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A S T R O N O M I C A L   O B S E R V A T O R Y   B E L G R A D E

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Vrnjačka Banja, Serbia, July 20-24, 2026

BOOK OF ABSTRACTS

Editors: Saša Simić, Luka Č. Popović and Lazar Novićević

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INVITED LECTURES

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
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Astronomical Observatory, Belgrade, Special Issues No. 7

A TWO-COMPONENT REVERBERATION MODEL FOR THE TIME-DEPENDENT BROAD Hβ PROFILE

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ABSTRACT

Broad emission-line variability in active galactic nuclei provides a direct probe of the geometry and kinematics of the broad-line region (BLR). We present a semi empirical, profile-resolved reverberation model that follows the time dependent evolution of the broad Hβ line after a single ionizing flare. The BLR is represented by two components: a flattened Keplerian disk-like region, which produces the velocity-structured wings, and a more velocity dispersed Gaussian-like cloud component, which contributes mainly to the line core. The flare is treated as a propagating perturbation, launched either centrally or from an off-centre position. The model constructs the line profiles in the observer frame. Thus, a profile seen at a given epoch is not an intrinsic snapshot of the BLR, but a retarded-time superposition of emission from regions with different light travel delays and line of sight velocities. The simulations therefore predict both the profile evolution and the associated velocity-resolved reverberation pattern. The results show that a two component BLR, driven by a single propagating flare, can reproduce the stages of the observed profile variability. This approach provides a physical framework for studying broad-line profile variability and velocity resolved reverberation in AGN monitoring data.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
Book of Abstracts, Eds. Saša Simić, Luka Č. Popović and Lazar Novićević
Astronomical Observatory, Belgrade, Special Issues No. 7

SEARCH FOR NEARBY SUB-PARSEC SUPERMASSIVE BINARY BLACK HOLES USING THE BROAD Hβ LINES

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ABSTRACT

Sub-parsec supermassive binary black holes (SMBBHs) systems occur as the last stage before the merger of their component black holes, in addition to being important sources of gravitational waves. Unlike their highly-separated counterparts, SMBBH with sub-parsec component separation are difficult to detect. These SMBBHs systems are expected to have activity similar the one exhibited by active galactic nuclei (AGNs), with some peculiarities. In this research, we detected several candidates of sub-parsec SMBBH systems from the peculiarities of the broad Hβ emission line profile. Using PoSKI SMBBH model, we also estimated several key parameters of the candidates. We used PCA method described by Eracleous et al. (2012) to obtain the possible candidates from SDSS DR16 QSO catalogue. We then fitted the extracted broad Hβ line with broad Hβ lines simulated using PoSKI model. We found 270 sub-parsec SMBBH candidates with varying degree of confidence in its fitting. Out of these 270 candidates, we found 24 candidates that should be monitored due to the possibility of mergers in near future. We determined that PoSKI model is capable of simulating the broad Hβ line of sub-parsec SMBBH. The PoSKI model can also be used to predict the broad Hβ line to be used for continuous observation.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
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Astronomical Observatory, Belgrade, Special Issues No. 7

ATOMIC AND MOLECULAR PROCESSES IN ACCRETION FLOWS OF CATACLYSMIC VARIABLE STARS

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ABSTRACT

Besides the acretion disks in the case of AGN, analogous, but of course much smaller accretion disks can be found in interacting binary star systems as are for example cataclysmic variables (CVs). There, matter is transferred from a main-sequence donor to a white dwarf through Roche lobe overflow, often forming an accretion disc. These systems provide an excellent laboratory for studying accretion dynamics and related atomic and molecular (A\&M) processes in astrophysical plasmas, which may be of interest and for AGN. CVs are often treated as scaled-down laboratories of AGN accretion physics, allowing accretion processes to be studied on much shorter timescales (seconds–days instead of years–centuries). Variability in their light curves appears in forms such as bursts, flickering, and superhumps, which differ in amplitude and characteristic timescales and are closely connected to instabilities in the accretion flow and angular momentum transport in the disc.

Atomic and molecular processes in the accretion disc and boundary layer strongly influence the observed spectra of CVs. Emission and absorption lines from ionized elements (e.g., H, He, C, N, O, Fe) arise through radiative recombination and collisional excitation, while Doppler broadening reflect the dynamic plasma conditions and Stark broadening provides possibilities for determination of plasma parameters and its modelling. These spectral

diagnostics provide key information about temperature, density, velocity fields, and mass accretion rates.

Despite significant progress, the mechanisms responsible for brightness variability such as flickering and bursts are not yet fully understood. Further investigation of A&M processes in accretion flows is therefore essential for explaining the microphysical origins of variability in interacting binary stars.

In this contribution we will present and discuss some of A\&M processes and their influence on spectral lines, of interest for physics of accretion disks.

Acknowledgements. The authors acknowledge the bilateral SANU-BAN joint research project, IC-RS/12/2026-2028: "Observational effects and accretion processes in selected binary stars".

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
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Astronomical Observatory, Belgrade, Special Issues No. 7

DISSECTING Fe II LINES IN AGN SPECTRA: REVEALING THE COMPLEX PHYSICS OF THE BROAD-LINE REGION

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ABSTRACT

The iron lines in AGN spectra are crucial for understanding the complex physics of the broad-line region, since these lines exhibit several properties which underlying physics in not well understood.

The location of the Fe II emission region within the AGN structure, atomic processes which lead to unexpectedly strong emission of Fe II and some correlations with other spectral properties, still remain the open questions. In order to investigate these issues, we used a large sample of the AGN Type 1 spectra from SDSS and we modeled the Fe II emission using a flexible Fe II template, that decomposes the optical Fe II emission into several line groups and components. In this way, we were able to trace the behavior of different Fe II line groups across sources with diverse spectral properties. Our results imply that an increased Eddington ratio may modify the broad line region structure, leading to specific physical conditions which may be responsible for emission of the additional Fe II components. This causes an enhancement of the optical Fe II emission, and consequently leads to some of the observed correlations, as quasar main sequence.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
Book of Abstracts, Eds. Saša Simić, Luka Č. Popović and Lazar Novićević
Astronomical Observatory, Belgrade, Special Issues No. 7

OBSERVATIONAL SIGNATURES FROM CONTINUUM REVERBERATION MAPPING OF ACCRETION DISKS SURROUNDING LOW-MASS-RATIO SUPERMASSIVE BLACK HOLE BINARIES

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ABSTRACT

It has remained challenging to reliably identify sub-parsec super-massive black hole binaries (SMBHBs), despite them being expected to be ubiquitous. We propose a new method using multi-band continuum reverberation mapping to identify low-mass-ratio SMBHBs in active galactic nuclei. The basic principle is that, due to the presence of a low-density cavity between the mini-disks and the circumbinary disk, the continuum emissions show a deficit at certain wavelengths, leading to a distinguishing feature in the relation between the inter-band time lag and wavelengths $\tau(\lambda)$. Specifically, the relation appears flat at short wavelengths because of the truncated sizes of the mini-disks and transits to a power law $\lambda^{4/3}$ at long wavelength stemming from the circumbinary disk. This transition feature is distinct from the uniform relation $\lambda^{4/3}$ of the standard accretion disk around a single black hole. Using the lamp-post scenario and assuming that only the secondary black hole is active in a low-mass-ratio SMBHB, we design a simple continuum reverberation model to calculate the transfer function of the accretion disks and the resulting $\tau(\lambda)$ relations for various SMBHB orbital parameters. The transition wavelength typically can lie at UV/optical bands, mainly depending on the total mass and orbital separation of the SMBHB. We apply our SMBHB model to the intensive multiwavelength monitoring data of the SMBHB candidate PG1302-102 and find that the SMBHB model can reproduce the inter-band time lags. Remarkably, the inferred total mass and

orbital period from the SMBHB fitting are consistent with values derived from other independent methods.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
Book of Abstracts, Eds. Saša Simić, Luka Č. Popović and Lazar Novićević
Astronomical Observatory, Belgrade, Special Issues No. 7

APPLICATION OF CONDITIONAL NEURAL FLOWS ON RECONSTRUCTION OF PHOTOMETRIC LIGHTCURVES OF ACTIVE GALACTIC NUCLEI

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ABSTRACT

Active galactic nuclei (AGN) exhibit stochastic variability in a wide range of timescales across the entire electromagnetic spectrum. These brightness variations carry information about the physical structure of the accretion flow and the coupling between the central ionizing source and the surrounding disk. Time-domain studies of AGN light curves are therefore an important tool for studying black-hole growth and accretion physics on otherwise unresolved scales. In photometric reverberation mapping, correlated variability between different bands is interpreted as the delayed and smoothed response of disk emission to a common driving signal, making multiband light curves a valuable probe of accretion-disk structure and inter-band time delays. However, the corresponding inverse problem is generally non-unique, since different combinations of latent drivers and response functions may produce similar observed light curves, especially under sparse cadence and noise. This makes uncertainty-aware probabilistic approaches particularly important for the interpretation of multiband quasar variability.

Here we present the application of Conditional Neural Flows (CNFs) to reconstruct missing light curve segments under realistic observational cadences. In contrast to approaches aimed at full simulator based inversion of reverberation mapping parameters, the goal of the present work is not to assume a unique recovery of the latent driving signal, but rather to examine whether CNFs can learn useful conditional distributions and informative latent representations from the incomplete multiband light curves. Our preliminary results show the capability of CNFs to be applied on forthcoming

large-scale surveys such as the Vera C. Rubin Observatory Legacy Survey of Space and

Time (LSST), which will deliver large numbers of irregularly sampled multiband AGN light curves.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
Book of Abstracts, Eds. Saša Simić, Luka Č. Popović and Lazar Novićević
Astronomical Observatory, Belgrade, Special Issues No. 7

MILLILENSING AND TNG SUBHALOES

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ABSTRACT

Recent simulation results indicate that commonly used analytical profiles fail to accurately reproduce the innermost regions of subhaloes within the CDM framework. We use numerical mass density profiles from TNG50 cosmological simulations to study how subhalo concentration influences their lensing efficiency.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
Book of Abstracts, Eds. Saša Simić, Luka Č. Popović and Lazar Novićević
Astronomical Observatory, Belgrade, Special Issues No. 7

AGN DISK TENSIONS FROM AN INCONSISTENT A-DISK CLOSURE (FINAL CLOSURE)

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ABSTRACT

The standard α-disk formalism parametrizes turbulent angular momentum transport through a dimensionless coefficient α, assumed to be spatially and thermodynamically invariant. While analytically convenient, this assumption leads to the classical thermal and viscous instabilities in radiation-pressure dominated regions. We show that this instability is not an inevitable consequence of radiation pressure, but is an artifact of enforcing a constant α across distinct thermodynamic regimes. We present a solution that follows directly from the internal consistency of the thin-disk equations. Implemented within the standard framework, it removes the classical radiation-pressure unstable branch without modifying the stress tensor or invoking additional transport physics.

Disk structure, including surface density, optical depth, and midplane temperature, becomes smooth and single-valued across regimes while preserving the standard effective-temperature profile. The resulting denser and more optically thick inner disk may naturally alleviate several long-standing AGN disk tensions, including oversized microlensing disk estimates, continuum reverberation lag excesses, and accretion-state dependent variability timescales. These results suggest that the classical radiation-pressure instability, and perhaps some associated AGN disk tensions, may be artifacts of an inconsistent viscosity closure.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
Book of Abstracts, Eds. Saša Simić, Luka Č. Popović and Lazar Novićević
Astronomical Observatory, Belgrade, Special Issues No. 7

ACCRETION DISKS ARE THE CENTER

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ABSTRACT

Accretion flows, observed as thin or slim accretion disks, are the center of activity in AGN. Some of their properties are mostly understood. Others are confirmed by recent observations but are still awaiting explanation.

In my talk, I will show how three observed properties of thin accretion disks, and a high-density BLR, can be combined into a comprehensive global picture of AGN: 1. Short-time-scale "continuum" variations. 2. Mass outflow episodes that change the disk SED on intermediate and long time-scales. 3. Variable ionizing disk luminosity which provides a more robust method to estimate BH mass in large AGN samples, especially at high redshift.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
Book of Abstracts, Eds. Saša Simić, Luka Č. Popović and Lazar Novićević
Astronomical Observatory, Belgrade, Special Issues No. 7

PHOTOMETRIC VARIABILITY AND DETECTABILITY OF SUPERMASSIVE BLACK HOLE BINARIES ON SUB-PARSEC SCALES

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ABSTRACT

Supermassive black hole binaries are expected to form during galaxy mergers and represent an important stage in the evolution of active galactic nuclei. On the sub-parsec scales, their orbital motion can induce photometric variability through periodic changes in the accretion flow, broad-line region geometry, and observed continuum emission. However, such signals are difficult and time-consuming to detect, making the investigation of the optimal parameter range for searches of great importance. In this work, we investigate the photometric variability and detectability of sub-parsec supermassive black hole binaries using a grid of synthetic models. The models include different black-hole masses, mass ratios, orbital separations, eccentricities, and redshifts. For each configuration, we generate continuum and line-emission light curves, using PoSKI model, with red and white noise taken into account, and analyze the detectability of periodic signatures using Lomb-Scargle periodogram, where special attention is given to the comparison between magnitude and color variability.

We found that period recovery is significantly more reliable in color than in magnitude time series, indicating that color variability can provide a more robust diagnostic of binary-induced periodicity. This suggests that color-based searches may reduce the impact of stochastic variability and observational noise.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
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Astronomical Observatory, Belgrade, Special Issues No. 7

POLARIZATION OF ACTIVE GALACTIC NUCLEI AND GRAVITATIONAL LENSED OBJECTS

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ABSTRACT

Polarization of Active Galactic Nuclei and Gravitational Lensed Objects: Polarization in the UV/optical spectra of Active Galactic Nuclei (AGNs) depends on the geometry of the innermost region but also on the different polarization mechanisms that are effective in the central region (accretion disk and Broad Line Region—BLR) of an AGN. The polarization can be caused by scattering material located around the accretion disk of a supermassive black hole, which is also important. Therefore, the AGN polarization measurements can indicate the geometry of the different emitting regions, especially the Broad Line Region (BLR), but also the mechanism of polarization in AGNs. On the other side, the polarization of the gravitationally lensed AGN (GL AGN) can also be observed and can be used for investigation of the inner structure of these objects. In this presentation we discuss the effect of polarization in AGNs and GL AGNs.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
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MILLIMETER SYNCHROTRON EMISSION FROM AGN CORONAE: A NEW PROBE OF STRONG GRAVITY

E. SHABLOVINSKAIA, C. RICCI, T. KAWAMURO, R. PALADINO AND C-S. CHANG

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ABSTRACT

The detection of high-energy neutrinos from the radio-quiet Seyfert galaxy NGC 1068 challenges the paradigm that extreme particle acceleration in active galaxies requires powerful relativistic jets. In radioquiet AGNs, the most compact and energetic region is the hot X-ray corona above the accretion disk, located within only a few gravitational radii of the supermassive black hole. While X-rays trace thermal Comptonization in this plasma, I will show using ALMA polarimetric and variability observations that the compact millimeter emission is synchrotron radiation produced in the same magnetized corona. The tight mm-X-ray connection, combined with the lower optical depth and minimal absorption at mm wavelengths, makes the mm band a uniquely penetrative probe of magnetic fields and non-thermal particle populations in the strong-gravity regime, offering a more direct view of the accretion-powered plasma than X-rays alone. The measured spectral slopes, variability, and polarization constrain the size, magnetic field strength, and particle content of the corona, providing physically motivated limits on hadronic acceleration. I will argue that magnetized coronae in radio-quiet AGNs may represent a previously unrecognized class of steady neutrino sources, and that coordinated mm, X-ray, optical, and neutrino observations with facilities such as IceCube and KM3NeT will enable a coherent multi-messenger view of particle acceleration in the immediate vicinity of supermassive black holes.

VII Conference on Active Galactic Nuclei and Gravitational Lensing, July 20-24, 2026, Vrnjačka Banja, Serbia
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ANALYSIS OF THE OPTICAL POLARIZATION OF BLAZARS BASED ON LONG-TERM MONITORING DATA

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ABSTRACT

Blazars are a subclass of active galactic nuclei whose jets are pointed toward the observer at a small angle. These objects are characterized by highly variable flux densities across all spectral ranges, as well as high and variable polarization. Studying the polarization of blazar optical radiation is a key indirect method of investigating the structure of the magnetic field in the emitting region. Long term monitoring of blazar optical polarization has revealed ordered changes in the EVPA (electric vector position angle) during certain periods, which are commonly called in the literature as "EVPA rotations" [1, 2].

This study searches for such events in the polarization curves of 32 blazars, based on long-term optical photopolarimetric observations, and analyzes their parameters. The study proposes a criterion for rotation completeness and examines differences in the average rotation parameters for blazars of different subclasses, such as BL Lac and FSRQ. The results show that the rotation amplitude decreases with increasing average polarization during rotation. Additionally, it is shownthat, for one-third of the sample, the average direction of the optical polarization position angle aligns well with the radio jet's position angle.

References
1. Larionov V. M. et al., 2008, A&A, 492, 389
2. Marscher A. P. et al., 2010, ApJ, 710, L126

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POLARIMETRY OF BLAZAR JETS: FROM RADIO TO X-RAYS

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ABSTRACT

Blazars represent the most extreme manifestation of relativistic jets in active galactic nuclei, where Doppler boosting amplifies non-thermal emission across the entire electromagnetic spectrum. Their spectral energy distributions (SEDs) display the characteristic double-humped structure, commonly interpreted within leptonic or hadronic frameworks. Despite extensive multiwavelength modeling, however, SED fitting alone often remains degenerate, allowing different physical scenarios to reproduce similar spectral shapes.

Polarimetry has long provided essential insights into jet physics, from early radio measurements establishing the synchrotron origin of emission to decades of optical monitoring revealing complex variability patterns. The degree and angle of polarization encode information about magnetic field ordering, particle acceleration, and emission-site localization. I review the phenomenology of radio and optical polarization in blazars, including variability patterns, polarization–flux relations, and quasi-periodic behavior, and discuss their interpretation in terms of particle acceleration processes, magnetic field structure, and jet geometry.

Recent advances extend these diagnostics into the X-ray band with the Imaging X-ray Polarimetry Explorer (IXPE). In high-synchrotron-peaked blazars, X-ray polarization probes the highest-energy synchrotron-emitting particles and provides new constraints on competing emission scenarios. Polarimetry across multiple energy bands thus offers a multi-dimensional approach to understanding the magnetic structure and energetics of relativistic jets.

LSST AND FLOWS OF CATACLYSMIC VARIABLE STARS

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ABSTRACT

Cataclysmic variables (CVs) are interacting binary stars in which matter flows from a main-sequence donor to a white dwarf, often forming an accretion disc. Brightness variability in CVs—such as bursts, flickering, and superhumps — usually arises from instabilities in the accretion flow, turbulence, and angular momentum transport. Spectral diagnostics from emission and absorption lines of ionized elements and molecular bands provide insights into temperature, density, velocity fields, and chemical composition.

CVs are often treated as scaled-down laboratories of AGN accretion physics, allowing accretion processes to be studied on much shorter timescales (seconds–days instead of years–centuries) while retaining analogous disc physics. The Vera C. Rubin Observatory (LSST) will provide real-time alerts for variable and transient events, enabling rapid detection of CV outbursts, coordinated follow-up, and detailed studies of the physical mechanisms driving variability.

We will present here our current work on an LSST broker orchestrator which will enable rich scientific use of the cases for CVs, and will facilitate real-time filtering and follow-up of transient events (work in progress). These observations will advance our understanding of accretion dynamics and the microphysical origins of variability in interacting binary systems.

Acknowledgements. The authors acknowledge the bilateral SANU-BAN joint research project IC-RS/12/2026-2028: "Observational effects and accretion processes in selected binary stars".

Conference Programme

Monday, July 20

15:00 - 16:30 – *Arrival and registration*

16:30 - 17:00 – Opening ceremony

Chair: H. Netzer

17:00 - 17:30 – Introduction talk

17:30 - 18:00 – Discussion: What is new in AGN investigation, LRDs and other stories

18:00 - 20:00 – *Welcome cocktail*

Tuesday, July 21

Talks with discussion - AGNs, GLs, Polarisation

Chair: S. Simić

9:30 - 10:00 – L. Č. Popović: POLARIZATION OF ACTIVE GALACTIC NUCLEI AND GRAVITATIONAL LENSED OBJECTS

10:00 - 10:30 – Shishkina E.V: ANALYSIS OF THE OPTICAL POLARIZATION OF BLAZARS BASED ON LONG-TERM MONITORING DATA

10:30 - 11:00 – Coffee break

Chair: E. Bon

11:00 - 11:30 – O. Vince: POLARIMETRY OF BLAZAR JETS: FROM RADIO TO X-RAYS

11:30 - 12:00 – *Discussion & Work on mini projects*

13:00 - 15:00 – *Lunch break*

Chair: **L. Č. Popović**

15:00 - 15:30 – E. G. Mediavilla: MILLILENSING AND TNG SUBHALOES

15:30 - 16:00 – E. Shablovinskaia: MILLIMETER SYNCHROTRON EMISSION FROM AGN CORONAE: A NEW PROBE OF STRONG GRAVITY

16:00 - 16:30 – Coffee break

16:30 - 18:00 – *Discussion & Work on mini projects*

<u>Wednesday, July 22</u>

Talks with discussion - Variability of AGNs and SMBBHs:

Chair: **J. Kovačević Dojčinović**

9:30 - 10:00 – Yan-Rong Li: OBSERVATIONAL SIGNATURES FROM CONTINUUM REVERBERATION MAPPING OF ACCRETION DISKS SURROUNDING LOW-MASS-RATIO SUPERMASSIVE BLACK HOLE BINARIES

10:00 - 10:30 – L. Novićević: PHOTOMETRIC VARIABILITY AND DETECTABILITY OF SUPERMASSIVE BLACK HOLE BINARIES ON SUB-PARSEC SCALES

10:30 - 11:00 – *Coffee break*

***Chair:* D. Ilić**

11:00 - 11:30 – E. Bon: A TWO-COMPONENT REVERBERATION MODEL FOR THE TIME-DEPENDENT BROAD Hβ PROFILE

11:30 - 12:00 – A. Deandra: SEARCH FOR NEARBY SUB-PARSEC SUPERMASSIVE BINARY BLACK HOLES USING THE BROAD *HB* LINES

12:00 - 13:00 – *Discussion & Work on mini projects*

13:00 - 19:00 – *Thematic excursion with lunch*

<u>Thursday, July 23</u>

Talks with discussion: Processes in AGNs

***Chair:* A. Kovačević**

9:30 - 10:00 – J. Kovačević Dojčinović: DISSECTING FeII LINES IN AGN SPECTRA: REVEALING THE COMPLEX PHYSICS OF THE BROAD LINE REGION

10:00 - 10:30 – A. Luis: APPLICATION OF CONDITIONAL NEURAL FLOWS ON RECONSTRUCTION OF PHOTOMETRIC LIGHT CURVES OF AGNS

10:30 - 11:00 – Coffee break

***Chair:* Đ. Savić**

11:00 - 11:30 – Mohammad-Hassan Naddaf: AGN DISK TENSIONS FROM AN INCONSISTENT A-DISK CLOSURE (FINAL CLOSURE)

11:30 - 13:00 – *Discussion & Work on mini projects*

13:00 - 15:00 – *Lunch break*

Talks with discussion: Atomic Processes in AGNs and other objects

Chair: V. Srećković

15:00 - 15:30 – M.S. Dimitrijević: ATOMIC AND MOLECULAR PROCESSES IN ACCRETION FLOWS OF CATACLYSMIC VARIABLE STARS

15:30 - 16:00 – V. Vujčić: LSST AND FLOWS OF CATACLYSMIC VARIABLE STARS

16:00 - 16:30 – Coffee break

Chair: O. Vince

16:30 - 17:30 – Presentations of MSc and PhD students about their thesis and interest in scientific work (around 10-15min)

17:30 - 19:00 – *Discussion & Work on mini projects*

19:30 – *Conference dinner*

Friday, July 24

***Chair:* J.-M. Wang**

10:00 - 11:45 – *Round table discussion and summary of the work on mini-projects*

11:45 - 12:00 – *Closing ceremony and check-out*

13:00 - 14:00 – *Lunch break*

14:00 – *Departure to Belgrade*

MINI-PROJECTS

Project 1: Physics of the AGN emitting regions
Investigate the physical conditions, emission mechanisms and kinematics of AGN central regions through spectral analysis and modeling.

Project 2: Strong gravitation and the centers of AGNs
Explore relativistic effects and dynamical signatures close to supermassive black holes using theoretical models and observational diagnostics.

Project 3: AGNs and super-massive binary black hole systems: Spectral Energy Distribution (SED) and microlensing effect
Model SEDs for binary supermassive black hole systems and investigate microlensing signatures to constrain emission-region structure.

Project 4: Databases for investigation of the physics of AGNs
Develop and use databases and tools to aggregate, query and analyze multi-survey AGN observations for population studies.

Project 5: SDSS and LSST in AGN and GL (Gravitational Lensing) investigations
Exploit SDSS and LSST survey data to identify AGN populations, search for lensing events and characterize large-scale variability.

Project 6: SDSS and LSST in AGN and GL (Gravitational Lensing) investigations
Apply time-domain analysis to SDSS and LSST light curves to study AGN variability and detect transient lensing or microlensing phenomena.

Project 7: Polarization of the AGN spectra and gravitational lenses
Measure and model polarization signatures to probe magnetic fields, scattering geometries and lensing-induced polarization effects.

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