationship between the near-Earth asteroids 2018 NC15 and 2026 LD1, which have very similar heliocentric orbits. Their small estimated sizes make them especially interesting, as this size range is underrepresented among known asteroid pairs. We generated orbital clones that sample the current uncertainties and plausible Yarkovsky drift rates, and integrated them backwards in time. We searched for close, low-velocity convergence and examined the role of planetary encounters in their past evolution. A small subset of clone combinations approaches within a few Hill radii of the larger body, with the most promising low-velocity encounters occurring only several centuries ago. These results support 2018 NC15–2026 LD1 as a plausible, very young near-Earth asteroid pair.

**COMPLEX BALMER-LINE STRUCTURE IN SNR 0509-67.5:
TRACING SHOCK PRECURSORS**

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We present an analysis of deep, high-spatial-resolution (~ 0.2 arcsec; ≈ 27 h integration) VLT/MUSE observations together with high-spectral-resolution (45 km s^{-1} FWHM) WiFeS observations of the young Balmer-dominated supernova remnant SNR 0509-67.5. The $H\alpha$ profiles are particularly complex in the south-eastern (SE) and north-western (NW) rims, where we also detect diffuse emission extending up to ≈ 6 arcsec beyond the remnant. While the narrow (FWHM $\sim 10 \text{ km s}^{-1}$) and broad (FWHM $\sim 1000 \text{ km s}^{-1}$) $H\alpha$ components are detected around the entire shell, the SE and NW rims exhibit a prominent intermediate component (FWHM $\sim 100 \text{ km s}^{-1}$), providing evidence for a fast-neutral precursor, together with a significantly broadened narrow component. In contrast, the emission beyond the remnant contains only the narrow $H\alpha$ component, whose width gradually decreases to $\approx 15 \text{ km s}^{-1}$ at distances of about 2 arcsec ahead of the outermost filaments. We interpret the prominent intermediate component and the broadened narrow component as evidence for efficient cosmic-ray acceleration in the SE and NW rims, while the extended narrow emission ahead of the shock is consistent with a cosmic-ray precursor, possibly with an additional contribution from a photoionization precursor. Notably, these rims coincide with regions of the lowest ambient density in the interstellar medium.

TWO CONSECUTIVE PROMINENCE ERUPTIONS OBSERVED FROM DIFFERENT VIEWPOINTS ON OCTOBER 8, 2013

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We examine two successive prominence eruptions that took place on the northeast solar limb on October 8, 2013. The first eruption began at approximately 07:18 UT, while the second one occurred at 20:58 UT in the same solar region. A partial halo CMEs were linked to both eruptions. The events were observed by the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) AIA/SDO and Solar Terrestrial Relations Observatory (STEREO) A and B observatories. As a result, we were able to use the high temporal and spatial data from three separate perspectives to examine the eruption kinematics. Additionally, the chromospheric evolution of filament eruptions was studied using H α images from the Global Oscillation Network Group. The related CMEs were examined in the LASCO field-of-view.

GALAXY MORPHOLOGY CLASSIFICATION USING MODERN DEEP LEARNING ARCHITECTURES

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Morphological classification of galaxies is essential for studying galaxy formation and evolution, as galaxy morphology provides valuable information about the physical processes that shape galaxies over cosmic time. The rapid growth of modern astronomical surveys has produced an unprecedented volume of imaging data, making manual classification increasingly impractical and emphasizing the need for reliable automated approaches. Building upon previous research in galaxy morphology classification, this study investigates modern deep learning architectures using the Galaxy Zoo 2 dataset. The study evaluates and compares state-of-the-art convolutional neural networks and transformer-based models in terms of classification performance, computational efficiency, and their suitability for astronomical image classification. In addition to assessing predictive accuracy, the research aims to identify the strengths and limitations of contemporary deep learning approaches for galaxy morphology classification. The proposed framework is intended to provide a robust methodology for automated galaxy classification and to support the efficient analysis of data from current and forthcoming astronomical surveys. Furthermore, the presented research establishes a foundation for future investigations involving larger datasets, more advanced artificial intelligence models, and next-generation astronomical observations.

EXOPLANET DETECTION FROM STELLAR LIGHT CURVES USING RECURRENT AND TRANSFORMER-BASED DEEP LEARNING MODELS

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The detection and characterization of exoplanets represent one of the most important challenges in modern astronomy. The increasing amount of photometric data obtained by current and future space missions requires reliable automated approaches capable of efficiently analyzing large collections of stellar observations. Transit-based exoplanet detection relies on identifying subtle variations in stellar brightness, which can be challenging due to observational noise and the complexity of astronomical time-series data. This study investigates the application of modern deep learning approaches for automated exoplanet detection from stellar light curves. The research explores the capabilities of recurrent neural network architectures and transformer-based models for learning temporal patterns associated with planetary transit signals. By comparing different deep learning approaches for analyzing stellar time-series data, this work aims to examine their potential for improving the efficiency and reliability of automated exoplanet detection. The presented research contributes to the application and evaluation of machine learning techniques for astronomical data analysis and establishes a foundation for future investigations involving larger datasets, advanced deep learning architectures, and next-generation astronomical surveys.

MULTI-HEIGHT PROBING OF HORIZONTAL FLOWS IN THE SOLAR PHOTOSPHERE

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Probing of horizontal flows refers to the ability to infer horizontal (transverse in general case) plasma motion from successive maps of photospheric intensity and/or line-of-sight (LOS) magnetic field. We tested whether simultaneous spectropolarimetric imaging in two magnetically sensitive optical spectral lines, which probe two different layers of the solar atmosphere (the photosphere and the temperature minimum), can help constrain the depth/height variation of horizontal flows. First, we tested the feasibility of our method using Fourier local correlation tracking (FLCT), a well-known optical flow method, to track physical quantities at different optical depths ($\log \tau_{500} = -1, -2, -3, -4$) in an atmosphere simulated with the MURaM code. To that end, we inferred the horizontal distribution of the LOS magnetic field component from synthetic spectropolarimetric observations of Fe I 525.0 nm and Mg I b2 spectral lines, applied FLCT to the time sequence of these synthetic magnetograms, and compared resulting velocities with the original height-dependent horizontal velocities. Tracking the LOS magnetic field component (which coincides with the vertical component at the disk center) yields horizontal velocities that, after appropriate temporal and spatial averaging, agree excellently with the horizontal component of the simulated velocities, both calculated at constant τ_{500} surfaces, up to the temperature minimum ($\log \tau_{500} = -3$). When tracking the temperature at constant τ_{500} surfaces, the correlation worsens significantly already at the mid photosphere ($\log \tau_{500} = -2$)

because temperature is strongly affected by radiation transport, making its behavior far from advective. Tracking the vertical component of the magnetic field inferred from synthetic observations of the Fe I 525.0 nm and the Mg I b2 spectral lines provides a satisfactory inference of the horizontal velocities in the mid-photosphere ($\log t_{500} \approx -1$) and the temperature minimum ($\log t_{500} \approx -3$), respectively. Our findings indicate that high-spatial-resolution spectropolarimetric imaging in solar spectral lines can be used in conjunction with optical flow methods to gain valuable insight into the horizontal plasma velocities over a range of heights.

A MAGNETICALLY-SUPPORTED DISK-CORONA MODEL FOR CHANGING-LOOK AGN TRANSITIONS

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Accreting supermassive black holes that undergo Changing-look events on timescales of months to a few years cannot be explained by standard accretion-disk theory; the radiation-pressure instability sets on at Eddington ratios well above the observed transition band and the viscous timescales are much longer than the observed duration. We show that a magnetically supported disk-corona model satisfies both constraints simultaneously. By constructing thermal-viscous stability maps and computing transition timescales directly from the converged vertical structure, we find that strongly magnetised configurations (i) bring the stability threshold to the empirical band at which transitions are observed to occur, and (ii) place the transition timescale in the months-to-years range, matching the observed durations. Both diagnostics independently localise the instability in the inner accretion flow. We compare the model predictions with a sample of five well-characterised Changing-Look AGN and find consistent constraints on the disk magnetisation across the sample, indicating a unified magnetised-disk origin for the Changing-Look phenomenon.

**SPHERICALLY SYMMETRIC NLTE MODEL ATMOSPHERES:
FROM FIRST STARS TO CLUMPED HOT DWARFS**

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We present applications of a static, spherically symmetric NLTE model atmosphere code that is based on accelerated lambda iteration and complete linearisation. Hydrogen-helium models of Population III stars provide ionizing photon fluxes for H I, He I and He II, and their evolution. For hot dwarfs, photospheric microclumping modifies the temperature structure, the populations of NLTE levels, the continuum flux and the profiles of selected lines. These applications demonstrate how the chemical composition and small-scale density inhomogeneities of hot stars shape their emergent radiation.

CLUMPED WINDS OF MASSIVE HOT STARS AND THEIR IMPACT ON MASS-LOSS DETERMINATIONS

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Mass loss is crucial for the evolution and final fate of massive stars, yet its empirical determination is strongly affected by wind clumping. I will present our three-dimensional Monte Carlo radiative-transfer modelling, which demonstrated that density and velocity inhomogeneities substantially modify UV resonance lines. Applied to Galactic O supergiants, these models showed that macroclumping can reconcile the discrepant mass-loss rates derived from HI and P V without requiring extremely low rates or subsolar phosphorus abundances. I will also discuss recent XShootU results for O-type giants and supergiants in the Large Magellanic Cloud. Their winds are found to be strongly clumped and affected by velocity porosity, while the derived empirical mass-loss rates agree with theoretical predictions within their considerable scatter. These findings highlight the importance of realistic clumping treatments and combined UV–optical spectroscopy.

**SER-SAG-S2 IN-KIND CONTRIBUTION TO VERA RUBIN
OBSERVATORY: FOLLOW-UP OBSERVATIONS WITH
THE 1.4-M MILANKOVIĆ TELESCOPE**

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The SER-SAG-S2 programme represents Serbia's observational in-kind contribution to the Vera Rubin Observatory in Chile, one of the world's leading facilities for time-domain astronomy, providing dedicated observing time with the 1.4-m Milankovic Telescope at the Astronomical Station Vidojevica (ASV). Within the programme, two observing nights per month are allocated to in-kind observations, providing a flexible resource for targeted follow-up.

Observing requests are received through dedicated proposals and direct communication, with the Observatory Control System (OCS) being developed for ASV. This flexible approach allows us to support both planned observing programmes and time-sensitive targets. The programme has already been used to follow up selected astronomical alerts, providing practical experience in rapid-response observations.

Through this in-kind, the Milankovic Telescope became a member of the Astronomical Event Observatory Network (AEON), placing our activities within the broader international ecosystem of facilities supporting coordinated and responsive time-domain observations. To support efficient exploitation of the observations, we have developed a dedicated data-reduction pipeline, providing an efficient path from raw Milankovic observations to reduced data products.

OPTICAL VARIABILITY AS A PROBE OF HIDDEN NUCLEAR ACTIVITY IN TYPE 2 AGNS

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Optical variability in Type 2 active galactic nuclei (AGNs) is rarely explored because the direct accretion-disc continuum is obscured by circumnuclear dust. Using a sample of 412 Type 2 AGNs obtained by cross-matching SDSS Stripe 82 multi-epoch photometry with the ALPAKA spectroscopic catalogue, the connection between optical variability and narrow-line region properties was investigated. Significant anti-correlations were found between optical RMS variability amplitudes and the luminosities of the [O III] $\lambda\lambda$ 4949,5007 and [N II] $\lambda\lambda$ 6548,6584 emission lines. Moderate anti-correlations were also detected between RMS variability and the velocity dispersions and equivalent widths of the [O III] λ 5007 and [N II] λ 6584 lines. The correlation with the [O III] and [N II] velocity dispersions appears to be secondary to the stronger relation between RMS variability and emission-line luminosity. These results show that optical variability in obscured AGNs retains information about the hidden nucleus. The observed relations suggest a link between variability, ionising output, and the global kinematic state of the narrow-line region.

ESTIMATING BARYONIC SPECIFIC ANGULAR MOMENTUM FROM STELLAR KINEMATICS

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Galaxies' baryonic specific angular momentum (sAM) is expected to be approximately conserved throughout their formation and most of their evolution, although it can be redistributed during interactions. Despite this, sAM varies significantly among different morphological types. To build a large sample of galaxies with measured sAM, particularly at the poorly sampled low-mass end of the galaxy mass function (i.e., dwarf galaxies), we explore the use of large and rapidly growing integral field unit (IFU) datasets. Since obtaining interferometric HI rotation curves remains observationally expensive, we build upon the approximate relation of Romanowsky & Fall (2012), who showed that for galaxies with stellar disks, roughly half of the total stellar angular momentum is enclosed within one effective radius (R_e). We generalize this relation to baryonic rather than stellar sAM and extend it to galaxies in which the baryonic mass has significant contributions from a stellar bulge and/or gas. Stellar rotation curves are derived from MUSE observations and corrected for asymmetric drift. Together with near-infrared photometry and HI blind survey data, they are used to estimate the total baryonic sAM. In this talk, we present a few representative galaxies spanning a range of stellar masses and gas fractions to illustrate the methodology. For these systems, interferometric H I rotation curves are available and serve as a benchmark for evaluating the recovered baryonic sAM.

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CONSTANT ROTATION VELOCITY APPROXIMATION

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Deploying a constant flat rotation velocity as a proxy for the true velocity field is commonly used to derive the total angular momentum of galaxies, without the need to map the complex galaxy rotation. However, a physically motivated constant, derived directly from the fundamental definition of angular momentum, better describes the system's dynamics and provides a much closer estimate of the galaxy's true total angular momentum.

SPOT MIGRATION AND ECLIPSE TIME VARIATIONS IN CLOSE BINARIES

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The availability of high-precision, uninterrupted space-based photometry, particularly from the Kepler and TESS missions, has ushered in a new era in the studies of close binary stars. Numerous continuous orbital cycles can now be examined for long-term trends, such as spot migration. The presence and location of spots are usually established through light curve synthesis methods. But recently, independent evidence of spot migration has been discovered in the small, quasi-periodic eclipse time variations that remain in the O-C residuals after the global trends related to changes in the orbital period have been removed. We present several close binaries from our recent research where a correlation between such eclipse time variations and the evolution of spot longitude was established, and discuss the mechanism behind the connection.

ARCHITECTURE OF DIRECTED PANSPERMIA: SYNTHESIS OF ORBITAL INTERCEPTION AND MECHANICAL PROTECTION OF BIOLOGICAL CARGO DURING HYPERVELOCITY IMPACTS

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Directed panspermia presents a method for securing the long-term continuity of terrestrial life by embedding biological payloads within interstellar objects for deep-space transit. However, executing an interception and subsequent emplacement at hypervelocity regimes presents severe mechanical and thermal constraints. Direct collision with a target at typical inbound velocities generates extreme peak pressures and thermal shocks capable of immediate payload sterilization. This paper presents a unified mission architecture designed to mitigate these hypervelocity energy states. By utilizing a high-velocity solar Oberth maneuver, the relative impact velocity can be reduced to the hydrodynamic flow regime. To ensure the survival of cryptobiotic cargo, we propose a high aspect-ratio kinetic penetrator. The structural architecture features a sacrificial phenolic-impregnated carbon ablator nose cone to vaporize target regolith, a middle acoustic-damping zone comprised of metal honeycomb and high-density silica aerogel, and a rear biological containment sphere suspended within a shear-thickening non-Newtonian fluid to maintain uniform hydrostatic pressure. Hydrodynamic penetration modeling demonstrates that this design achieves a safe burial depth within the target matrix, providing long-term preservation and shielding against galactic cosmic radiation without exceeding the structural or thermal thresholds of the biological payload.

**INFLUENCE OF CLOSE SUPERMASSIVE BINARY BLACK HOLES
ON SPECTRA OF ACTIVE GALACTIC NUCLEI: THE CASE
LOWER MASSES BLACK HOLES**

MSc thesis presentation

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We investigate the influence of sub-pc supermassive binary black holes (SMBBHs) on the variability in spectra of active galactic nuclei (AGNs), assuming that the masses of components are smaller than $10^6 M_{\odot}$. We used the PoSKI model (Popović et al. 2021) to simulate a net of spectra taking SMBBH parameters, i.e., their different phases, masses and mass ratios. We explore changes in spectral parameters. We analyse the resulting broad line light curves and full width at half maximum (FWHM) variations during several orbits. Our analysis demonstrates that the simulated broad line profiles depend strongly on the mass ratio of the components. We found that the intensity light curves and FWHM variability could indicate the presence of SMBBHs with smaller masses than $10^6 M_{\odot}$. Finally, we conclude that the long-term AGN monitoring campaigns can be very prospective for detections of lower-mass SMBBHs in the centre of these objects.

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**INTEGRATING VIRTUAL REALITY INTO ASTRONOMY
EDUCATION: FROM FUNDAMENTAL CONCEPTS TO
ADVANCED RESEARCH TOPICS**

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Virtual reality (VR) technologies offer new opportunities to enhance astronomy education, public outreach, and the communication of scientific results through immersive and interactive experiences. This poster presents examples of how VR can be integrated at different educational levels, from introductory undergraduate courses to advanced topics in planetary science. We demonstrate two case studies: an interactive visualization of apparent solar motion illustrating the concepts of true solar time and mean solar time, commonly introduced in basic astronomy courses, and a VR simulation of the Yarkovsky effect, a complex non-gravitational force relevant to the long-term orbital evolution of asteroids and typically studied in advanced planetary science curricula. These examples highlight the potential of VR to improve conceptual understanding of astronomical phenomena and the dissemination of research results through immersive and engaging experiences.

THE EDGE-ON GALAXIES IN THE DESI SURVEY: EGIDE PROJECT

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We present the EGIDE (The Edge-on Galaxies in the DESI survey) project - a catalogue of 149,215 edge-on galaxy candidates created using the data of the DESI Legacy Imaging Survey DR10 images. The catalogue size is ten times bigger than its predecessor and covers more than half of the sky. It is constructed in an automatic way utilizing the full power of manual annotations from the GalaxyZoo volunteers, implemented in the Zoobot neural model, which was fine-tuned to search for edge-on galaxies specifically. To ensure the credibility of the dataset, subsequent manual supervision was done. The EGIDE catalogue provides homogeneous SExtractor photometry in griz bands, total stellar mass estimation, redshift values for 98% of the sample, star formation rates and other information. All of this is publicly available at The Edge-on Galaxy Database site. The preliminary analysis focused on differences between edge-on galaxies in the so-called blue sequence and red cloud populations. These galaxies demonstrate distinct properties: the number of redder galaxies drops with increasing a/b ratio faster than for the bluer galaxies; galaxy thickness varies with galaxy colour: red sequence galaxies are thicker than blue cloud galaxies; the flattening ratio $q=b/a$ increases with total stellar mass significantly only for redder cloud galaxies. It is an intriguing result, that the same trend of q increasing for the high-mass end is detected from both the statistical models of figures of revolution and direct observations of edge-on galaxies in EGIDE independently.

**FEEDING THE LITTLE MONSTER: AN ACCRETING
INTERMEDIATE-MASS BLACK HOLE IN A MINOR MERGER**

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We report the discovery of a candidate intermediate-mass black hole (IMBH) in the secondary galaxy of a 10:1 minor merger at $z=0.216$. Combining 6.6 Ms of archival Chandra observations, we detect a luminous supersoft X-ray source with no significant hard X-ray emission. Spectral modeling favors thermal accretion-disk emission with $kT = 0.18\text{-}0.30$ keV and $\log(LX/\text{erg s}^{-1})=40.53\text{-}41.24$, implying a black hole mass of approximately $10^3\text{-}10^4$ Msol accreting at a substantial fraction of the Eddington rate. The discovery supports theoretical predictions that minor mergers can drive rapid growth of black holes in dwarf galaxies and sheds new light on the emergence of the first supermassive black holes.

**NAUKA U KULTURI: RAZMATRANJE MOGUĆNOSTI
UNAPREĐENJA EDUKATIVNO-KULTURNIH PROGRAMA
U ASTRONOMSKOJ OPSERVATORIJU U BEOGRADU**

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Tema ovog rada je unapređenje edukativno-kulturnih kapaciteta Astronomske opservatorije u Beogradu (AOB), sa ciljem uspostavljanja uspešne komunikacije između ove naučne institucije i šire javnosti. Osnovana 1887. godine, AOB predstavlja jednu od najstarijih i najznačajnijih naučnih i kulturnih ustanova u Srbiji. U radu se analiziraju konkretni modeli organizovanja građanskih radionica i programa koji popularizuju bogatu istoriju Opservatorije, njeno kulturno nasleđe, kao i savremeni naučni rad njenih saradnika. Poseban akcenat stavljen je na specifične aktivnosti saradnika AOB-a u domenu zaštite, očuvanja i prezentacije ovog specifičnog naučnog i materijalnog nasleđa. Rad ukazuje na modele transformacije tradicionalnog naučnog prostora u dinamično kulturno središte, čime se doprinosi naučnoj pismenosti i zaštiti kulturne baštine u širem društvenom kontekstu.

UNIFIED SELF-SUPERVISED FRAMEWORK FOR MILNE-EDDINGTON INVERSION AND MAGNETIC FIELD AZIMUTH DISAMBIGUATION

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Milne-Eddington inversion of spectropolarimetric data and the removal of the 180° azimuth ambiguity are conventionally carried out as two separate steps, the ambiguity being resolved after the fact by a disambiguation routine operating on the already-inverted field. We describe a self-supervised convolutional neural network that performs both tasks in a single differentiable pass, fitting the Stokes profiles of the Fe I 6301.5 and 6302.5 Å pair through an Unno-Rachkovsky forward model, while penalties on the vertical current density and on the angle to a potential reference field select the azimuth branch. The network is optimized directly against the observed profiles, and its dilated receptive field supplies the spatial context that pixel-by-pixel inversions lack by construction. On synthetic profiles built from a MURaM cube, where the field is known, it recovers the field strength, the signed line-of-sight component and the transverse component with high fidelity. Applied to various observations, our single network trained without labels matches the accuracy of the conventional two-code pipeline while returning a disambiguated vector field directly.

A SYSTEMATIC SURVEY OF THE VON ZEIPPEL-LIDOV-KOZAI RESONANCE ACROSS THE SOLAR SYSTEM: FROM INSIDE JUPITER'S ORBIT TO THE TRANS-NEPTUNIAN REGION

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The von Zeipel-Lidov-Kozai (ZLK) mechanism drives secular oscillations of eccentricity and inclination that shape the orbital architecture of small bodies throughout the Solar System, but a catalog-wide observational census of ZLK-resonant bodies has so far been lacking. We present two complementary systematic surveys that together cover essentially the entire numbered small-body population: 1,037 numbered trans-Neptunian objects (TNOs) with semi-major axes $a > 30$ AU and 863,471 asteroids with $a < 4.9$ AU from the AstDyS catalog. Orbits were integrated in a full N-body model (Sun, eight planets, Pluto) using the "resonances" python package, with integration spans ranging from 100 kyr up to 300 Myr for some TNO candidates. Concurrent membership in two-body and three-body mean-motion resonances (MMRs) was tested for every ZLKR candidate. In the trans-Neptunian region, 81 objects ($\sim 7.8\%$) display clear ZLK libration and 23 additional objects exhibit transient behavior. Every confirmed librator is simultaneously trapped in a two-body MMR with Neptune – direct empirical confirmation of long-standing theoretical predictions. The most populated resonances are 2N-3 (58 objects), 4N-7 (15), 1N-2 (9), and 3N-5 (7); libration centers cluster near 90 and 270 deg for all populated MMRs except 1N-2, where they are shifted to approximately 120, 150, 300, and 330 deg.

**THE EQUATION BETWEEN 3-BODY MEAN MOTION
RESONANCES AND YARKOVSKY DRIFTS ON
ECCENTRICITIES IN THE RANGE (0.2, 0.3)**

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We studied the motion of asteroids across the 3-body mean motion resonances with Jupiter and Saturn and with the Yarkovsky drift speed in the semimajor axis of the asteroids. The research was conducted using numerical integrations performed using the Orbit9 integrator with 72000 test asteroids. We calculated time delays, dtr , caused by the six 3-body resonances on the mobility of test asteroids with 10 positive and 10 negative Yarkovsky drift speeds, which are reliable for Main Belt asteroids. We devised equations that approximately describe the functional relation between the average time spent in the resonance, the strength of the resonance, and the semimajor axis drifts (positive and negative) with the orbital eccentricities of asteroids in the range (0.2, 0.3). Finally, this study shows that the functional relation we obtain for 3-body MMRs for orbital eccentricities of asteroids in the range (0.2, 0.3) is analogous to that previously obtained for orbital eccentricities of asteroids in the ranges (0, 0.1) and (0.1, 0.2) in Milić Žitnik (2021, 2023), respectively.

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ASSESSING THE ACCURACY AND RANGE OF VALIDITY FOR SEMI-ANALYTIC MEAN MOTION RESONANCE WIDTH FORMULA

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Building on the analytical framework for mean motion resonance (MMR) width established by Murray and Dermott (1999) and the resonance strength calculations of Gallardo (2006), Soja et al. (2011) derived a functional relationship between resonant width and strength. While Soja et al. (2011) defined the model's validity for eccentricities below ~ 0.3 and low inclinations, our research identifies further limitations, specifically regarding 1:1 resonances and high-intensity resonant zones. This study presents analytical MMR width calculations and validates these results through a comparative analysis with numerical simulations conducted in Orbit9.

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MCMC PARAMETER ESTIMATION FOR INFLATIONARY COSMOLOGICAL MODELS

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This work focuses on the numerical framework used to estimate parameters of the inflationary cosmological models and the calculation of cosmological observational quantities. It relies on our previous work, where we presented the inflationary cosmological models implemented within the "inflationSim" simulation package: the standard single scalar field model, tachyon-field-driven inflation, and the Randall-Sundrum II (RSII) braneworld model and its extensions. The holographic model with several classes of potential was also considered. A Metropolis-Hastings MCMC algorithm has been introduced into the simulation framework, generating the full posterior distribution of model parameters conditioned on observational constraints. In our work the accent is on two observational quantities-parameters, the scalar spectral index n_s and the tensor-to-scalar ratio r . This replaces a geometric assessment of compatibility regions in parameter space with a quantitative estimate of uncertainties and correlations among the parameters. In parallel, eight independent methods for computing n_s and r have been implemented and compared, ranging from first- and second-order slow-roll approximations to the full numerical solution of the Mukhanov-Sasaki equation. Based on a sample of simulations of the holographic model, analytic methods accounting for a variable sound speed c_s - show the best agreement with Planck 2018 constraints. Alongside Planck, the MCMC posteriors were also compared against more recent ACT DR6 constraints ($n_s = 0.9709 \pm 0.0038$, with $r < 0.038$ combined with BK18) and DESI BAO measurements ($n_s = 0.9690 \pm 0.0035$ in combination with Planck), which shift the central value of n_s upward relative to the Planck-only result. These improvements are based on a previous approach to parameter estimation for these models, based on sampling of parameter space and binary classification of results using machine learning methods. Our approach allows extending to models with more parameters.

**DYNAMICAL PROPERTIES OF SPIRAL GALAXIES
AS A SIGNATURE OF SATELLITE GALAXY
TIDAL DISRUPTION**

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We investigate the dynamical response of a spiral galaxy to the tidal disruption of a dwarf satellite galaxy using N-body simulations of galaxy mergers. We analyze the evolution of the host galaxy's dark matter halo and stellar disk. The angular momentum of both the disk and halo is calculated throughout the merger to characterize the transfer of orbital angular momentum from the satellite to the host galaxy. We further investigate the development and evolution of disk warping as a possible dynamical signature of the satellite's tidal disruption. Our results demonstrate how the disruption of a low-mass companion can leave measurable imprints on the structure and dynamics of the host spiral galaxy.

THE EFFECT OF THE INITIAL ORBITAL PERIOD ON THE EVOLUTION OF MASSIVE CLOSE BINARY SYSTEMS

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The effect of the initial orbital period on the evolution of massive close binary systems is investigated using the stellar evolution code MESA. Binary systems composed of two zero-age main-sequence stars (ZAMS) are modeled, with initial masses of 50 and 45 $M_{\odot}$ and initial orbital periods ranging from 3 to 10 days. Two mass-transfer scenarios are considered: conservative mass transfer, in which all material lost by the primary star is accreted by the secondary component, and non-conservative mass transfer, in which a fraction of the transferred material is lost from the system. The results show that the initial orbital period and accretion efficiency significantly influence the evolutionary behavior and final properties of the systems. Depending on the initial configuration, the primary star fills its Roche lobe and initiates Case A or Case B mass transfer at different evolutionary stages. Conservative models with initial orbital periods between 4 and 8 days evolve into contact systems, while the remaining conservative models and all non-conservative models remain detached. The primary stars develop carbon–oxygen cores with masses of approximately 20 $M_{\odot}$. Based on the obtained CO-core masses, the corresponding black hole masses are estimated and the potential formation of double black hole systems is investigated. The models indicate that systems with non-conservative mass transfer and shorter initial orbital periods have a higher probability of evolving into double black hole binaries, making them potential progenitors of gravitational-wave sources.

NOISE REDUCTION OF VLF SIGNAL AMPLITUDE AS EARTHQUAKE PRECURSOR: STATISTICAL STUDY

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In recent years, the noise reduction of VLF signal amplitude has been considered as one of the possible types of earthquake precursors. This research began at the end of the previous decade with the analysis of the ICV signal emitted in Italy and recorded in Serbia in the period around the Mw 5.4 earthquake near Kraljevo, Serbia. In this study, we present an analysis of the aforementioned change in the periods around 66 earthquakes. The effects of earthquake and VLF signal characteristics are analyzed, and the obtained results indicate the importance of the characteristics of both the considered earthquake and the analyzed signal for the occurrence of amplitude reduction before the observed events.

**A COMMENT ON QUASI-PLANAR ORBITS FOR STEADY STATE
AND AXIAL SYMMETRY**

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Quasi-planar orbits characteristic for discs of spiral galaxies are described with quasi-integrals, the energy one in the plane of symmetry and action conservation. The subject is to examine the conditions of their validity.

**VERTICAL EVOLUTION OF EXOCOMETARY GAS -
II. MRI-DRIVEN VISCOUS EVOLUTION AND
DIFFUSION OF GAS IN DEBRIS DISCS**

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The presence of CO gas in debris discs around main-sequence stars raises important questions about the origin, evolution, and transport of secondary gas. Previous models have generally assumed a constant turbulent viscosity, although the efficiency of angular momentum transport is expected to depend on the ionization state of the gas through the magneto-rotational instability (MRI). In this work, we extend the one-dimensional gas evolution model EXOGAS by implementing a self-consistent prescription for MRI-driven viscosity, allowing the viscosity parameter to evolve together with the gas chemistry and ionization structure. We investigate the influence of the CO production rate, the initial CO surface density, and the adopted viscosity limits on the evolution of the gas. Our simulations reveal two distinct evolutionary regimes. At low CO production rates, the gas becomes sufficiently ionized for MRI to develop, resulting in efficient turbulent transport and high viscosity. In contrast, higher production rates lead to stronger shielding of the disc midplane, suppressing ionization, weakening MRI activity, and reducing the viscosity by several orders of magnitude. We also find that only unrealistically high initial CO surface densities significantly modify the long-term evolution, while variations in the minimum and maximum viscosity parameters primarily affect the quantitative evolution without changing the overall behaviour. Compared with models assuming constant viscosity, the self-consistent MRI prescription predicts substantially higher gas surface densities in systems with high CO production rates, highlighting the importance of coupling turbulence to the evolving physical conditions of debris disc gas.

THIEF GALAXY GROUPS: SIGNATURES OF CLUSTER PASSAGE

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We investigate galaxy groups that currently reside in the field but have previously passed through a galaxy cluster. Although these systems may appear similar to ordinary field groups, dynamical interactions experienced during cluster passage are expected to leave measurable imprints on their properties. Using the IllustrisTNG300 simulation, we statistically compare such cluster-processed groups with a sample of regular field groups over a mass range of $(8 \times 10^{11}, M_{\odot})$ to $(7 \times 10^{13}, M_{\odot})$. We distinguish between two populations of processed groups. The first, referred to as thief groups, have captured additional member galaxies during their passage through a cluster. The second, non-thief groups, have not captured any new members. Our analysis shows that thief groups are generally less compact and contain more galaxies than regular field groups, indicating that cluster processing leaves observable signatures in their present-day properties. In contrast, non-thief groups exhibit properties largely indistinguishable from those of ordinary field groups, making their cluster-processed history difficult to identify observationally.

COMMUNICATING ASTROBIOLOGY RESEARCH THROUGH AN INTERACTIVE EXHIBITION AND THE EDUCATIONAL CARD GAME KOSMOKVEST

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Astrobiology is an inherently interdisciplinary field, connecting astronomy, biology, physics, chemistry, geology and philosophy. However, for younger students and the general public, its research questions are often known mainly through science fiction rather than through real scientific concepts. For this reason, science promotion activities can play an important role in presenting astrobiology as an important and inspiring research field. In this contribution, we present a scientific outreach programme developed within the project “Imagine, Explore, Discover - Life Beyond Earth”, supported by the Centre for the Promotion of Science. The project was connected with the activities of the Laboratory for Experimental Astrobiology, established at the Institute of Physics in Belgrade two years ago, and was aimed especially at high school students and bachelor’s students from different faculties. As part of the project, we organized the educational interactive poster exhibition “SciFi in SciFa - from science fiction to science facts” in four cities across Serbia. Through visual materials and adapted texts, visitors were introduced to the main topics studied in astrobiology, including the possibility of microbial life on other planets, as well as the biological limitations of worlds and organisms described in science fiction books and films. A central part of the outreach activity was our original educational card game “KosmoKvest”. In the game, players explore astrobiological terms, extremophilic bacterial species, and conditions on planets and satellites in the Solar System by reading short texts connected to each term through QR codes. Players in the role of scientists build an interstellar path toward a planet or satellite by connecting related terms, while players in the role of disinformers, together with unexpected action cards and black holes, can disrupt their path. Here, we present the concept and implementation of these outreach activities, together with impressions from student volunteers who guided the exhibition and from visitors. We discuss how the exhibition and KosmoKvest contributed to visitors’ understanding of astrobiological research, acquisition of new scientific knowledge, and broadening of their horizons through this amusing and interactive activities.

THE RESULTS OF LIGHT POLLUTION QUESTIONNAIRE IN THE TERRITORY OF BELGRADE

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This research was conducted within the Project Urban Observatory of Belgrade (UrbObsBel), funded by the Science Fund of the Republic of Serbia, and started in January 2024. The project enabled the acquisition of quantitative measures of light pollution in the Belgrade territory from different locations. One of the project goals was to investigate the light pollution effects and awareness in the human population. For that purpose, the specific light pollution questionnaire has been assembled and anonymously filled by individuals living in different Belgrade municipalities. The questionnaire provided the data on individual knowledge and awareness about the light pollution problem, personal opinion and behavior in the context of this issue, and readiness for necessary changes that could partially diminish the effects on human health. One of the striking results reveals that many of the community members are not well informed, and they have poor knowledge about the effects of light pollution on human health, as well as the protective measures. Future research and actions should provide a more comprehensive way of distributing quantitative data, together with the protective measures and increased awareness of the light pollution problem, which would lead to a better and safer living environment. This research was supported by the Science Fund of the Republic of Serbia, no. 6775, Urban Observatory of Belgrade.

**URBAN OBSERVATORY OF BELGRADE (URBOBSBEL):
STUDY OF LIGHT POLLUTION IN BELGRADE AND AT
THE ASTRONOMICAL STATION VIDOJEVICA**

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Urban Observatory of Belgrade (UrbObsBel) is a three-year project funded by the Science Fund of the Republic of Serbia started in January 2024. Several instruments aimed for the study of light pollution were mounted at the Astronomical Observatory of Belgrade (AOB) and at the Astronomical Station Vidojevica (ASV). In this study we present comprehensive findings on light pollution levels measured using Sky Quality Meter (SQM) devices designed to measure the luminance of the night sky, over an approximately one-year period. We also use the data obtained with the SQM device mounted in the downtown Belgrade at Kalemegdan provided by the Astronomical Society "Ruđer Bošković". Our analysis indicates that urban areas experience substantially higher levels of light pollution which increase over time compared to the dark area in the southern Serbia where the ASV is situated. Our findings underscore the importance of mitigating excessive artificial lighting to preserve natural night skies. This research provides valuable insights for policymakers, urban planners, and environmentalists seeking to reduce the adverse effects of light pollution. This research was supported by the Science Fund of the Republic of Serbia, no. 6775, Urban Observatory of Belgrade.

HOW TO DECOMPOSE THOUSANDS OF GALAXIES: A TEMPLATE-BASED APPROACH

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Photometric decomposition is a widely used method for deriving galaxy structural parameters from imaging data. One of the major challenges in this process is finding suitable initial conditions for the iterative optimization of the model parameters. In the literature, a variety of approaches have been proposed for estimating initial parameters, ranging from brute-force searches and manual parameter tuning to sophisticated computer vision algorithms and machine-learning techniques. In this talk, we present a new approach for determining initial decomposition parameters based on template matching. We apply this method to the decomposition of galaxies from EGIPS, a large sample of edge-on galaxies, and discuss its potential for enabling efficient and robust photometric decomposition of large galaxy samples.

IDENTIFYING GALAXY PROPERTIES THAT GOVERN GAS-PHASE METALLICITY IN ILLUSTRISTNG WITH MACHINE LEARNING

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Gas-phase metallicity is regulated by star formation, gas inflows from the surrounding environment, and gas outflows powered by stellar and AGN feedback. As such, it is a fundamental tracer of galaxy evolution. However, star formation, galaxy environment, and gas inflows and outflows are closely interconnected, making it difficult to disentangle their individual contributions to galaxy metallicity. In this work, we employ different machine learning techniques to identify and rank the galaxy properties that are most predictive of gas-phase metallicity in the IllustrisTNG cosmological simulation. Our preliminary results suggest that the three most important parameters in determining gas-phase metallicity are star formation rate, stellar metallicity and baryonic gravitational potential of the galaxy. Our results provide new insight into the relative importance of galaxy properties that govern chemical enrichment.

SIMULATION BASED INFERENCE FOR STOCHASTIC GRAVITATIONAL WAVE BACKGROUND

MSc thesis presentation

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The Laser Interferometer Space Antenna (LISA), scheduled for launch in the mid-2030s, will probe the millihertz gravitational-wave regime, where a stochastic gravitational-wave background (SGWB) is expected to arise from the superposition of unresolved astrophysical sources such as compact binaries and supermassive black hole populations. Extracting physical parameters from this background is a high-dimensional Bayesian inverse problem, complicated by the computational cost of repeatedly evaluating forward models within traditional likelihood-based inference frameworks.

Standard approaches such as Markov Chain Monte Carlo (MCMC) and nested sampling rely on explicit likelihood evaluations, which can become computationally prohibitive for realistic Gravitational Waves (GWs) inference problem. This motivates simulation-based inference (SBI), which uses machine learning to approximate the posterior directly from simulated data, without ever evaluating a likelihood as an alternative approach. This work presents an amortized SBI pipeline for SGWB parameter estimation, built on neural posterior estimation trained via neural spline flows, with separate networks for the signal and noise components of a simplified LISA data model.

The focus is on exploring whether splitting the posterior estimator, into separate signal and noise networks that work in parallel to infer the parameters, is advantageous compared to a single joint network, especially when the training prior is adaptively narrowed around the target observation. Several strategies for this adaptive prior focusing are explored and compared, including approaches from the recently proposed dynamic, round-free sequential SBI methods. The data-compression architecture feeding each flow is also examined, comparing a fully-connected baseline against networks that exploit the per-channel structure of the LISA A/E/T data streams and cross-channel correlations via message passing on a graph. Posterior quality is assessed throughout using calibration diagnostics (simulation-based calibration via PP-plots), agreement with reference MCMC posteriors (Jensen-Shannon divergence), and an internal reference-free consistency check based on comparing independently trained twin networks via KL divergence. The framework is further validated against an analytically tractable high-dimensional benchmark.

SEARCH FOR A CONNECTION BETWEEN ICECUBE NEUTRINOS AND OPTICAL POLARIZATION IN BLAZARS

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Blazars are considered candidate sources of astrophysical neutrinos, while optical polarization and rotations of the electric-vector position angle (EVPA) trace the reconfiguration of the magnetic field in the jet. We investigate whether there is a statistical connection between the arrival of IceCube neutrinos and episodes of EVPA rotations for a sample of 32 gamma-bright blazars using the IceCube event catalog and long-term optical polarimetric monitoring data. Preliminarily, we find no robust connection within the current sensitivity. We discuss the results in the context of multi-zone jet models, in which the optical/gamma-ray emission regions and the neutrino-production zone may be spatially separated.

UBVRI PHOTOMETRY OF THE 2017 SUPEROUTBURST OF THE WZ SGE-TYPE DWARF NOVA ASASSN-17PM

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Using our UBVRI photometric monitoring together with observations reported by other authors, we investigated the WZ Sge-type dwarf nova ASASSN-17pm during its superoutburst. Our observations began immediately after the discovery of the outburst on 22 November 2017 and continued for approximately one month. The superoutburst exhibited an unusual combination of photometric variability, including (1) a relatively low outburst amplitude of about 5 mag, (2) double-wave brightness modulations detected between the onset of the outburst and the plateau stage, and (3) complex quasi-periodic variations produced by the superposition of orbital modulation and ordinary superhumps with evolving periods. Period analysis suggests that the double-wave modulation is associated with the orbital period, while the evolving superhumps dominate the photometric variability during the main stage of the superoutburst. The multicolor observations enabled us to trace the evolution of the superoutburst in two-color diagrams. Taken together, these results enable us to suggest possible physical interpretations of the processes occurring in the close binary system ASASSN-17pm during the superoutburst and of the system geometry.

SIMULATING INTERSTELLAR OBJECT DETECTIONS WITH THE RUBIN OBSERVATORY LSST

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Interstellar objects (ISOs) provide a unique opportunity to investigate the physical and dynamical properties of small bodies formed in extrasolar planetary systems. The upcoming Legacy Survey of Space and Time (LSST) at the Vera C. Rubin Observatory is expected to significantly increase the number of detected ISOs, making realistic population modeling essential for interpreting future observations. We present an improved synthetic population generator capable of producing stationary ISO populations within an arbitrary heliocentric volume over an arbitrary time interval, providing a powerful tool for realistic sky survey simulations. A wide range of synthetic populations is generated by varying the kinematic properties, size distributions, and albedos of the objects. Both inactive and active interstellar objects are considered, with cometary activity represented by several different activity models. The detectability of these populations is evaluated through survey simulations performed with SORCHA (Solar System Survey Simulator for LSST). The results provide constraints on the expected number and characteristics of detected ISOs and quantify how different assumptions about the underlying ISO population affect the survey's detection efficiency.

**ACTIVITIES OF THE EUREKA ASTRONOMICAL SOCIETY
ON THE PROMOTION OF ASTRONOMY 2023 - 2026**

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In the paper, we will present all activities in the field of astronomy promotion that the association has implemented in Kruševac and beyond in the period since the previous conference. The emphasis will be on the project to build a solar astronomical observatory and an astronomical camp on Jastrebac, as well as on expanding cooperation from primary and secondary schools to kindergartens in the city and the Correctional Center.

СЕЋАЊЕ НА ВОЈИСЛАВУ ПРОТИЋ БЕНИШЕК (1946 - 2026)

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Предавање је посвећено Војислави Протић Бенишек (1946 - 2026), која је читав свој радни и животни век провела на Астрономској опсерваторији у Београду. Поред најважнијих података из њене биографије и библиографије, биће речи и о њеном залагању за очување научне баштине Астрономске опсерваторије (АО), очувању комплекса АО, њеној промоцији и унапређењу. Поред фотографија и архивске грађе, биће приказане и путањске карактеристике астероида 5397 Војислава, који је 2006. године именован по њој. У завршном делу излагања говорићемо о личности Војиславе Протић Бенишек, која је обележила једно време на Астрономској опсерваторији у Београду.

**THE IMPORTANCE OF SERBIA'S INCLUSION IN
INTERNATIONAL SPACE RESEARCH INITIATIVES**

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The Republic of Serbia is involved in international initiatives and projects dealing with space exploration. Space is becoming an increasingly important topic today, not only in scientific circles, but also in political, economic, and legal circles. That is why Serbia's return to COPUOS and the agreements it has with China, Russia, Kazakhstan, as well as the signing of the Artemis Agreement are important for Serbia's further engagement and positioning in these circles. In the paper, we will analyze the Republic of Serbia's past activities in this field, the economic, legal, and political significance of the steps being taken, as well as proposals for further activities, cooperation, and the potential Serbia should leverage in this field.

BIOSIGNATURES FROM THE METABOLIC MODEL OF A METHANOGEN-ACETOGEN MICROBIAL COMMUNITY

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Methanogenic microorganisms have contributed to major geological changes in Earth's history, notably the largest mass extinction, Permian-Triassic. Since they are producing most of global methane, changes in their metabolism and growth can create a biosignature visible at the planetary scale. Both acetogen (acetate-producing) and methanogen (methane-producing) organisms are present in anaerobic microbial communities, which are widespread in marine sediments. We are investigating the metabolic model of a simplified community using flux balance analysis, which calculates the biomass growth and fluxes of chemical reactions. The community is made of two species: *Methanosarcina barkeri*, a methanogen that can grow on acetate, and *Clostridium ljungdahlii*, an acetogen. An extinction event similar to Permian-Triassic is simulated by a rapid increase in organic molecules and nickel, which favors both species. We will analyze potential biosignatures under different conditions for microbial community growth. Results from this simplified model could serve as the basis for investigating communities with more species. They could also assist models that simulate the impact of microorganisms in geological changes on Earth and other planetary bodies where methane emissions are relevant, such as Mars and Titan.

**GROUND-BASED MUON OBSERVATIONS OF SOLAR ACTIVITY
AND SPACE WEATHER: THE BELGRADE MUON STATION
AND THE GLOWCOST NETWORK**

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Cosmic-ray muons provide a ground-based probe of solar activity and space weather through their sensitivity to heliospheric conditions. Since 2002, the Belgrade Muon Station has continuously monitored muon intensity at ground level and shallow underground, creating one of the region's longest observational records. A new mobile cosmic-ray detector has recently been deployed, and the station has joined the global gLOWCOST network of small muon detectors for monitoring heliospheric effects on cosmic-ray fluxes. Detector response, energy sensitivity, and calibration were determined using Geant4 Monte Carlo simulations, enabling accurate muon flux reconstruction from measured count rates. Time-series analysis of these data is used to investigate Solar Cycle 25 modulation and space-weather effects. Together, the long-term measurements, mobile detector, and gLOWCOST network strengthen ground-based studies of cosmic-ray modulation and solar-terrestrial interactions.

ACTIVITY IN SERBIA CONCERNING ASTRONOMICAL CONTESTS IN 2010-2023

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The authors present their rich experience in organising astronomical contests for secondary school pupils from Serbia both national and international. In the period 2010-2023 much of the work – task preparation and checking of participants' answers on the national level, obtaining financial support and national team leading on the international level – belonged to the present authors.

QUASI-DETERMINISTIC PRECURSORS OF MAJOR SOLAR FLARES: SPECTRAL-PROBABILISTIC ANALYSIS OF SOFT X-RAY VARIATIONS

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Reliable short-term forecasting of major solar flares requires the identification of stable precursors that emerge hours to days before the eruptive event. We apply a spectral-probabilistic method to the analysis of GOES soft X-ray time series in the 0.5–4 Å and 1–8 Å wavelength bands. The method is based on the assumption that the observed signal consists of two statistically independent components: a stochastic background process and an additional process associated with flare preparation. The emergence of the second component reduces the small-scale randomness of the signal and produces measurable changes in the probability density structure of the time series. To quantify these effects, we analyze the evolution of a statistical functional Ln , which characterizes the degree of order in the signal distribution. We show that quasi-deterministic structures systematically appear in Ln - prior to X-class flares. These structures include long linear trends, quasi-parallel channels, drifting boundaries, and closed geometric configurations referred to as “flare parallelograms.” Their formation reflects a statistically significant reduction in signal stochasticity and indicates a transition of the solar active region toward a partially self-organized state. The method was applied to three X-class flares observed on 14 July, 29 July, and 5 August 2024. In all events, a consistent sequence of statistical signatures was detected within 160–15 hours before flare onset. Linear trends appeared first, followed by stable channel structures, then drifting boundaries, and finally flare parallelograms emerging approximately 10–20 hours before the impulsive phase. During the final 15–5 hours, a rapid increase in Ln was observed, corresponding to the final destabilization stage of the active region. The high reproducibility of these patterns across independent events suggests that they are not random fluctuations but manifestations of universal physical processes in pre-flare evolution. The spectral-probabilistic approach therefore provides a new class of diagnostic indicators for early warning of strong solar activity and may complement existing flare prediction techniques based on magnetic-field analysis and machine learning.

ЕУСТАХИЈА АРСИЋ

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Прва српска песникиња, после Јефимије, је Еустахија Арсић, рођена у фрушкогорском граду Ириг (14. март 1776. преминула 17. фебруара 1843. године у Араду). У књизи "ПОЛЕЗНАЈА РАЗМИШЉАНИЈА" Еустахија пише о природним појавама: Сунцу, Сатурну, микроскопу, звездама, ветровима, дуги, и спомиње име научника светског гласа Њутна. У књизи појединачно описује природне појаве и љепоте годишњих доба. Појаве описује сликовито, поетично и детаљно при прелазу годишњих доба. У књизи описује физичке, метеоролошке појаве често коректно, а има и понекад да није са становништа данашњице.

COMPARISON OF DENSITY-BASED CLUSTERING ALGORITHMS FOR ASTEROID FAMILY IDENTIFICATION

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The search for new asteroid families depends not only on the linking distance but also on the clustering algorithm itself, a choice that is rarely examined in practice. We removed $\hat{A}$ members of 79 known families from the January 2025 catalog of synthetic proper elements using a Random Forest classifier, and clustered $\hat{A}$ the remaining background of 747,215 objects in the Zappalà metric, once with DBSCAN and once with HDBSCAN. Candidate clusters in both runs are filtered by the same criteria: minimum of 60 members, separation from known families, velocity compactness, and V-shape signature in absolute magnitude. HDBSCAN in its default excess-of-mass mode turns out to be useless here, as each dynamical zone collapses into a single cluster of over 200,000 objects, so leaf selection is mandatory. With this configuration, HDBSCAN returns 49 candidates with 7,474 members, whereas DBSCAN returns 29 candidates (4,614 members) at 55 m/s. Of the eight DBSCAN candidates stable over linking distance s of 45-65 m/s, six are recovered independently by HDBSCAN and six are entirely dissolved into noise. Candidates for DBSCAN are a bit more likely to be consistent with the Nesvorny 2024 classification (48% vs 43%) implying a cleaner, albeit smaller, set of candidates.

CUBESAT MISSIONS DEDICATED TO ASTRONOMICAL RESEARCH

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We present an overview of existing and planned CubeSat missions dedicated to astronomical research. Based on this overview, we assess the potential of our CubeSat platform "Sinergy" for space-based astronomical observations, with a particular focus on transit photometry of exoplanets. To support this assessment, we used our CubeSat mission database and developed a model of the CubeSat attitude determination and control system with magnetorquers and reaction wheels as actuators.

**IDENTIFICATION OF STRUCTURES IN THE UNIVERSE
THROUGH QUASAR CLUSTERING**
MSc thesis presentation

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Quasars are powerful tracers of the large-scale structure of the Universe at redshifts where dense galaxy samples are harder to obtain. In this work, we use the Quia quasar catalog, considering the $G < 20.5$ and $G < 20.0$ magnitude-limited samples, to reconstruct and characterize the cosmic web traced by quasars. After applying a sigma-clipping selection in the $(z, z_{\text{error}}/z)$ plane, we retain approximately 67.2% of the $G < 20.0$ sample and 61.3% of the $G < 20.5$ sample. We then build volume-limited samples, estimate their luminosity function and two-point correlation function using the Landy-Szalay estimator, and assign halo masses to the quasar hosts. From this information, we reconstruct the density field with a halo-based method and extract the filamentary skeleton using DisPerSE. We analyze the dependence of the filament properties on the smoothing scale and apply a geometric filtering procedure to mitigate boundary-induced artifacts in the skeleton. The final filament catalog is characterized separately in the Galactic North and South through length distributions, vertex-separation distributions, occupation statistics, cumulative distribution functions, and filament number densities. These measurements reveal indications of hemispheric asymmetries. We therefore perform a targeted overdensity analysis using radial filament counts, angular sweeps on the sky, quasar-filament cross-correlation measurements, and visual inspection of quasar concentrations around the reconstructed skeleton. We find consistent signatures of simultaneous overdensities in both quasars and filaments, not primarily associated with the Magellanic Clouds, suggesting the possible presence of a large-scale structure, potentially analogous to reported features such as the Hercules-Corona Borealis Great Wall or the Giant GRB Ring. This work demonstrates that quasar samples, halo-based density reconstruction, and DisPerSE skeleton extraction provide a reproducible route to mapping the cosmic web across large cosmological volumes.

IGNITING FAST COSMIC-RAY ACCELERATION VIA NON-LINEAR STRUCTURES AT HIGH-MACH-NUMBER SHOCKS

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We present a comprehensive study of cosmic-ray (CR) acceleration and shock evolution across various field inclinations, using extensive 2D and 3D particle-in-cell (PIC) simulations of high-Mach-number collisionless shock waves. Our results demonstrate that short large-amplitude magnetic structures (SLAMS) grow upstream of the shock, driving rapid particle acceleration. In the quasi-parallel regime, SLAMS mediate a novel quasi-periodic shock acceleration (QSA) mechanism that accelerates electrons from thermal to CR energies within a few ion gyrations. Crucially, we detect SLAMS for the first time in 3D PIC simulations of quasi-perpendicular shocks, revealing that QSA operates effectively across both geometries despite the computational constraints of 3D runs. While SLAMS strongly affect electrons, they universally enhance injection and initial acceleration of both particle species, while acceleration mechanisms diverge at higher energies. Once CRs start to diffuse across SLAMS, they undergo diffusive shock acceleration (DSA) at lower shock inclinations, whereas particles at higher inclinations accelerate via shock drift acceleration (SDA) sustained by the perpendicular magnetic field component.

PRVE GALAKTIČKE MAPE PLANETARNIH SISTEMA

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Broj potvrđenih egzoplanetarnih sistema premašio je 5500 i raste iz dana u dan. Osnovni podaci o planetama i njihovim matičnim zvezdama javno su dostupni kroz razne online kataloge i baze podataka, gde se mogu naći vrednosti različitih fizičkih i orbitalnih parametara. Međutim, galaktičke koordinate planetarnih sistema nisu dostupne ni u jednoj bazi podataka. Bez podataka o galaktičkim koordinatama planetarnih sistema, nemamo predstavu kako su planete koje detektujemo raspoređene u različitim delovima Galaksije, što ograničava uvide planetarnih nauka i astrobiologije. Sa ciljem da popunimo ovu prazninu, pretražili smo Simbad bazu podataka u potrazi za galaktičkim koordinatama i paralaksama svih matičnih zvezda iz exoplanet.eu kataloga. Našli smo galaktičke koordinate za 5380 planetarnih sistema (99.5% svih potvrđenih sistema), kao i paralakse za 4913 sistema (90.9% svih potvrđenih sistema). Na osnovu ovih podataka, dobili smo prve mape planetarnih sistema u Galaksiji. Na mapama se uočava grupisanje planeta u pravcu centra Galaksije, kao i nekoliko grupacija duž projekcije ekliptike. Rastojanja dobijena iz paralaksi pokazuju da se 98.1% detektovanih planetarnih sistema nalazi unutar 2 pc od Sunca, dok se najudaljeniji potvrđeni sistem nalazi na rastojanju od 45 pc.

XXI Serbian Astronomical Conference — Detailed programme			
Belgrade · 5–8 October 2026			
Time	Type	Speaker / Chair	Title
Monday 5 Oct			
13:30 - 14:30	Registration		Registration
chairs: Milica Anđelić, Dragana Ilić (Scientific Organizing Committee Chairs)			
14:30 - 15:00	Opening ceremony		Opening ceremony
15:00 - 15:45	Plenary	Knežević Zoran	Asteroid synthetic proper elements: computational complexity, failures, comparison of the catalog contents and data accuracy
15:45 - 16:30	Plenary	Ivezić Željko	Rubin Observatory's LSST: status report
16:30 - 17:00	Coffee break		
Special Session — Vera C. Rubin Observatory / LSST (chair: Dragana Ilić)			
17:00 - 17:30	Invited	Kovačević Anđelka	Serbian Directable Software In-Kind Contribution for AGN Science in the Vera C. Rubin Observatory Legacy Survey of Space and Time
17:30 - 17:45	Talk	Lakićević Maša	SER-SAG-S2 In-Kind Contribution to Vera Rubin Observatory: Follow-up Observations with the 1.4-m Milanković Telescope
17:45 - 18:00	Talk	Jurkić Tomislav	Supercomputer Bura as part of the Croatian In-Kind Contribution to Rubin/LSST: Supporting Data-Intensive Astronomy and Scientific Collaboration
18:00 - 18:15	Talk	De Bonis Natale	Multi-Head ALNP: An Attentive Latent Neural Process for AGN light curve reconstruction and parameters inference
18:15 - 18:30	Talk	Spasojević Nemanja	Simulating Interstellar Object Detections with the Rubin Observatory LSST
18:30 - 18:45	Talk	Aleksić Jovan	Beyond the survey: Complementary activities in the Rubin observatory framework
18:45 - 20:00	Welcome reception		
Tuesday 6 Oct			
S5 · Extragalactic astronomy & cosmology (chair: Luka Popović)			
9:00 - 10:00	Plenary	Ho Luis	Supermassive Black Holes at Cosmic Dawn
10:00 - 10:15	Talk	Mićić Marko	Feeding the Little Monster: An Accreting Intermediate-Mass Black Hole In A Minor Merger
10:15 - 10:30	Talk	Pleasri Majda	Thief Galaxy Groups: Signatures of Cluster Passage

10:30 - 11:00	Coffee break		
S5 · Extragalactic astronomy & cosmology (chair: Stanislav Milošević)			
11:00 - 11:30	Invited	Bešlić Ivana	Mapping the Multi-phase Baryon Cycle in Cool-Core BCGs with JWST/MIRI
11:30 - 11:45	Talk	Klopić Kristina	HI flows inside and around nearby late-type galaxies
11:45 - 12:00	Talk	Chugunov Ilia	The nature of spiral structure in NGC 783 inferred from colour gradients in arms
12:00 - 12:15	Talk	Lalović Ana	Constant Rotation Velocity Approximation
12:15 - 12:30	Talk	Grozdanović Marko	The search for optical counterparts to isolated FASHI HI sources
12:30 - 14:00	Lunch break		
S5 · Extragalactic astronomy & cosmology (chair: Djordje Savić)			
14:00 - 14:30	Invited	Stalevski Marko	Blue excess hot DOGs and their link to local AGN
14:30 - 14:45	Talk	Bon Edi	Probing Broad Line Region Physics Active Galactic Nuclei
14:45 - 15:00	Talk	Kouzis Marios	A magnetically-supported disk-corona model for Changing-Look AGN transitions
15:00 - 15:15	Talk	Karlica Mile	On The Modelling of Gamma Ray Burst Spectra Within Nonhomogeneous Astrophysical Radiators Paradigm
15:15 - 15:30	Talk	Egorov Andrei	Multiwavelength detection prospects for annihilating heavy WIMP dark matter around M31*
15:30 - 16:00	Coffee break		
S5 · Extragalactic astronomy & cosmology (chair: Ana Lalović)			
16:00 - 16:15	Talk	Milošević Stanislav	Dynamical properties of spiral galaxies as a signature of satellite galaxy tidal disruption
16:15 - 16:30	Talk	Jovanović Milena	Estimating Baryonic Specific Angular Momentum from Stellar Kinematics
16:30 - 16:45	Talk	Marchuk Alexander	The edge-on galaxies in the DESI survey: EGIDE project
16:45 - 17:00	Talk	Bilek Michal	Predicting the gravitational fields of low-surface-brightness spheroids
17:00 - 17:15	Talk	Milošević Milan	MCMC Parameter Estimation for Inflationary Cosmological Models
17:15 - 17:30	Flash talks		Poster session S1
17:30 - 18:00	Flash talks		Poster session S5

Wednesday 7 Oct

S5 · Extragalactic astronomy & cosmology (chair: Zarija Lukić)

9:00 - 9:45	Plenary	Sejnak Uroš	Using AI to advance understanding of our universe
9:45 - 10:15	Invited	Salak Dragan	Molecular outflows at high redshift probed by absorption lines
10:15 - 10:30	Talk	Savchenko Sergey	How to Decompose Thousands of Galaxies: A Template-Based Approach
10:30 - 11:00	Coffee break		

S3 · Solar, stellar physics & the ISM (chair: Dušan Vukadinović)

11:00 - 11:30	Invited	Damiani Cilia	PLATO: Terrestrial planet hunter
11:30 - 11:45	Talk	Latković Olivera	Spot migration and eclipse time variations in close binaries
11:45 - 12:00	Talk	Dakić Vinka	Supernova explosions of runaway stars and young neutron stars above the Galactic plane
12:00 - 12:15	Talk	Kubátová Brankica	Clumped Winds of Massive Hot Stars and Their Impact on Mass-Loss Determinations
12:15 - 12:30	Talk	Kubát Jiří	Spherically symmetric NLTE model atmospheres: from first stars to clumped hot dwarfs
12:30 - 14:00	Lunch break		

S3 · Solar, stellar physics & the ISM (chair: Dejan Urošević)

14:00 - 14:30	Invited	Raymond John	Radiative Shocks in SNRs: Magnetic Fields and Cosmic Rays
14:30 - 15:00	Invited	Arbutina Bojan	Radio evolution of supernova remnants
15:00 - 15:15	Talk	Knežević Slađana	Complex Balmer-Line Structure in SNR 0509-67.5: Tracing Shock Precursors
15:15 - 15:30	Talk	Zeković Vladimir	Igniting Fast Cosmic-Ray Acceleration via Non-Linear Structures at High-Mach-Number Shocks
15:30 - 16:00	Coffee break		

S3 · Solar, stellar physics & the ISM (chair: Bojan Arbutina)

16:00 - 16:15	Talk	Jelić Vitor	The multiphase interstellar medium observed at low-radio frequencies
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S6 · Interdisciplinary studies

16:15 - 16:30	Talk	Veselinović Nikola	Ground-Based Muon Observations of Solar Activity and Space Weather: The Belgrade Muon Station and the gLOWCOST Network.
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16:30 - 16:45	Talk	Nina Aleksandra	Noise reduction of VLF signal amplitude as earthquake precursor: statistical study
16:45 - 17:30	Flash talks		Poster session S3 and S6
20:00	Conference dinner		
Thursday 8 Oct			
S1 · Astrometry, dynamical astronomy & planetology			
9:00 - 9:15	Talk	Jovanović Miljana D.	Linking Gaia CRF with ICRF by means of V and R magnitudes of selected quasars
9:15 - 9:30	Talk	Milić Žitnik Ivana	A systematic survey of the von Zeipel–Lidov–Kozai resonance across the Solar System: from inside Jupiter's orbit to the trans-Neptunian region
9:30 - 9:45	Talk	Knežević Nikola	A Candidate Very Young Pair of Small Near-Earth Asteroid
9:45 - 10:00	Talk	Gavrilović Marko	Modeling the Yarkovsky Effect for Tumbling Asteroids
10:00 - 10:15	Talk	Janković Marija	Properties of extrasolar planetesimal belts from ARKS
10:15 - 10:30	Talk	Dujko Saša	Lightning on the exoplanet K2-18b
10:30 - 11:00	Coffee break		
S6 · Interdisciplinary studies (chair: Ivan Milić)			
11:00 - 11:30	Invited	Mitrašinović Ana	Beyond the Galactic Habitable Zone: A contemporary view of galactic habitability
11:30 - 11:45	Talk	Žižak Teodora	Prve galaktičke mape planetarnih sistema
11:45 - 12:00	Talk	Lukić Dragan	Architecture of Directed Panspermia: Synthesis of Orbital Interception and Mechanical Protection of Biological Cargo during Hypervelocity Impacts
12:00 - 12:15	Talk	Konstantin Jasmina	Exoplanet detection from stellar light curves using recurrent and transformer-based deep learning models
12:15 - 12:30	Talk	Oleg Yakovlev	CubeSat missions dedicated to astronomical research
12:30 - 14:00	Lunch break		
S7 · History of astronomy, education & outreach (chair: Milica Andjelić)			
14:00 - 14:15	Talk	Tomić Zoran	The importance of Serbia's inclusion in international space research initiatives
14:15 - 14:30	Talk	Rovčanin Branislav	The results of light pollution questionnaire in the territory of Belgrade
14:30 - 14:45	Talk	Mijatović Vesna	Наука у култури: разматрање могућности унапређења едукативно-културних програма у Астрономској опсерваторији у Београду

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 Department of Astronomy, Faculty of Mathematics, 2026

14:45 - 15:00	Talk	Baucalo Katarina	Department of Astronomy at Petnica Science Center: 2024-2026
15:00 - 15:15	Talk	Stanković Miloš	Activities of the Eureka Astronomical Society on the promotion of astronomy 2023 - 2026
15:15 - 15:30	Talk	Todorović Nataša	Sećanje na Vojislavu Protić Benišek
15:30 - 16:00	Coffee break		
Poster session and closing (chair: Milica Andjelić)			
16:00 - 16:45	Flash talks		Poster session S6 and S7
16:45 - 17:00	Closing remarks		
17:00 - 18:30	Assembly		Assembly (Skupština Društva astronoma Srbije)

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