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XV SERBIAN CONFERENCE ON SPECTRAL LINE SHAPES IN ASTROPHYSICS

Niš, Serbia, June 9-13, 2025

BOOK OF ABSTRACTS

Editors: Paola Marziani, Milan S. Dimitrijević, Luka Č. Popović and Đorđe V. Savić

БЕОГРАД 2025
BELGRADE 2025

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TOGETHER WE ARE STRONGER: SYNERGIES IN ASTROPHYSICS AND AI TO ADVANCE OUR UNDERSTANDING OF THE UNIVERSE

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The Vera C. Rubin Observatory will capture the night sky in a way never before possible – in four dimensions – and will offer insight into more of the universe than any previous mission. Over the course of ten years, it will track changes in the universe over time, from objects in the Solar System and stellar explosions to the most distant galaxies.This unique dataset will become a kind of legacy of humanity – a record of the night sky as it appears today, before numerous artificial satellites change it forever.The project has spurred numerous technological innovations, including the construction of the largest camera ever built. This camera will capture up to 1,000 images every night, each containing more than 3 billion pixels. To display just one of these images in full resolution, it would take as many as 3,500 HD televisions.Alongside engineering feats, the scientific community is increasingly applying artificial intelligence to enhance the understanding of the night sky and open the door to new discoveries about the universe.

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Fe II REVERBERATION MAPPING IN NGC 5548

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Reverberation mapping (RM) is a powerful technique used to probe the geometry and kinematics of the broad-line region (BLR) in active galactic nuclei (AGN). By measuring the time delay (lag) between fluctuations in the continuum emission and the response in emission lines, we can estimate the size of the BLR and infer black hole masses. While Hβ RM is well established, Fe II RM is more challenging due to the complexity of the Fe II emission blends. NGC 5548 is one of the most extensively studied AGNs and serves as a benchmark for RM studies. Using a decade-long Fe II and continuum lightcurves from archival spectroscopic monitoring we find that the Fe II lags range from 43 to 58 days, consistently longer than the Hβ lags (which range from about 5 to 26.5 days). The Fe II reverberation mapping in NGC 5548 confirms the existence of a delayed Fe II response, which implies that the Fe II emitting region lies at the outskirts of the BLR.

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SPECTRAL ENERGY DISTRIBUTION MODELING OF BROAD EMISSION LINE QUASARS: FROM X-RAY TO RADIO

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We study the differences in physical properties of quasar-host galaxies using an optically selected sample (SDSS DR7) of radio loud (RL) and radio quiet (RQ) quasars in the redshift range $0.15 < z < 1.9$, which we have further cross-matched with the VLA-FIRST survey catalog. The sources in our sample have broad Hβ and Mg II emission lines ($1000\,\mathrm{km/s} <$ FWHM $< 15000\,\mathrm{km/s}$) with a subsample of high broad line quasars (FWHM $> 15000\,\mathrm{km/s}$). We construct the broadband spectral energy distribution (SED) of our broad line quasars using multi-wavelength archival data and targeted observations with the AstroSat telescope. We use the state-of-the-art SED modeling code CIGALE v2022.0 to model the SEDs and determine the best-fit physical parameters of the quasar host galaxies, namely their star-formation rate (SFR), main-sequence stellar mass, luminosity absorbed by dust, e-folding time, and stellar population age. We find that the emission from the host galaxy of our sources is between 20%–35% of the total luminosity, as they are mostly dominated by the central quasars. Using the best-fit estimates, we reconstruct the optical spectra of our quasars which show remarkable agreement in reproducing the observed SDSS spectra of the same sources. We plot the main-sequence relation for our quasars and note that they are significantly offset from the main sequence of star-forming galaxies. Furthermore, the main sequence relation shows a bimodality for our RL quasars indicating populations segregated by Eddington ratios. We also examine the relation between host galaxy and AGN properties. We conclude that RL quasars in our sample with lower Eddington ratios tend to have substantially lower star-formation rates for similar stellar mass. Our analyses thus provide a completely independent route for studying the host galaxies of quasars and addressing the radio dichotomy problem from the host galaxy perspective.

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LINE-LOCKED OUTFLOWS FROM QUASARS

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Quasar surveys reveal a high fraction of kinematically coupled metal-rich narrow absorption-line (NAL) systems with a velocity difference that corresponds to the wavelength separation of the CIV (1548Å, 1550Å) doublet members. This phenomenon, termed line-locking, reflects on the role of radiation-pressure force in driving astrophysical outflows, but its implications for their physics have been largely overlooked. In this talk we present the conditions for line locking to occur, and find that driving forces other than radiation pressure force (e.g., drag forces, cosmic-rays) are likely negligible. Further, extreme fine-tuning of the properties of the line-locked kinematic systems seems to be implied, which challenges most theories for cloud and outflow formation with implications for quasar feedback. It is argued that quasars must have largely evacuated their gaseous environs for line-locking to operate. We explore the possibility that line-locked NAL systems are tracers of individual (unmixed) circumstellar envelopes, and that a detailed study of their composition and dust content can shed light on the physics of their progenitors over a wide range of redshifts. Pending theoretical challenges associated with line-locked systems will be highlighted, and implications for the general phenomenon of quasar outflows will be discussed.

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CALCULATION OF PASCHEN LINES FOR ASTROPHYSICAL AND FUSION PLASMAS

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Paschen lines allow interesting spectroscopic diagnostics in the near infrared region of astrophysical, laboratory and fusion plasmas. The shapes of Paschen lines are mainly influenced by Stark broadening, which increases with the principal quantum number. In astrophysics, the Paschen gamma ($P\gamma$) and Paschen delta ($P\delta$) lines are commonly employed as diagnostic tools in standard stars of spectral types B to M, serving as benchmark for validating and refining model stellar atmospheres [1]. In tokamaks, particularly in the JET divertor, Paschen lines help diagnose the plasma properties [2]. We first present Paschen line calculated with the line shape code PPP [3], which retains ion dynamics effects with the frequency fluctuation model [4]. The main broadening mechanisms affecting the Paschen lines will be discussed for plasma densities between 10^{19} and 10^{21} m^{-3}. We are also currently interested in diagnosing fusion plasmas through the first Paschen lines of hydrogen in the presence of an oscillating electric field. The Paschen beta ($P\beta$) line of hydrogen in the experimental conditions of the spherical tokamak QUEST in Kyushu (Japan) has been measured in the presence of an electron cyclotron heating microwave beam. Additionally, the $P\beta$ line of deuterium will be measured on the Heliotron J at Kyoto University in the presence of a radio frequency wave. In the observation region, the plasma has a temperature on the order of 100 eV and an electron density of $5 \text{x} 10^{18}$ m^{-3}. Line shapes obtained by a numerical simulation of the plasma microfield, and a numerical integration of the emitter Schrödinger equation [4], will be presented for a future comparison with the line shapes measured in the fusion devices.

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PROBING ACTIVE GALACTIC NUCLEI VARIABILITY ACROSS TIME AND SPACE WITH LSST

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The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) begins full operations this year, initiating an unprecedented era for time-domain astrophysics. In this light, we present a framework for probing Active Galactic Nuclei (AGN) variability with the Vera C. Rubin Observatory's LSST, grounded in theoretical scaling relations and realized through two novel software tools. Motivated by self-organized criticality (SOC), we aim to characterize both periodic and stochastic components of AGN variability across a broad range of black hole masses and redshifts. The framework includes QhX (Quasar harmonic eXplorer), a nonlinear tool for detecting multi-periodic and emergent structures in red noise, and QNPy (Quasar Neural Process in Python), a probabilistic model that reconstructs

light curves and infers transfer functions across irregular cadences using context-aware latent representations. The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) begins full operations this year, ushering in an unprecedented era for time-domain astrophysics.We systematically evaluate the impact of LSST and ZTF-like cadences on the fidelity of light curve recovery, transfer function inference, and latent space clustering. Performance metrics (negative log likelihood, mean square error) across bands demonstrate robustness to survey strategy, enabling more flexible application of diverse cadence modes without compromising model performance. We further present cadence-informed detectability maps for supermassive black hole binaries, highlighting the regions of orbital parameter space where periodic variability is recoverable across mass ratios and eccentricities. Using QhX, we demonstrate the detection of both real and injected sinusoidal signals and identify off-diagonal structures in frequency-frequency correlation matrices, which reveal signatures of resonances, chirping, and disk–binary coupling. This framework is the cadence-robust analysis pipeline and supports LSST's mission to uncover the multi-scale dynamics of black hole accretion.

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ARTIFICIAL INTELLIGENCE APPLIED TO PLASMA SPECTROSCOPY

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Artificial intelligence is now deeply integrated across nearly all fields including plasma physics [1, 2, 3] and more generally plasma science [4]. The field of plasma spectroscopy is no exception and there are many examples witnessing the evolution of this scientific practices. The integration of machine or deep learning methods (ML/DL) in plasma spectroscopy may have various purposes including real-time inference of plasma dynamics in magnetic fusion devices or the prediction of the plasma parameters [5]. In this paper, I will present a short review of the various applications of machine-learning and deep-learning algorithms in the field of plasma spectroscopy with a focus on magnetic fusion plasmas. I will also report on our own work related to the use of neural networks such as Convolutional Neural Networks to theoretical Balmer-α line spectra emitted by hydrogen isotopes for the hydrogen isotopic ratio prediction for Tokamak plasmas [6].

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STUDY OF THE IONIZED GAS IN AND AROUND GALAXIES WITH MANGAL EMISSION LINES MAPPER

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The tunable filter photometer MaNGaL (Mapper of Narrow Galaxy Lines) is operating at the 2.5-m telescope of the Moscow State University since November, 2017. The instrument is based on the scanning Fabry-Perot interferometer, that is a sort of low-resolution large-field 3D-spectroscopy providing continuum-free images in the selected emission lines. I briefly review the main scientific results obtained with this device in the study of ionized gas properties related with star-forming and active galaxies.

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PROBING SUPERMASSIVE BLACK HOLES IN DISTANT QUASARS WITH PHOTOMETRIC REVERBERATION MAPPING IN THE RUBIN ERA

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Reverberation mapping accurately determines virial black hole masses for redshifts z < 0.2 using the relationship between the Hβ broad-line region (BLR) size and the 5100 Å continuum luminosity established with $\gtrsim$ 200 AGNs. For quasars at z $\sim$ 2-3, determining the BLR size is time-consuming and limited by seasonal gaps, requiring $\sim$ 10-20 years of monitoring C IV emission lines. In this work, we demonstrate that an efficient alternative is to use a continuum size-luminosity relation, which can be obtained up to 150 times faster using photometric reverberation mapping (PRM). We outline the method and its feasibility based on simulations and propose an observational strategy that can be carried out with ground-based meter-class telescopes equipped with narrow and medium-band filters. As a case study, we focus on the ESO La Silla 2.2 meter telescope observations with a well-defined sampling rate which recovers our predictions - a testament to the validity of our scaling relation. These observations provide the scaling factor between the accretion disk and the C IV-based BLR sizes, which is (1) crucial for estimating the masses of black holes at higher redshifts extending beyond the cosmic noon, (2) evaluating the contribution of the diffused continuum emission and assessing the standard accretion disk theory, and, (3) validating quasars as cosmological distance indicators and bridge the gap between the local and early Universe. I will also highlight some recent advances in preparation for Rubin's first light and a sneak-peak on Gemini/SCORPIO - an 8-channel imager and spectrograph poised to be the workhorse for Rubin's follow-up.

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STARK BROADENING IN SOLID-DENSITY PLASMAS: A COMPUTATIONAL APPROACH

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The generation of solid-density plasmas using free-electron lasers opened up the possibility of experimentally studying the atomic structure of these extreme systems. While much successful work has been done on this topic the shape of the spectral lines emitted under these conditions has not been thoroughly studied. This is owed, in part to the fact that most transitions are very short-lived (fs scale), and their lifetime is dictated by intra-atomic processes such as Auger decay, which makes the use of typical line-shape approaches inadequate. In this work, we focus on the Heα emission of a solid-density Mg plasma generated at the LCLS. Recent work (Pérez-Callejo et al., 2024) showed that this line is emitted from a plasma in local thermodynamic equilybrium (LTE), which makes traditional lineshape models applicable. We present results using the standard theory of the Stark effect as well as Molecular Dynamics simulations, both methods adapted to study a crystalline plasma, where the ionic structure needs to be carefully considered. The results are compared with the experimentally-measured lineshape and the influence of different broadening mechanisms is discussed.

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SPECTROSCOPIC DIVERSITY OF ASTROPHYSICAL TRANSIENTS

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Astrophysical transients are objects that change brightness on human-observable timescales, including events such as stellar explosions (supernovae, SNe) and the tidal disruption of stars by supermassive black holes (TDEs). These phenomena exhibit diverse spectroscopic signatures that reveal their physical mechanisms and environments. Searches and observations of transients are driven by their exceptional value for both astrophysical and cosmological studies. Most notably, Type Ia supernovae (SNe Ia), with their standardizable light curves, have been used as distance indicators, leading to the discovery that the expansion of the Universe is accelerating. TDEs offer a valuable probe into the otherwise dormant supermassive black holes at the centers of galaxies; their spectra are typically dominated by broad emission lines of hydrogen, helium, and occasionally high-ionization species. I will also discuss the emerging field of gravitationally lensed supernovae, which provide powerful astrophysical and cosmological insight. When a supernova is strongly lensed by a foreground galaxy or cluster, the light from the background explosion is magnified—enabling the detection of distant SNe that would otherwise remain undetected. These events can produce multiple images with time delays, allowing for spectroscopic studies of the same explosion at different phases and enabling time-delay cosmography—a method to constrain the Hubble constant independently from standard probes. I will conclude by anticipating what we can expect in the near future from upcoming wide-field surveys, such as those by the Vera C. Rubin Observatory and the Nancy Grace Roman Space Telescope.

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CALCULATION OF PASCHEN LINES FOR ASTROPHYSICAL AND FUSION PLASMAS

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A selection of problems related to the modeling of Stark broadening is considered, for astrophysical and laboratory plasma diagnostic applications. At the atomic level, a proper description of a line shape requires the ion microfield evolution be accounted for during the time of interest of the transition under consideration; this is the so-called ion dynamics issue. In addition, the lines presenting a structure such as Hβ can exhibit an asymmetry due to presence of multipolar interactions, which is significant at high density regimes and must be retained in calculations. Some observed spectra from magnetized plasmas also exhibit lines with a Zeeman triplet structure due to both linear and quadratic terms in the Hamiltonian, which must also be retained in calculations. We provide a review of these problems and present new spectra calculations. A focus is put on plasma conditions relevant to stellar atmospheres, magnetic fusion experiments, and magneto-inertial fusion experiments carried out in laboratory. Features that are common to each of these plasmas (e.g., the plasmas can have the same electron density range) are discussed. We present calculations and also report on line shape fittings which have been performed for diagnostic applications.

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THE AGN CONTENT IN EROSITA/DR1 AND THE SPECTROSCOPIC FOLLOW-UP

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Galaxy evolution can only be understood if its AGN phases are accounted for. For that, a complete and pure census of AGN is needed. Hunting for AGN in X-ray is the most obvious way to go, given the low emission from galaxies at this frequency. In the last 20 years, XMM and Chandra have provided us mostly with pencil-beam surveys, thus sampling the faint and high-redshift regime. Finally, with eROSITA, we can also sample the rare (local and z>5.5) and faint Universe. In my talk, I will review the multi-wavelength properties (including redshifts) of the first eROSITA AGN sample and compare them with AGN selected from other surveys.

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THE LINESHAPE DATABASE PROJECT

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Lineshape calculations rely on complex numerical codes, consuming substantial computational resources. This is particularly true for computer simulation methods [1].

No standard format exists for exchanging these data. Furthermore, these complex lineshapes cannot be easily interpolated. However, such an interpolation is frequently required in practice, for example, to obtain the best fit of an experimental spectrum. Accounting for a distribution of plasma parameters (e.g., due to fluctuations driven by turbulent motion) leading to non-trivial lineshapes [2] increases the number of calculations required.

A fast interpolation procedure is needed to generate a line profile based on a limited number of pre-calculated lineshapes. While this can be done relatively easily in specific applications [3], it is not feasible in more general cases. Although there are some in-house software solutions designed for this purpose [4], they have not been widely adopted. This work aims to develop open-source tools to address these challenges and to be useful and used by both theoreticians and experimentalists.

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PROGRESS REPORTS

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GREEN BEAN GALAXIES AND THE FADING ECHOES OF AGN ACTIVITY

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“Green bean” galaxies, thought to be remnants of quasar ionisation, are extended ionised clouds detected in the SDSS sky survey at redshifts up to $z \sim 0.2{-}0.6$. They appear elongated and have a bright green colour in optical images. We present observations of a sample of these galaxies obtained with the Russian 6-m telescope, utilizing both long-slit spectroscopy and 3D spectroscopy with scanning Fabry-Perot interferometer. While their characteristic green colour may be explained by [O III] $\lambda5007$ line emission redshifted into the r-filter, the origin of their gas reservoirs and the accretion histories of radio-emitting remain poorly understood. Our study focuses on ionisation properties, kinematics, and morphology of the external gaseous clouds, with particular attention to spatial variations in line ratios and velocity structures. Furthermore, we investigate the relation between the ionized gas systems and synchrotron radio emission, probing whether they exhibit signatures of past or ongoing jet activity. This allows us to explore the phases of AGN activity cycles, including possible transitions between “on” and “off” states, and the role of radio feedback in shaping the ionised gas.

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TRACING SUPER MASSIVE BLACK HOLE CANDIDATES VIA THE MAIN SEQUENCE OF QUASARS

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The Main Sequence (MS) of quasars, characterized by well-defined correlations among emission line properties, Eddington ratios, and spectral features, offers a robust framework for identifying outliers that may harbor supermassive binary black holes (SMBBHs). In this study, we explore the use of quasar MS diagnostics, particularly deviations in line shifts, widths, and ionization indicators, as potential signatures of binary systems embedded in active galactic nuclei (AGN). SMBBHs can perturb the dynamics of the broad-line region (BLR). Ultimately, this method can refine our understanding of BLR structure in complex AGN systems and provide a pre-selection strategy for follow-up observations and gravitational wave precursor studies. Although SMBBHs are widely predicted as natural outcomes of galaxy mergers and play a crucial role in galaxy evolution, gravitational wave generation, and accretion physics, electromagnetic observational confirmation remains challenging. To date, only a limited number of robust candidates have been identified. In this work, we present effective observational strategies and key astrophysical environments conducive to the detection of SMBBHs, with a particular emphasis on diagnostic features in broad Balmer emission lines. We also introduce an initial analysis of a flux-limited sample of quasars exhibiting evolved spectral properties within the quasar main sequence, focusing on sources belonging to the B1 population, where SMBBH related signatures may be more prominent or dynamically amplified.

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ANALYSIS OF STARK BROADENING PARAMETERS OF N II SPECTRAL LINES

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We propose a study of Stark broadening parameters of N II spectral lines. The conditions of interest cover wide temperature interval (from 5 000 K to 200 000 K) and a perturber density of 10^{17} cm^{-3}, suitable for astrophysical applications, laboratory diagnostics and for proton-boron fusion plasma research. The interactions that broad the spectral lines include particles as electrons, protons, alpha particles and boron ions in different stages of ionization. Recently, many experimental and theoretical studies are dedicated to proton-boron nuclear fusion which delivers energy with several significant advantages (Belloni, 2022).

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INTERACTION OF THE RELATIVISTIC JET AND THE NARROW-LINE REGION OF PMN J0948+0022

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In the study of active galactic nuclei (AGN), some sources have been extensively observed across various epochs and wavelengths. PMN J0948+0022 is one such source, displaying significant multiwavelength variability that has provided valuable insights into AGN structure and contributed to our understanding of this entire class. Initially, PMN J0948+0022 was classified as a jetted Narrow-Line Seyfert 1 (NLS1) galaxy. However, recent observations have revealed a different profile for the Hβ line, characteristic of Intermediate Seyfert galaxies (IS). After verifying the robustness of this profile change, we conducted a standard analysis of the SDSS, X-Shooter, and MUSE spectra of the source. Our analysis indicated a more significant variability in the narrow-line region (NLR) compared to the broad-line region (BLR), which we interpreted as an interaction between the NLR and the relativistic jet. These findings provide new insights into the changing-look AGN phenomena, illustrating how different AGN classes can be interconnected and enhancing our understanding of AGN evolution.

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ON THE STARK BROADENING OF Sn III SPECTRAL LINES

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Spectral lines of tin are present in stellar spectra, so that the corresponding data on Stark broadening are of interest for their analysis and modeling, as well as for abundance determination, atmosphere modeling, etc., especially for white dwarfs and A and late B type stars. Our choice of Sn III is additionally motivated by the paper of Ganeev (2023) who stated that for development of techniques for high-order harmonics generation (HHG) in ablated materials is very important diagnostics of laser-induced and other plasmas. He also underline the significance of the metal elements from the fifth period of the periodic table, where also tin belongs, as good targets for optimal laser-induced plasma formation. Consequently, tin may be a promising plasma medium for HHG, particularly when laser-induced breakdown spectroscopy is used. In order to satisfy the need for Stark broadening data of Sn III, we calculated Stark line widths and shifts due to collisions with electrons, protons and ionized tin for 19 Sn III spectral lines, by using the semiclassical perturbation theory. Results are compared with existing theoretical and experimental results.

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ON THE STARK BROADENING OF N V SPECTRAL LINES

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Spectral lines of N V are present in white dwarf spectra, where the collisions with charged particles are important, so that the corresponding data on Strak broadening are of interest for identification, analysis and synthesis of N V lines in their spectra, as well as for abundance determination of nitrogen etc. An additional stimulation for the choice of N V spectral lines is their interest for proton-boron fusion. Namely, in investigations of p-B fusion target is often BN (see e.g. Margarone et al., 2014), so that Stark broadening data for spectral lines of nitrogen ions are of interest for investigation, modelling and diagnostics of proton-boron fusion plasma. In order to satisfy such needs we calculated, using the semiclassical perturbation theory (Sahal-Bréchot et al., 2014), Stark broadening parameters for 30 N V spectral lines, broadened by collisions with alpha particles, B III, B IV, B V and B VI ions, for a grid of temperatures and densities. Stark broadening parameters of these lines, broadened by collisions with electrons, protons and ionized helium, have been calculated in Dimitrijević and Sahal-Bréchot (1992), but only up to T = 500.000 K what is not enough for the p-B fusion experiments (see e.eg. Magee et al., 2023). Here, we also extended these calculations to higher temperatures of interest for p-B fusion. Here we will present the obtained results and discuss their applications.

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AN AUTOMATIC MOLECULAR LINE IDENTIFICATION USING MILLIMETER OBSERVATIONS

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Observations conducted with modern telescopes in the sub- and millimeter range have provided key insights about processes within star-forming regions. These instruments deliver high-resolution ($\lambda/\Delta\lambda = 10^7$) spectra across broad bandwidths, revealing a dense forest of molecular emission lines which can serve as tracers of kinematic, physical, and chemical conditions in sources. Line profiles can provide information about gas dynamics and excitation mechanisms.

The identification of emission lines requires rigorous cross-matching of observed frequencies with laboratory spectroscopic catalogs, while accounting for source-specific excitation conditions. To address this, we developed an automated line identification pipeline. In this pipeline we applied a consecutive Gaussian fitting algorithm to determine the observed central frequencies of emission lines and a procedure to automatically cross-match these values with entries in molecular spectroscopic databases (CDMS and JPL). In six observational spectra toward the young stellar object we resolved >400 emission lines, attributing 99% to rotational transitions of SO, OCS, SiO, HCO, H_2CO, SO_2, H_2CS, complex organic molecules CH_3OH, CH_3CCH and CH_3CN ladder transitions, CH_3OCH_3, CH_3OCHO, CH_3CHO, C_2H_3CN etc. We found up to 9-atom molecules like C_2H_5CN, isotopologues $^{13}CH_3OH$, $S^{33}O$, $S^{33}O_2$, $S^{34}O$, $OC^{34}S$, $H_2C^{33}S$, $H_2C^{34}S$ and deuterated species like HDO. Application of this pipeline reduced spectral line analysis time from $\sim$40 hours per spectrum (manual processing) to $<$10 minutes, achieving a limit of $\geq 5\sigma$ for line detections. This work was supported by RSF grant 24-22-00097.

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Mg II LINE PROFILE VARIABILITY IN SDSS J2320+0024: CLUES TO A BINARY SUPERMASSIVE BLACK HOLE

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Supermassive binary black holes (SMBBH) are expected to form during galaxy mergers, but direct confirmations remain challenging, especially at sub-parsec separations. Indirect signatures, such as periodic variability in quasar light curves and evolving spectral line profiles, offer promising alternatives for identifying such candidates.

We carried out a search for long-period (100–600 days) variability in quasars using high-precision (1–2%) gri photometry from the SDSS Stripe 82 survey, spanning six years. Periodic candidates were identified through Lomb-Scargle analysis and cross-matched with ZTF and Pan-STARRS data, extending the light curve baseline to over 20 years. All five final candidates were confirmed quasars, with the most promising one (P = 278 days) also flagged as variable in the Chandra X-ray catalog.

To investigate the nature of the top candidate, we analyzed three epochs of Mg II spectra, combining new observations with archival SDSS data. The line profile reveals a time-evolving double-peaked structure, suggesting dynamic changes in the broad-line region. To interpret this behavior, we compared synthetic magnitudes with photometric data and applied the PoSKI model. The results are consistent with the presence of a compact supermassive binary black hole system — a scenario of particular interest for understanding black hole coalescence and future gravitational wave emission.

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PROBING KEPLERIAN ROTATION IN QUASARS USING MICROLENSING-INDUCED LINE PROFILE DISTORTIONS

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Direct observational evidence regarding the kinematics within the regions emitting the characteristic broad emission lines (BELs) in active galactic nuclei and quasars remains scarce. Gravitational microlensing, induced by compact stellar-mass objects in lens galaxies, introduces distortions in quasar BEL profiles, providing a unique opportunity to probe the innermost regions of distant quasars. Here, I present a novel method for deriving rotation curves at light-day spatial scales in gravitationally lensed quasars by analyzing microlensing-induced changes in the wings of high-ionization ultraviolet emission lines. Employing Bayesian techniques, I measure the sizes of the emission regions and test whether the observed velocity-dependent microlensing effects are consistent with a Keplerian disk model. The results reveal a smooth, monotonic increase in magnification with velocity, strongly supporting the Keplerian rotation of an inclined disk. This study provides the first direct observational evidence of Keplerian rotation within quasar inner regions, covering radial distances from approximately 0.5 to 20 light-days.

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X-RAY SPECTROSCOPY OF FILAMENTS IN CYGNUS LOOP SUPERNOVA REMNANT

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Relativistic jets are among the most important players in the feedback processes between active galactic nuclei (AGN) and their host galaxies. By propagating through the interstellar medium, they can transfer part of their energy into the gas and heating it up, or produce compression shocks that eventually induce star formation. In a few cases, during relativistic jets' flares, the innermost part of the AGN seems to be affected. The broad-line region (BLR), indeed, can respond to the flares, by increasing (or decreasing) the line luminosity. To date, only a handful of sources have shown this behavior, mostly powerful flat-spectrum radio quasars, such as CTA 102, 3C 454.3, and 3C 345. However, this phenomenon was recently observed for the first time in a jetted narrow-line Seyfert 1 galaxy, PKS 2004-447. The source underwent a gamma-ray flare in 2019, which altered the BLR and produced a flux excess redshifted by 250 km/s, and observed by the X-shooter instrument in the Balmer, Paschen, and He I permitted lines. This new emission feature was no longer visible 1.5 years later, suggesting a causal connection with the flare. The emission lines coming from the same atomic transition series show a similar velocity offset for this "red excess", but the offset changes for different line series. This discovery suggests that the relativistic jet can affect the physics of the BLR in all classes of jetted AGN, and that flaring activity can lead to the formation of additional and localized broad emission components. Our results highlight the importance of optical spectroscopy for flaring jetted AGN, and that our understanding of the jet-BLR -connection is still very limited.

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RYDBERG ATOMS IN ASTROPHYSICAL PLASMAS: MODELING AND DATA RESOURCES

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The dissociative recombination (DR) of the NS^+ molecular ion with free electrons is a pivotal reaction in interstellar chemistry and laboratory plasma modeling, influencing the abundance and lifetimes of nitrogen- and sulfur-bearing species. In this work, we present a detailed analysis of the NS^+ DR process, with a particular focus on the indirect mechanism mediated by Rydberg states of the neutral NS molecule. Utilizing a hybrid approach that combines semi-empirical modeling and multichannel quantum defect theory (MQDT), we simulate the electron energy-dependent cross section by incorporating contributions from multiple Rydberg series converging to the NS^+ ionization threshold. Each resonance is modeled via the Breit–Wigner formalism, accounting for capture widths, predissociation rates, and autoionization lifetimes. Recent experimental findings on the Rydberg structure of NS are integrated to refine quantum defect parameters and validate energy level placements. Our results highlight the dominant role of low-lying Rydberg resonances in enhancing the DR cross section at sub-electronvolt energies, underscoring their significance in both astrophysical and controlled plasma environments. The implications of this study extend to improved kinetic models in molecular clouds and reactive plasma simulations.

Keywords: dissociative recombination, Rydberg states, Breit–Wigner resonance, quantum defect theory, interstellar chemistry, plasma kinetics, electron–molecule collisions.

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INVERTIGATING THE ORIGIN AND TRANSPORT OF WATER IN THE UNIVERSE USING SUBMILLIMETER AND MILLIMETER SPECTRAL LINES

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The formation of water in the Universe attracts significant scientific interest, as this molecule is fundamental to all known life. Water emissions are observed throughout the Universe: from our Solar System to distant high-redshift galaxies. Previous space-based infrared telescopes performed extensive observations of water emission lines, enabling researchers to identify the primary formation pathways for both water and its isotopes. Thanks to the high spatial (hundreds to thousands of AU) and spectral (resolutions up to $\sim 10^7$) resolution of these observations, we have been able to pinpoint specific regions where water forms in galactic star-forming environments and constrain the physical conditions governing this process. Results obtained from studying nearby objects are now being extrapolated to distant high-redshift galaxies.

With ground-based telescopes we can only study emission lines from less abundant isotopes of water including deuterated species. In this conference contribution, we will present the current paradigm of water's life cycle in the Universe and share our findings on the abundance of deuterated water in star-forming regions.

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MULTI-HEIGHT PROBING OF HORIZONTAL FLOWS IN SOLAR PHOTOSPHERE USING HIGH-RESOLUTION SPECTROPOLARIMETRY

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Probing of horizontal flows refers to the ability to infer horizontal plasma motion from successive maps of photospheric intensity and/or line-of-sight magnetic field. The most commonly used method for tracking features and calculating velocities is *Local Correlation Tracking* (LCT), and its derivative FLCT (F stands for Fourier). FLCT calculates the relative displacement vector in the x, y plane between two images that makes the patterns of the two features best match each other. In this work, we test the feasibility of recovering plasma flows at multiple atmospheric heights using FLCT. Our work is based on the premise that different spectral lines probe different depths of the solar atmosphere. Namely, spectral line opacity rapidly increases as we approach the line center, with substantial changes occurring at picometer scales. Different wavelengths, experience different opacities and thus sample different layers of the solar atmosphere.

In our work, multi-height diagnostic is achieved by tracking synthetic magnetograms obtained through a robust inversion of synthetic spectropolarimetric observables in two spectral lines: Fe I 525.0 nm and Mg I b2. These two lines probe the low/mid photosphere and upper photosphere/temperature minimum, respectively. We synthesized the polarized spectra of the two lines and then obtained synthetic magnetograms using Milne-Eddington inversion for the Fe I line and weak field approximation for the Mg I line. Tracking vertical magnetic fields inferred from synthetic observations of the Fe I 525.0 nm and the Mg I b2 spectral line yields satisfactory inference for the horizontal velocities in the mid photosphere and temperature minimum ($\log \tau = -1$ to $\log \tau = -3$), respectively.

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CHANGES IN RELATIVE INTENSITIES AMONG OPTICAL Fe II LINES IN AGN SPECTRA

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We use a large sample of high-quality Type 1 active galactic nuclei (AGNs) spectra, taken from SDSS, to investigate the relative intensities among Fe II emission lines in the 4000-5600 Å range. We perform the fitting procedure using a complex Fe II template made by modifying the Fe II template given in Kovačević et al. (2010).The new template includes more parameters of freedom for Fe II multiplets, thus enabling more sophisticated analysis of the complex Fe II features. The Fe II lines were divided into two large groups: *consistent*, those whose relative intensities are in accordance with theoretical calculations following their transition probabilities, and *inconsistent*, those whose observed relative intensities are significantly stronger than theoretically expected. We found that the strength of the inconsistent Fe II lines relative to the consistent ones are correlated with the line widths and Eddington ratio. They have similar relative intensities in the spectra with narrow Fe II lines and high Eddington ratio. As spectra have broader lines and a smaller Eddington ratio, the inconsistent Fe II lines tend to have smaller intensities relative to consistent Fe II lines. In the case of spectra with very broad lines, they disappear,while consistent Fe II lines could still be strong.

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SPECTROSCOPIC ANALYSIS OF SPECIFIC ANGULAR MOMENTUM IN DISK GALAXIES

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To better understand galaxy formation and evolution, we measure their specific angular momentum, a fundamental physical property thought to be conserved. Its correlation with baryonic mass — the so-called Fall relation — holds for galaxies across a wide range of masses, sizes, and gas content. This relation is shaped by both external and internal factors, which can provide insight into galaxy evolution pathways.

Radio interferometric observations of the HI line have revealed flat rotation curves extending to very large radii, making them ideal for measuring angular momentum. However, in their absence, more detailed and reliable IFU observations can be used, provided that stellar rotation velocities, derived from IFU data, are corrected for non-circular motions. Observations have shown that in disk-like galaxies, half of the specific angular momentum (sAM) is contained within one effective radius. Consequently, the total sAM can be measured for all such galaxies using IFU spectroscopy that spans at least one effective radius. We demonstrate that for the spiral galaxy NGC 3351, sAM can be fully recovered from the available IFU spectroscopy. The proposed method can significantly expand the current galaxy sample by several orders of magnitude.

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EVIDENCE FOR A STRATIFIED ACCRETION DISK WIND IN AGN

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We present observational evidence supporting the presence of a stratified accretion disk wind in active galactic nuclei (AGN), based on multi-wavelength spectroscopic analysis of broad and narrow emission lines. The diversity in emission line profiles, ionization potentials, and kinematic signatures suggests a structured outflow emerging from the accretion disk, with different zones contributing to specific spectral features. High-ionization lines (e.g., CIV λ1549) exhibit strong blueshifts and asymmetric profiles indicative of fast, inner winds, while low-ionization lines (e.g., Hβ, MgII λ 2800) show more symmetric profiles consistent with predominant emission from slower, denser regions farther out, although exhibiting systematic blueshifts in quasars radiating at high Eddington ratios. The intermediate ionization lines (e.g., AlIIIλ1860) present a situation that is intermediate in terms of shift amplitudes, although in several super-Eddington candidates radial outflow velocites may reach values comparable to the ones of the high ionization lines. These results are consistent with radiatively driven wind models featuring radial stratification. We made preliminary photoionization modeling assuming subsequent layers of outflowing gas absorbing the radiation emitted from the corona and the

hotter disk regions. Our findings provide new constraints on the geometry and physical conditions of AGN winds and offer insight into their role in AGN feedback and broad-line region (BLR) dynamics along the quasar main sequence.

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VERY MASSIVE STARS AT COSMOLOGICAL DISTANCES

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Investigating tiny structures (<100pc size) inside of the galaxies until recently was only feasible at lower redshift. Thanks to the new stellar evolutionary models and synthetic spectra of very massive stars (VMS, $M>150M_{\odot}$) as well as the availability of precise lensed models we can properly interpret and analyze spectroscopic properties of a young massive star cluster (YMC) at cosmological distances. I will present the YMC dubbed as 5.1l detected at z=2.37 and located in Sunburst Lyman-continuum (LyC) galaxy. We investigated and confirm the presence and segregation of VMS in the central parts of the 5.1l YMC. Furthermore, we find that the fraction of LyC radiation generated from the VMS is not negligible. Our estimates indicate that YMC harbor around 400 VMS which is 1% of the total population of O-type stars in the cluster (stars capable of producing LyC radiation). Moreover, we estimated that 15% of LyC radiation emitted by YMC is produced by VMS and the rest is generated from less massive O-type stars.

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PROBING SOLAR POLAR MAGNETIC FIELDS: A SPATIALLY-COUPLED APPROACH WITH DISAMBIGUATION

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Accurate determination of photospheric magnetic fields is crucial for deciphering solar atmospheric dynamics, particularly in the polar regions, where projection effects and geometric complexities significantly challenge conventional analyses. In this study, we address the biases introduced by limited spatial resolution in spectropolarimetric data via an advanced, spatially coupled inversion method and subsequent magnetic field disambiguation.

We generate realistic observations by calculating synthetic Stokes profiles from an MHD atmosphere model, and by applying spatial degradation to mimic the effect of a telescope PSF. We then apply both traditional pixel-to-pixel inversion and the spatially-coupled approach. By comparing (i) the "true" magnetic field and line-of-sight (LOS) velocity from the original data $(\vec{B}, v_{\mathrm{LOS}})^{O}$, (ii) the results from spatially-coupled inversion of the convolved data $(\vec{B}, v_{\mathrm{LOS}})^{S\text{-}c}$, and (iii) the outcomes of pixel-to-pixel inversion $(\vec{B}, v_{\mathrm{LOS}})^{C}$, we quantitatively assess the improvement in recovering underlying magnetic structures. Furthermore, we implement a robust disambiguation procedure (minimum-energy method) to resolve the inherent 180° ambiguity in the transverse magnetic field components. Our results indicate that, within specific ranges of magnetic field strengths

and LOS velocities, the spatially coupled inversion significantly outperforms traditional methods, yielding a more accurate reconstruction of both magnetic and velocity fields. These findings underscore the potential of advanced inversion techniques and magnetic field disambiguation for polar observations.

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HIGH-RESOLUTION, HIGH-SPECTRAL FIDELITY SPECTROPOLARIMETRY OF THE LOWER SOLAR ATMOSPHERE

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Over the last decade, we have witnessed the development of several techniques that allow us to perform spectropolarimetric imaging of the lower solar atmosphere (photosphere and lower chromosphere) at the diffraction limit while sampling the shapes of the spectral lines in detail. Namely, the slit spectrum reconstruction technique and the integral field unit solutions like MiHI prototype and HeSP at SST delivered unique sets of data that set new standards for the upcoming solar observations. The properties of these datasets necessitate the development of new analysis techniques (i.e. spectropolarimetric inversion codes) to use their full potential.

This talk will focus on the current state-of-the-art techniques used to collect and analyze solar data with very high spatial and spectral resolution. We will review the current inversion techniques and recent progress, and challenges in the field. As an example of recent science results we will present several solar plage observations in the Na I D1 and Fe I 630nm spectral lines and several interesting findings we have uncovered. Namely, we focus on the plage magnetic topology, time dependence of the plage structure, and a detailed insight into the convective velocities. Finally, will discuss physics-constrained spectropolarimetric inversions using conventional inversion codes and newly developed Physically-informed neural networks (PINNs).

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EMISSION LINE SHAPE, TIME DELAY, AND THE SIZE OF BROAD LINE REGION IN 2.5D FRADO MODEL

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The broad emission-line profiles observed in active galactic nuclei (AGN) arise from the complex dynamics of clouds within the Broad Line Region (BLR). Using a physically motivated FRADO (Failed Radiatively Accelerated Dusty Outflow) model of cloud distributions launched by radiation pressure on dust, we investigate the generic spectral line shapes and their dependence on black hole properties and accretion dynamics. By convolving a large grid of simulations using the 2.5D FRADO code with photon-flux weighted emissivity, we analyze the width, asymmetry, and time-delay histograms of emission lines. Our results show that line widths increase with black hole mass and viewing angle, while higher accretion rates lead to narrower profiles and enhanced blue-wing emission, indicative of outflow structures. Furthermore, we find that peak time-delays provide a more robust measure of BLR size, offering new insights into the radius-luminosity relation. These findings contribute to a deeper understanding of AGN kinematics and spectral variability.

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PROBING BLR KINEMATICS VIA DOUBLE-PEAKED Ca II

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Double-peaked emission lines are observed in a small fraction of active galactic nuclei (AGN) and offer a means to determine key properties of the line-emitting region, known as the broad-line region (BLR). Until now, studies of double-peaked emitters (DPEs) have focused almost exclusively on the Balmer lines Hβ and Hα, while investigations of double-peaked lines in the UV or near-infrared remain scarce. Notably, we recently reported – for the first time – broad double-peaked emission profiles in the near-infrared Ca II triplet for individual sources, namely NGC 1566 and NGC 4593. These detections represent the first of their kind to date. The profiles enabled us to link the kinematics of the Ca II-emitting phase of the BLR to those of a rotating relativistic disk, largely unaffected by internal turbulence, thus allowing a more direct interpretation of the underlying BLR dynamics. In this talk, we summarize our recent findings and discuss the potential of Ca II emission profiles as a powerful diagnostic tool for probing the kinematics of the BLR.

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A MULTIWAVELENGTH HST/SWIFT CAMPAIGN OF MRK 279: MAPPING THE ACCRETION DISK AND BROAD-LINE REGION

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The variability of active galactic nuclei (AGN) is one of their most distinctive features and has been successfully used over the past four decades to infer fundamental properties of their central engines. In particular, reverberation mapping (RM) – which traces the propagation of a perturbing signal as it reflects off, or is reprocessed by, surrounding material – has proven to be a powerful tool for probing the structure of the accretion disk (AD) and broad-line region (BLR) in AGN. Although RM is now an established technique, the highest-quality campaigns – that is, those combining multi-wavelength, high-cadence observations from both space- and ground-based telescopes – remain exceptionally rare. Among the best-studied targets are NGC 5548 and Mrk 817, which were observed as part of the STORM campaigns. Here, we present initial results from a 50-day HST/STIS monitoring campaign of the AGN Mrk 279, conducted with daily cadence and spanning the UV to near-infrared regime. These observations are complemented by contemporaneous *Swift* monitoring with XRT and UVOT. In this talk, we focus in particular on the structure and ionization response of the BLR in Mrk 279, investigating how multiple emission-line species react to variations in the ionizing continuum.

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THE BALDWIN EFFECT AND THE Mg II - 3000 Å LUMINOSITY RELATION FOR BLAZARS

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This study investigates the relationship between the Mg II λ2798 Å emission line and the 3000 Å continuum luminosity, as well as the Baldwin Effect, in a sample of 40,685 radio-quiet (RQ) quasars and 441 Flat Spectrum Radio Quasars (FSRQs). We perform a comprehensive re-evaluation of the Mg II–3000 Å correlation, explicitly accounting for dispersion introduced by AGN variability. After excluding >3000 radio-loud sources, we employ a binning technique to mitigate variability effects, yielding a refined empirical relation. Our analysis reveals statistically significant differences in the slopes of the line–continuum luminosity relation between RQ quasars and FSRQs, with a parallel discrepancy in the Baldwin Effect. These findings imply either (1) intrinsic differences in the accretion disk spectra of RQ AGNs and FSRQs or (2) jet-induced continuum emission in FSRQs contributing to Broad Line Region (BLR) ionization. We further examine the Non-Thermal

Dominance (NTD) parameter, finding that a substantial fraction of both RQ quasars and blazars exhibit NTD < 1, suggesting that the accretion disk alone cannot fully explain BLR ionization. Finally, we demonstrate that the Baldwin Effect emerges naturally from the line–continuum luminosity relationship, requiring no additional physical mechanism to explain its origin.

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LONG TERM SPECTROPOLARIMETRY OF CHANGING LOOK ACTIVE GALACTIC NUCLEI NGC 3516

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The Seyfert galaxy NGC 3516 has undergone major spectral changes in the past years. Here, we present long term spectropolarimetric variability in optical band. Archival polarimetric data that are publicly available cover 6 epochs from 1975-1996. Two decades later, we have obtained high-quality spectropolarimetric data using NOT ALFOSC and SAO BTA instruments over 6 epochs from 2017-2021 when the system was in a quiet state, until a flare-burst occurred in early 2021. We find that the degree of polarization rotates by $\sim 90^{\circ}$ with the onset of the change in 1993. Simultaneously, polarization degree drops from $\sim$0.5-0.7 % to $\sim$0.3 % we obtained recently.

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GENERATING A LARGE NUMBER OF SIMULATIONS FOR AGN SPECTRA AND LIGHT-CURVES USING THE POSKI MODEL

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In this work we have used the PoSKI model for supermassive binary black holes (SMBBHs) to simulate spectra and light-curves for a large number of different AGN scenarios. We create a list of different combinations of basic input parameters, like masses and mutual distance between components, eccentricity, inclination angle, and flux contribution ratios of SMBBH. Additionally we introduce in the spectra the red noise to model the intrinsic stochastic variability, and white noise to account for the instrument noise and simulate realistic observations. Particular simulations are conducted with homogeneous cadences (100 points) for two full orbits of the binary system and 200 points in the wavelength range from 1000 to 10000 Å. We create photometric light curves in six LSST filter bands: u, g, r, i, z, y. As a result, we generated spectra for each orbital phase to present the spectrum and light-curve variability across different input parameter sets. By using this simulations, we are able to investigate influences and dependencies of basic parameters on expected variability of SMBBH systems in a given parameter space.

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RYDBERG ATOMS IN ASTROPHYSICAL PLASMAS: MODELING AND DATA RESOURCES

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This research examines the influence of Rydberg atoms (RA) across various astrophysical environments. It covers a wide range of physical conditions, enabling the simulation of different types of astrophysical plasmas. The study highlights the importance of Rydberg states in identifying weakly ionized regions within Active Galactic Nuclei (AGN)-including both broad-line regions (BLR) and narrow-line regions (NLR)-as well as in determining the populations of excited hydrogen atom states in the solar photosphere and in diagnostic modeling. The work also investigates weakly ionized geocosmic plasmas and white dwarf atmospheres. The findings are relevant to laboratory plasma experiments, offering valuable insights into plasma behavior under controlled conditions. The paper also outlines key data sources, such as SerVO, and discusses their integration with the VAMDC.

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ELECTRON-DRIVEN COLLISIONAL PROCESSES IN WEAKLY IONIZED ASTROPHYSICAL PLASMAS

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This contribution emphasizes the growing significance of atomic and molecular data in interpreting, diagnosing, and modeling complex physical processes. It focuses on electron-driven collisions involving small molecules, which are critical for accurate simulations. We present dissociative recombination rate coefficients for a broad parameter range, offering valuable data for diverse scientific applications. These rates help reveal molecular ion presence and inform on excited-state populations, ionization, and optical properties in weakly ionized media and cold astrophysical plasmas, improving the understanding and modeling of such environments.

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EXPANDING SKIRT'S CAPABILITIES: X-RAY RADIATIVE TRANSFER IN PARTIALLY IONIZED MEDIA

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The SKIRT[1] radiative transfer (RT) code (Camps & Baes 2015, 2020), originally developed as a Monte Carlo code for dust RT (Baes et al. 2003, 2011), has recently been expanded to include a broader range of physical processes and applications, including X-ray RT. These extensions focused on absorption and scattering by dust, pure electrons, and neutral gas, with AGN circumnuclear media as the primary application (Van der Meulen 2023), and also incorporated polarized Compton scattering (Van der Meulen2024). However, many X-ray sources involve a medium that is neither fully neutral nor fully ionized, resulting in a partially ionized state where different ions of the same element coexist. We aim to extend SKIRT's capabilities to handle this complexity.

This new implementation will enable SKIRT to treat partially ionized media, incorporating not only the existing treatment of photoabsorption and fluorescence but also additional physical processes such as radiative (de)excitation and continuum recombination. These are essential for accurately modeling the soft X-ray spectra of both Compton-thin and obscured sources (e.g. Guainazzi et al. 2007, Kallman et al. 2014). Our long-term goal is to develop a self-consistent model that internally uses precomputed Cloudy (Gunaskera et al. 2023) tables to determine the ionization structure. As a first step, however, we adopt a simpler approach by importing a fixed ionization structure from Cloudy.

[1]https://skirt.ugent.be/

This development will substantially improve our ability to model X-ray radiation in extreme environments. With its modular design and broad applicability, SKIRT offers an ideal platform for integrating the necessary physics. Its Monte Carlo framework supports detailed, self-consistent simulations across a wide range of source geometries and physical conditions. As a key application, we highlight the potential of this extension for spectropolarimetric analysis of MHD-driven accretion disk winds in AGN and X-ray binaries.

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METALLICITY AND SMALL-SCALE KINEMATICS IN LOCAL STARFORMING GALAXY

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We present a comprehensive study of the nearby dwarf irregular galaxy NGC 2366 - a local analog of Green Pea galaxies. We focus on the spectral analysis to investigate the local gas kinematics, excitation, and metallicity of star-forming regions both in the most bright region Mrk 71 and the regions beyond.

Observations were conducted using the SCORPIO-2 multimode focal reducer on the 6-m BTA Russian telescope, employing both Fabry-Perot Interferometer (FPI) data and long-slit spectroscopy. The FPI data allowed us to map gas kinematics in the Hα emission line, revealing complex velocity structures across the galaxy and regions with significant non-thermal broadening, indicative of outflows and potential supernova remnants.

Long-slit spectroscopy provided detailed information on the ionization state and chemical abundances of galactic HII regions. We derived electron temperatures and oxygen abundances using the direct T$_e$ method, revealing variations across the galaxy. In particular, we examined the prominent star-forming region Mrk 71 and its associated outflow, characterizing their complex spectral features and report the discovery of a new Wolf-Rayet star candidate.

POSTERS

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REFINING BLACK HOLE MASS ESTIMATES IN TYPE 1 AGN: DEPENDENCE ON Hβ LINE PROPERTIES

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Active Galactic Nuclei (AGN) are compact regions at the centers of active galaxies that exhibit a pronounced excess in luminosity, typically attributed to the accretion of gas onto a central supermassive black hole (SMBH). Reliable estimates of SMBH masses are essential for understanding both AGN physics and galaxy evolution. In this study, we explore the robustness of black hole mass estimates derived from the broad Hβ emission line in Type 1 AGN spectra, using a sample from the Sloan Digital Sky Survey (SDSS). We compare these virial mass estimates with stellar velocity dispersion (σ_*) as an independent tracer of supermassive black hole mass. Our analysis reveals that the correlation between Hβ-based masses and σ_* significantly improves in specific spectral sub-samples, namely those with broader Hβ profiles, red-ward asymmetry, high continuum luminosity, and no evident signatures of outflows. These results indicate that, in AGN exhibiting such spectral characteristics, the Hβ line can serve as a more reliable virial mass estimator. This has important implications for the selection of AGN sub-populations in future spectroscopic surveys and for refining empirical scaling relations used in SMBH mass determinations.

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EXPLORING EMISSION LINE VARIABILITY AND JET-BROAD LINE REGION INTERACTION IN THE BLAZAR TON 599

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Blazars, a highly variable Active Galactic Nuclei (AGNs) subclass, provide a unique opportunity to explore the physical processes within their relativistic jets and emission regions. In this study, we investigate the multiwavelength variability of the blazar TON 599, a Flat Spectrum Radio Quasar (FSRQ), with a particular emphasis on its emission line behavior. We focus on the Mg II $\lambda 2798$ Å emission line, a key tracer of the ionized gas in the broad-line region (BLR), and its role in jet-induced variability. In addition to optical emission lines, we analyze gamma-rays (0.1–300 GeV), X-rays (0.2–10 keV), optical continuum ($\lambda 3000$ Å), optical polarization, and millimeter-wavelength light curves. Three cross-correlation methods are employed to investigate temporal relationships between the emission line and continuum across various wavelengths. Using the Non-Thermal Dominance (NTD) parameter, our analysis confirms that synchrotron emission dominates the continuum during active states, highlighting the jet's primary role in the observed variability. The Mg II emission line exhibits quasi-simultaneous variability with the optical continuum, suggesting photoionization driven by the jet's non-thermal radiation. Additionally, the minimal time lag between gamma-ray and optical/near-ultraviolet emissions supports a synchrotron self-Compton origin for the most variable component of the gamma-ray emission. These findings highlight the importance of emission line variability and multiwavelength observations in constraining the interaction

between jets and the BLR in blazars. The results contribute to a deeper understanding of AGN emission mechanisms and the complex interplay between jets and their surrounding environments.

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MICROFIELD DISTRIBUTION FUNCTION IN STRONGLY MAGNETIZED PLASMAS

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In a dense plasma, the study of spectral lines requires an understanding of the physical properties of the system. Two types of particles interact with an emitter: electrons (light and fast) and ions (quasi-static). Electrons are generally described by the theory of impacts of collisions. Ions, considered quasi-static, create a uniform electric microfield around the emitter. This ionic microfield results from the thermal fluctuations of ion positions and plays an important role in the broadening of spectral lines. The effect of the microfield is incorporated into the expression of the line profile through the distribution of the electric field. Plasmas subjected to a magnetic field (weak or strong) have energy level modifications (lifting of degeneracy, shifts). It is essential to know the statistical distribution $P(E)$ of the field to analyse these effects. This knowledge helps in better understanding the spectral modifications in dense plasmas under a magnetic field.
Keywords: plasma, electric microfield, magnetic field, line profile

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METALLICITY AND SMALL-SCALE KINEMATICS IN LOCAL STARFORMING GALAXY

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We present new panoramic data of a spectacular collisional system Arp118 comprising of a distorted disk galaxy NGC 1144 and an elliptical galaxy NGC 1143. Using observations at the 2.5-m Moscow State University telescope we have mapped the line-of-sight velocity and brightness distribution fields for the Hα and [NII] emission lines. These images reveal, for the first time, the extended emission knots and filaments around the central galaxies of the system – an ionized gas envelope. It extends up to 22 kpc in projection from the NGC 1144 active nucleus. Using SDSS data, we have studied the surroundings of merging galaxies NGC 1143/1144 and have found 10 galaxies inside 400 kpc projected radius, whose measured spectral redshifts coincide with the central galaxies NGC 1143/1144 within the radial velocities of 500 km/s. Thus, Arp 118 can be considered as a group of galaxies in the process of merging its two most massive members.

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MACHINE LEARNING TECHNIQUES AND THE STELLAR SPECTRAL FEATURES

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Spectral data obtained at the 6-m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences and at the MaNGA survey were analyzed for the peculiar galaxy UGC 4261 in detail. This object is merging with a companion galaxy. During the spectral study, in addition to the standard lines for HII regions, additional emission lines (the strongest, in the [OIII] λ 5007 Åregion) were detected. Using the NIST, Atom tracer, and AtomicLineList databases, the unknown lines were identified with permitted FeI lines. The presence of these lines helps us to study the interstellar/intergalactic medium. The emission line profiles revealed the presence of several components and were approximated by Gaussians. One of them was kinematically coincided with regions emitting in Fe I lines. Our estimate of the electron density and temperature based on the [SII], [OIII], [NII] and H_β, H_α lines showed that the iron lines are formed in the densest and coldest regions observed in this system. Lower estimates of the FeI flux were obtained. The question of using obtained values for direct estimation of the iron abundance is under consideration due to its low accuracy. Whether this iron was ejected by supernovae, which are actively being born in the galaxy's nuclear region as a result of gas infall, or whether it is located in tidal structures and illuminated by regions of active star formation remains to be seen.

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DEEP VLT/MUSE OBSERVATIONS OF SNR 0509-67.5

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We present the analysis of deep (∼27 hours on-source) VLT/MUSE observations of the supernova remnant SNR 0509-67.5 in the Large Magellanic Cloud. The Hα line profiles were analyzed across the remnant, identifying both narrow and broad components that exhibit azimuthal variations in their parameters – fluxes, centroids, and widths. We compare theoretical predictions of broad-line widths to our measurements at 231 positions along the forward shock, where proper motion was determined using HST images taken 10 years apart. In some locations, the observed broad-line widths are significantly smaller than expected for the measured shock velocities assuming full electron-proton equilibration, suggesting efficient cosmic-ray acceleration in those regions. Also, the broad-line width is found to be larger on the northeastern side, indicating a higher shock velocity; however, this contradicts astrometric measurements. Additionally, the broad-line centroid is blue-shifted on the southwestern side, suggesting that the nearer limb of the supernova remnant appears brighter. The narrow-line centroid displays an east-west gradient, which may reflect a velocity gradient in the ambient medium. In contrast, the narrow-line width reveals a bipolar pattern, with slightly broader values in the southeast and northwest – possibly indicating enhanced cosmic-ray efficiency in these regions.

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A PHYSICS-INSPIRED FRAMEWORK FOR AGN CLASSIFICATION IN TIME-DOMAIN SURVEYS

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The classification of active galactic nuclei (AGNs) in large-scale optical time-domain surveys is challenged by irregular sampling and diverse variability behavior. Traditional methods often focus on direct time-series statistics and/or spectral features, overlooking the dynamical structure of lightcurves. We propose a novel deep learning pipeline that employs physically inspired representations of variability: the first derivative, characterizing the rate of flux variation, and the second derivative, describing the temporal acceleration of variability.

Using high-quality light curves from a highly imbalanced dataset of $\sim$ 40,000 AGNs from the Zwicky Transient Facility (ZTF) Data Release 6 (DR6), we construct 2D maps of these variability derivatives—encoding both smooth modulations and rapid transitions in observed magnitudes. These dynamic feature maps are used as input to a ResNet-based convolutional neural network (CNN) trained to classify AGN sources as core-dominated Type-1 AGNs (Q $\sim$ 20,000), Type-1 AGNs with X-ray emission (QX $\sim$ 4,000), and Type-1 AGNs with radio emission (QR $\sim$ 2,000). The pilot results from this master's thesis show that this dual-derivative approach improves classification accuracy of AGN subclasses, providing a scalable, physically motivated basis for light curve classification in current (ZTF) and upcoming Vera C. Rubin Observatory Legacy Survey of Space and Time.

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SPECTRAL DECOMPOSITION OF TYPE 1 AGN OPTICAL SPECTRA FROM SDSS AND GAIA

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Relativistic jets are among the most important players in the feedback processes between active galactic nuclei (AGN) and their host galaxies. By propagating through the interstellar medium, they can transfer part of their energy into the gas and heating it up, or produce compression shocks that eventually induce star formation. In a few cases, during relativistic jets' flares, the innermost part of the AGN seems to be affected. The broad-line region (BLR), indeed, can respond to the flares, by increasing (or decreasing) the line luminosity. To date, only a handful of sources have shown this behavior, mostly powerful flat-spectrum radio quasars, such as CTA 102, 3C 454.3, and 3C 345. However, this phenomenon was recently observed for the first time in a jetted narrow-line Seyfert 1 galaxy, PKS 2004-447. The source underwent a gamma-ray flare in 2019, which altered the BLR and produced a flux excess redshifted by 250 km/s, and observed by the X-shooter instrument in the Balmer, Paschen, and He I permitted lines. This new emission feature was no longer visible 1.5 years later, suggesting a causal connection with the flare. The emission lines coming from the same atomic transition series show a similar velocity offset for this "red excess", but the offset changes for different line series. This discovery suggests that the relativistic jet can affect the physics of the BLR in all classes of jetted AGN, and that flaring activity can lead to the formation of additional and localized broad emission components. Our results highlight the importance of optical spectroscopy for flaring jetted AGN, and that our understanding of the jet-BLR -connection is still very limited.

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COMPARISON OF SDSS AND GAIA QSO DATA: SEARCHING FOR ANOMALIES IN QSO SPECTRA

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Quasars (QSOs) are one of the most luminous, powerful and energetic objects in the Universe. QSOs inhabit the centre of galaxies and are powered by supermassive black holes accreting material. With large scale surveys such as Gaia and the Sloan Digital Sky Survey (SDSS) we can search for photometric and spectral flux anomalies across time in a more meaningful way. The aim of this work is to evaluate flux agreements and flag potential gross errors between Gaia DR3 and SDSS DR18 photometric observations of QSOs within different redshift ranges, leveraging overlapping datasets. A cross-matched sample of over 500,000 QSOs was compiled by querying SDSS DR18 and Gaia DR3 archives. Fluxes in Gaia's BP and RP bands were directly compared to integrated SDSS spectra across corresponding wavelength intervals, with correlation coefficients and linear fits used to quantify agreement. Outliers were identified via flux ratio thresholds and further investigated individually. An analysis including all redshift ranges yields a stronger correlation of $\rho = 0.600$. Most outliers are linked to noisy or faint spectra in SDSS or large flux uncertainties in Gaia, rather than systematic redshift-dependent effects.

Programme of 15th SCSLSA

Venue: Hotel Tami Residence, Niš, Serbia, 9-13 June 2025.

The time zone is CEST

	Monday, June 09, 2025	
16:00 -	Arrival	
16:00 - 17:00	Registration	
17:00 - 17:30	**Opening ceremony (P. Marziani and M.S. Dimitrijevic)**	

DATABASES AND SPECTRAL LINE SHAPES FROM LABORATORY TO SPACE PLASMA

Chair: **M. S. Dimitrijević**

17:30 - 18:00	**Joël Rosato** **France**	Line shape modeling for the characterization of stellar atmospheres, magnetic fusion and magneto-inertial fusion experiments: an overview of current challenges
18:00 - 18:30	**Ibtissem Hanachi Algeria**	Calculation of Paschen lines for astrophysical and fusion plasmas
18:30 - 18:50	Anastasiya Farafontova Russia	An automatic molecular line identification using millimeter observations
18:50 - 21:30	**Welcome reception**	

Tuesday, June 10, 2025

SPECTRAL LINE SHAPES AND ASTROPHYSICAL PHENOMENA

Chair: **P. Marziani**

09:30 - 10:00	**Doron Chelouche Israel**	Line-locked Outflows From Quasars
10:00 – 10:20	Mile Karlica Serbia	On non-thermal emission of inhomogeneous astrophysical sources
10:20 - 10:40	Jelena Kovačević-Dojčinović Serbia	Changes in Relative Intensities Among Optical Fe II Lines in AGN Spectra
10:40 - 11:10	**Coffee break**	

EMISSION LINES IN STARS, NEBULAE AND ACTIVE GALAXIES

Chair: **L. Č. Popović**

11:10 - 11:40	**Alexei Moiseev Russia**	Study of the ionized gas in and around galaxies with MaNGaL emission lines mapper
11:40 - 12:00	Anastasiya Yarovova Russia	Metallicity and small-scale kinematics in local starforming galaxy NGC 2366
12:00 - 12:20	Ivan Milić Serbia	High-resolution, high-spectral fidelity spectropolarimetry of lower solar atmosphere
12:20 - 12:40	Teodor Kostić Serbia	Multi-height probing of horizontal flows in solar photosphere using high-resolution spectropolarimetry
12:40 - 13:00	Djordje Mijović Serbia	Probing solar polar magnetic fields: a spatially-coupled approach with disambiguation
13:00 - 15:00	**Lunch break**	

SPECTRAL LINE PHENOMENA IN PLASMAS FROM DIFFUSE TO DENSE STATES

Chair: **V. Srećković**

15:00 - 15:30	**Mohammed Koubiti France**	Artificial intelligence applied to plasma spectroscopy
15:30 - 15:50	Evgeny Stambulchik Israel	The Lineshape Database project
15:50- 16:10	Milan S. Dimitrijević Serbia	On the Stark broadening of N V spectral lines
16:10 - 16:40	**Coffee break**	

POSTER SESSION: SPECTRAL LINES IN ASTROPHYSICAL AND LABORATORY PLASMA

Chair: **A. Kovačević**

16:40 - 17:40	Poster session	5 min presentations

Wednesday, June 11, 2025

SURVEYS AND SPECTRAL LINE VARIABILITY IN EXTRAGALACTIC OBJECTS

Chair: **J. Kovačevic-Dojčinović**

9:30 - 10:00	**Mara Salvato Germany**	The AGN content in eROSITA/DR1 and the spectroscopic follow-up

10:00 - 10:30	**Swayamtrupta Panda Chile**	Probing Supermassive Black Holes in Distant Quasars with Photometric Reverberation Mapping in the Rubin era
10:30 - 10:50	Martin Ochmann Germany	Probing BLR Kinematics via Double-Peaked Ca II; A multiwavelength HST/Swift campaign of Mrk 279: Mapping the accretion disk and broad-line region
10:50 - 11:10	Marta Fatović Italy	Mg II Line Profile Variability in SDSS J2320+0024: Clues to a Binary Supermassive Black Hole
11:10 - 11:30	Malte Andrés Probst Germany	A clear view of the BLR through the variability of WPVS48
11:30 - 11:50	Uroš Meštrić Serbia	Very massive stars at cosmological distances
11:50 - 12:10	Saša Simić Serbia	Generating a large number of simulations for AGN spectra and light-curves using the PoSKI model
12:10 - 14:00	**Lunch break**	
14:00 - 20:00	**Conference excursion with dinner**	

Thursday, June 12, 2025

ATOMIC PARAMETERS AND SPECTRAL LINE SHAPES

Chair: **E. Stambulchik**

9:00 - 9:30	**Gabriel Pérez-Callejo Spain**	Stark broadening in solid-density plasmas: A computational approach
9:30 - 9:50	Milan S. Dimitrijević Serbia	On the Stark broadening of Sn III spectral lines

9:50 - 10:10	Vladimir Srećković Serbia	Rydberg Atoms in Astrophysical Plasmas: Modeling and Data Resources
10:10 - 10:30	Magdalena Christova Bulgaria	Analysis of Stark Broadening Parameters of N II Spectral Lines
10:30 - 10:50	Felix Iacob Romania	Calculation of the electron cation dissociative recombination cross section in interstellar media
10:50 - 11:30	**Coffee break**	

SPECTRAL LINE PHENOMENA IN EXTRAGALACTIC OBJECTS

Chair: **D. Chelouche**

11:30 - 12:00	**Avinanda Chakraborty Italy**	Spectral energy distribution modeling of broad emission line quasars: From X-ray to radio
12:00 - 12:20	Arina Arshinova Russia	Green bean galaxies and the fading echoes of AGN activity
12:20 - 12:40	Ana Lalović Serbia	Spectroscopic Analysis of Specific Angular Momentum in Disk Galaxies
12:40 - 13:00	Victor Manuel Patiño Álvarez Mexico	The Baldwin Effect and the Mg II - 3000 Å Luminosity Relation in Blazars
13:00 - 15:00	**Lunch break**	

SPECTRAL LINE PHENOMENA IN EXTRAGALCTIC OBJECTS

Chair: **D. Ilić**

15:00 - 15:30	**Federica Bianco USA**	Together we are stronger: synergies in astrophysics and AI to advance our understanding of the Universe

15:30 - 15:50	Maria S. Kirsanova Russia	Investigating the origin and transport of water in the universe using submillimeter and millimeter spectral Lines
15:50 - 16:10	Benedetta Dalla Barba Italy	Interaction of the relativistic jet and the narrow-line region of PMN J0948+0022
16:10 - 16:30	Alfredo Amador-Portes Mexico	Exploring the Broad-Line Region of PKS 1510-089: Jet Contributions and Mass Estimation
16:30 - 17:00	**Coffee break**	

SPECTRAL LINE SHAPES IN DIFFERENT SPACE CONDITIONS

Chair: **E. Bon**

17:00 - 17:20	Paola Marziani Italy	Evidence for a Stratified Accretion Disk Wind in AGN
17:20 - 17:40	Nataša Bon Serbia	Tracing Super Massive Black Hole Candidates via the Main Sequence of quasars
17:40 - 18:00	Milica Andjelić Serbia	X-ray spectroscopy of filaments in Cygnus Loop supernova remnant
18:00 - 18:20	Daniele Tagliacozzo Italy	Expanding SKIRT's Capabilities: X-ray Radiative Transfer in Partially Ionized Media
20:00 - 23:00	**Conference Dinner**	

Friday, June 13, 2025

SPECTRAL LINE RESEARCH: NEW FRONTIERS

Chair: **S. Panda**

10:00 - 10:30	**Andjelka Kovačević Serbia**	Probing AGN Variability Across Time and Space with LSST

10:30 - 10:50	Mohammad Hassan Naddaf Belgium	Emission line shape, time delay, and the size of broad line region in 2.5D FRADO model
10:50 - 11:10	Carina Fian Spain	Probing Keplerian Rotation in Quasars using Microlensing-Induced Line Profile Distortions
11:10 - 11:30	**Coffee break**	

SPECTRAL LINE VARIABILITY AND OTHER CHARACTERISTICS IN AGNs

Chair: **S. Simić**

11:30 - 12:00	**Tanja Petrushevska Slovenia**	Spectroscopic diversity of astrophysical transients
12:00 - 12:30	**Edi Bon Serbia**	Fe II Reverberation Mapping in the Active Galaxy NGC 5548
12:30 - 12:50	Djordje Savić Serbia	Long term spectropolarimetry of changing look active galactic nuclei NGC 3516
12:50 - 13:00	**Official closing of the conference**	
13:00 - 14:45	**Lunch break**	
15:00	**Departure**	

POSTERS

P01	Sladjana Marčeta Mandić	Refining Black Hole Mass Estimates in Type 1 AGN: Dependence on Hβ Line Properties
P02	Safia Mokadem	Spectral line shapes asymmetry in hot and dense plasma
P03	Jonhatan Uriel	Exploring Emission Line Variability and Jet-Broad Line Region Interaction in the Blazar Ton 599

P04	Guerrida Houria	Microfield distribution function in strongly magnetized plasmas
P05	Aleksandrina Smirnova	The extended ionized gas filaments in the merging group of galaxies Arp 118
P06	Lilia Shaliapina	Detection of Fe I emission lines in the spectrum of interacting/merging galaxies
P07	Sladjana Knežević	Deep VLT/MUSE Observations of SNR 0509-67.5
P08	Shoaib Jamal Shamsi	A Physics-Inspired Framework for AGN Classification in Time-Domain Surveys
P09	Nandita Das	Spectral decomposition of type 1 AGN optical spectra from SDSS and GAIA
P10	Thara Rubi Caba Pineda	Comparison of SDSS and Gaia QSO Data: Searching for Anomalies in QSO spectra

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