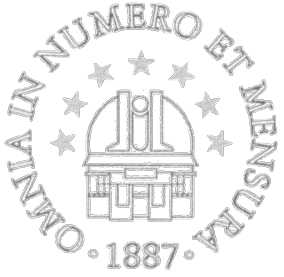
PROGRAMME AND ABSTRACTS:

V Conference on Active Galactic Nuclei and Gravitational Lensing

June 13-17, 2022, Topola, Serbia

Editors: L. Č. Popović and S. Simić



Belgrade, 2022

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Scope of the Conference

Investigation of nature of the emitting ionized gas in galactic nuclei is one of important subjects in astrophysics today. Firstly, investigating the processes in the central parts of these objects, we can learn about the innermost parts of other 'normal' galaxies. Secondly, AGN are the most powerful sources, located at different cosmological time-scales, and their investigation is cosmologically important. Finally, a part of emission from these objects (e.g. in the X-rays) has its origin very close to a massive black hole, and investigation of this emission can help us understand the physical processes in a strong gravitational field. On the other side, a number of AGN are affected by gravitational lensing effect.

Gravitational lensing is in general achromatic: the deflection angle of a light ray does not depend on its wavelength. However, the wavelength-dependent geometry of the various emission regions may result in chromatic effect. Studies aimed at determining the influence of microlensing on spectra of lensed quasars (hereafter QSOs) ought to account for the complex structure of the QSO central emitting region. Since the sizes of the emitting regions are wavelength-dependent, microlensing by stars in a lens galaxy will lead to a wavelength-dependent magnification.

Many interesting details about the physics of processes that are taking place within AGN can be identified in the signal of their emitting regions (as e.g. Broad Line Region- BLR), but they suffer from a still missing complete picture of the complex kinematical and thermodynamical properties of the line emitting plasma. Since it is not yet possible to directly observe the spatial distribution of the broad line emitting medium, although many important achievements were

obtained in the angular resolution of AGN cores at radio wavelengths, spectroscopic data are still the most useful way to investigate physics within the central part of an AGN.

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**V Conference on Active Galactic Nuclei
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ATOM-RYDBERG ATOM COLLISIONAL PROCESSES IN THE BRL REGION OF AGNs

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The significance of hydrogen atom–Rydberg atom collisions in AGN has been investigated. The results may be useful for the diagnostics, modelling, and confirmation of existence of very dense weakly ionized domains in clouds in broad-line region of active galactic nuclei. Moreover, the results of the present work suggest that the investigated processes are of interest for the research of Rydberg states of hydrogen and for the study of their influence during the cosmological recombination epoch.

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A BRIEF HISTORY OF SERBIAN INVOLVEMENT IN LSST

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I will summarize Serbian involvement in LSST since 2010. In kind contribution of Serbian Technical group (STG) is already recognized and I will point toward possible further contributions of STG to Rubin operations.

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SUPERCOMPUTER 'BURA' AS A SOFTWARE PROCESSING CENTRE FOR LSST VERA C. RUBIN OBSERVATORY

Tomislav Jurkić[1], Lovro Palaversa[2] and Oleksandra Razim[2]

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Large long-term surveys such as LSST at Vera C. Rubin Observatory will obtain a huge, petabyte-scale of data. Such vast amount of data would need substantial computer resources in order to be processed, analysed and visualised. Therefore, supercomputers and high-performing computing facilities play an important role as IDAC (International Data Access Centre) and/or SPC (Software Processing Centre) in LSST scientific community. As a part of LSST Vera Rubin Observatory in-kind contribution of Croatian participation group (CPG), we are offering HPC supercomputer 'Bura' at University of Rijeka as a software processing centre. In this talk, the main features of HPC 'Bura' will be presented, as well as possibilities of its use by LSST scientific community, mainly (but not exclusively) in the areas covered by Transients and Variable Stars (TVS) and Stars, Milky Way & Local Volume (SMWLV) scientific collaborations. Various possible scientific cases where 'Bura' could be used, and interesting for wider scientific community, will be described.

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RUBIN IN-KIND HALF YEAR UPDATE ON DEVELOPMENT OF TIME DOMAIN PIPELINE FOR PERIODICITY SEARCHING

Andjelka Kovačević[1,2], Dragana Ilić[1], Viktor Radović[1], Rachel Street[3], Luka Č. Popović[1,2,3,4], Mladen Nikolić[1], Nikola Andrić Mitrović[1] and Iva Čvorović-Hajdinjak[1]

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A time-domain pipeline for the Vera C. Rubin Legacy Survey of Space and Time (LSST) data periodicity mining is the subject of our directable software inkind contribution.

The pipeline will be used to support the development of scientific collaboration infrastructure for the recipients of the LSST Active Galactic Nuclei (AGN) and Transient and Variable Stars (TVS) scientific collaborations. The outputs of the pipeline are the extracted light curve periodic features (periodicities, uncertainties, and periods likelihood), which will be used by the AGN and TVS SC for their variability investigation. Within the pipeline, at least four different time domain techniques will be implemented. The pipeline will also include (non)

parametric modeling of LSST light curves, and statistical probability on the identified periodicities.

As the pipeline is developed (between January 2022 and June 2022), here we provide half year periodic updates.

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LSST TELESCOPE IN-KIND CONTRIBUTION (SER-SAG-S2)

Jelena Kovačević-Dojčinović[1], Maša Lakićević[1], Sladjana Marčeta-Mandić[1,2], Dragana Ilić[2], Luka Č. Popović[1,2], Saša Simić[3], Isidora Jankov[2], Iva Čvorović-Hajdinjak[2], Branislav Vukotić[1],Viktor Radović[2] and Andjelka Kovačević[2]

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One of the two accepted in-kind contributions of the Serbian AGN Group (SER-SAG) to the Legacy Survey in Space and Time (LSST) was the optical follow-up of bright LSST transients with Milankovic 1.4 Telescope (denoted by the LSST as SER-SAG-S2). Here we will review the progress in SER-SAG-S2 LSST telescope in-kind contribution. We will summarize the characteristics of the 1.4 m telescope Milankovic at Astronomical Station Vidojevica and its observational possibilities. We will expose the experience of the SER-SAG-S2 team in several testing observational nights up to now and we will present the plan for future activities.

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KINEMATICS OF EXTENDED IONIZED-GAS REGIONS AROUND ACTIVE GALAXIES

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In modern concept active galactic nuclei (AGN) are supermassive black holes with accretion of the external matter. Often, the reason of the accretion is galaxies' interaction. According "unified AGN model", ionization cones are the regions in which most part of the UV and optical radiation concentrates. These cones are able to ionize gas not only in the galactic disk but beyond it. In present work we analyzed in detail kinematics of the extended ionised-gas regions in several Seyfert galaxies using 3 D spectroscopic data obtained at the 6-m Russian telescope with the multi-mode focal reducer SCORPIO-2. We built kinematic models of the gas motions. Also we choose preliminary initial conditions of the galaxies' interactions using the numerical calculations database GalMer.

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THE FIRST SPECTROSCOPIC DUST REVERBERATION PROGRAMME ON ACTIVE GALACTIC NUCLEI

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We have initiated the first spectroscopic dust reverberation programme on active galactic nuclei in the near-infrared. Spectroscopy enables measurement of dust properties auch as flux, temperature and covering factor with much higher precision than photometry. But its particular strength is that it can measure both luminosity-based dust radii and dust response times. As I will show, this can constrain the astrochemistry of the hot dust. In this talk, I will discuss results from monitoring campaigns on NGC 5548, Mrk 876, Mrk 509 and the ongoing, long-term campaign on the quasar 3C 273. Our intent now is to take the spectroscopic dust reverberation programme to a larger scale. I will discuss the different ways in which this can be successfully accomplished in the near future.

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MICROLENSING OF BLAZARS JETS: FACT OR FICTION?

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Blazar variability makes identification of lightt curve microlensing signatures almost impossible. PKS 1413+135 is a puzzling nearby radio bright blazar that appears to be hosted by a Seyfert galaxy. This will be the only known blazar in a spiral galaxy, contradicting our understanding of blazar host galaxies. Is it possible that we are instead observing a background blazar through the lens of the spiral galaxy? I will discuss our recent efforts in understanding this peculiar system and what blazar microlensing can bring in studying jet structure with unprecedented resolution.

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MAGIC FOR 1-M TELESCOPE OF SAO RAS

Eugene Malygin, Elena Shablovinskaya, Roman Uklein, Vladimir Amirkhanyan, Alexander Perepelitsyn, Irina Afanasieva and Victor Afanasiev

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We present a principal scheme and the result of methodical measurements for the multi-mode focal reducer MAGIC (Monitoring of Active Galaxies by Investigation their Cores). The instrument is installed at the Cassegrain focus ($f/13$) of the 1-meter Zeiss-1000 telescope of SAO RAS, where regular monitoring observations of AGN are carried out in the photometric, spectroscopic, and polarimetric modes.

Reducing the focal length makes it possible to obtain a sufficiently large field of view for photometry and a large slit height for spectroscopy of $\sim 12'$, as well as a large field of view for polarimetry with a quadrupole Wollaston prism of $\sim 6.5'$. This feature makes the complex study of extended nebulae and galaxies efficient.

During the first year of observation, it was found that the spectral mode in the range of 4200-7000Å provides R $\sim$ 1000; for a starlike target up to 14 mag in medium-band filters with a seeing of $1''$ for 20 minutes of total exposure, the photometry accuracy is better than 0.01 mag and the polarization accuracy is better than 0.6%.

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PECULIAR LINE PROFILES: LOOKING FOR SECULAR CHANGES

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The current understanding of the emitting line regions of type-1 AGN ascribes the broadening of low-ionization lines to a virial velocity field. In most sources, the line profiles are indeed fairly symmetric and little shifted with respect to the quasar rest frame. In a minority of cases, however, the Balmer line profiles show shifts of large amplitude, by over 1000 km/s. Even if the investigation of these cases started more than 30 years ago, they remain unexplained as yet, in part because of lack of repeated observations. This project would involve the collection of new spectra of sources with peculiar Balmer line profiles. Some direct implications could be derived for the region dynamics in case significant changes were detected. Variable sources could become preferential targets for eventual high cadence monitoring.

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VERY HIGH CADENCE, VELOCITY-RESOLVED REVERBERATION MAPPING OF A POPULATION B AGN

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Reverberation mapping has achieved important results, among them the observational basis for the computation of black hole masses in large samples of AGN. To go further, one has to resort to velocity-resolved reverberation mapping that holds the promise to gain insight on the dynamical status of the line emitting gas. Results obtained until now are still affected by poor cadence and other technical difficulties. Population B sources radiate at modest Eddington ratio and their profile widths and asymmetries indicate distances from the central black holes of just a few hundred gravitational radii, with a light travel time much shorter than the one deduced from the response of the line core. Round-the-clock monitoring (with a cadence of 1 exposure/hour for 7-10 days) of a Population B AGN of moderate luminosity holds the promise to map the response of the innermost part of the emitting region to continuum changes on the shortest variability timescales.

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CROATIAN IN-KIND CONTRIBUTION TO THE RUBIN LSST

Lovro Palaversa[1], Oleksandra Razim[1], Tomislav Jurkić[2] and Krešimir Tisanić[1]

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In order to obtain Rubin LSST data access rights before the expiration of the embargo, international contributors are required to make a quantifiable *in-kind contribution*. With this in mind a Croatian LSST participation group (CPG) was formed. Main contributions of this mini-consortium of three institutions are directable software development contribution effort and computing resources. CPG's experiences related to the in-kind proposals and contributions will be described, with a focus on directable software development contributions. Tomislav Jurkić will focus on computing resources in a related talk.

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EMULART: EMULATING RADIATIVE TRANSFER WITH AUTO-ENCODERS

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Dust is a major component of the interstellar medium. Through scattering, absorption and thermal re-emission, it can profoundly alter our observations. Models for dust composition and distribution are necessary to better understand and curb the impact of dust on observations. Furthermore, dust emission is important for understanding various astrophysical objects which it surrounds.

Radiative transfer modelling is a critical tool in the study of the impact of attenuation and reddening by dust on the observed properties of galaxies and active galactic nuclei. From comparing the resulting simulations with real observations in the corresponding wavelengths we can infer physical properties. These simulations present, however, approximately a linear computational cost increase with the desired information resolution.

We propose the use of an autoencoder, for dimensionality reduction, combined with a spatial approximate Bayesian inference method to emulate radiative transfer high information models from low information models.

We show, for a simple spherical dust shell model with anisotropic illumination, that our approach successfully emulates the reference

simulation starting from less than 1% of the information. Our emulations of the model at different viewing angles present median residuals under 15% across the spectral dimension, and under 48% across spatial and spectral dimensions; furthermore, it infers estimates for ∼85% of information not present on the input, all within a total running time around 20 minutes, estimated to be 6× faster than the present target high information resolution simulations, but up to 50× faster when applied to more complicated simulations.

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POLARIZATION OF LENSED QUASARS

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Gravitationally lensed quasars are important phenomena in modern astrophysics. The light from these objects is amplified, and we can detect objects at large redshift; therefore, the investigation of lensed quasars and their geometry is crucial for cosmology. Gravitational lenses can be used to constrain the innermost structure of lensed quasars e.g. probing the accretion disk structure and its temperature profile, as well as the structure and kinematics of the broad line region. Consequently, spectropolarimetric observations can provide information about the structure of lensed quasars, however, the nature of polarization in lensed quasars is not yet clearly understood. We observed two objects: SDSS J1004+4112 and Q0957+561 with the 6m SAO RAS and Robopol telescopes. We modeled the geometry of the emitting regions using the radiative transfer codes STOKES and SKIRT in polarimetry modes taking into account the dominant

polarization mechanisms. For computing the lensing effects, we used the LENSTRONOMY package. Finally, we discuss the influence of gravitational macro- and microlensing on the optical polarization of lensed quasars.

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New results of the polarimetry of AGN with equatorial scattering

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The study of the features of equatorial scattering in polarized light makes it possible to consider the geometry and kinematics of the matter near the SMBH in the center of the type 1 AGN in detail. However, despite its powerful potential, AGN spectropolarimetry is a complex observational task implemented on only a few large telescopes in the world. Therefore, today the task of both collecting more statistical data of the studied objects and searching for unique sources is relevant. In this report, I will present a number of the most interesting observational results obtained in the last few years on BTA/SCORPIO-2. Among them are the results of spectropolarimetry in UV lines of the distant quasar SBSS 1419+538 (z = 1.86) and the gravlensed quasar Q0957+561 (z = 1.41), as well as the results of the detection of new quasars with signs of equatorial scattering. Also, the first results of polarimetrimetric monitoring of Sy1 in broad lines, which is carried out on the small telescopes of SAO, Asiago and Rozhen, are presented.

Due to this, new estimates of the size of the equatorial scattering region are obtained, which turn out to be on average 2 times smaller than the IR estimates obtained earlier.

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INSTALLING, ADOPTING AND USING CLOUD DATA STORAGE IN REALISATION OF LSST TASKS

Saša Simić[1], Dragana Ilić[2], Andjelka Kovačević[2], Luka Č. Popović[2,3], Tomislav Jurkić[4], Lovro Palaversa[5] and Domagoj Ruždjak[6]

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The Vera C. Rubin Observatory is preparing for the start of the Legacy Survey of Space and Time (LSST) ten-year long operation. In this context, the LSST Transient and Variable Star Scientific Collaboration, in partnership with the Heising Simons Foundation, has invited applications for kickstarter grants to improve the readiness of teams involved in LSST operations. With this project, we bring together two LSST in-kind groups from Serbia and Croatia with the goal of expanding their research capacities in the areas of data storage, processing, and administration for LSST-related science.

We anticipate a requirement for an important component - data storage - as part of the proposed collaboration. Both organizations will generate a substantial amount of data as a result of their LSST in-kind contributions, i.e. the intermediate and final data products of LSST-related work. As a result, we suggest here the acquisition and installation of cloud data storage (CDS) at the University of Kragujevac in Serbia. Furthermore, the data storage will be used as a data legacy repository long after the LSST project is completed.

The primary goals of this project are to develop the region's first open-access storage system for LSST-related science, to promote long-term collaboration between the two LSST in-kind teams, and to expand astronomical research capacity at the University of Kragujevac. We will cover the potential usage of the CDS for scientific simulation support during the pre-run phase, as well as data storage during the LSST telescope's operating time in this talk. We go through the cloud system's accessible services and established capabilities in depth, as well as the options for integrating them into our software demands.

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DISSECTING THE ACTIVE GALACTIC NUCLEUS IN CIRCINUS GALAXY

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Circinus galaxy is the closest Seyfert 2 galaxy and harbours the second brightest active galactic nucleus (AGN) in the mid-infrared (MIR). Recent MIR interferometry and single dish imaging, together with detailed radiative transfer modeling, have cast this galaxy in a major role as a prototype in the emerging paradigm of 'polar dust AGN', in which a major fraction of the MIR emission is associated with dusty winds blown away from the sublimation zone by the radiation pressure. Namely, high angular resolution observations with several instruments mounted on the Very Large Telescope (VLT) revealed that a major fraction of the MIR emission is coming from the polar region, in contrast to the expectations from a standard AGN picture of equatorial dust distribution. By employing radiative transfer modelling, we demonstrated that both the observed morphology and spectral energy distribution can be explained with a compact dusty disc and a hollow dusty cone illuminated by a tilted anisotropic central source. Driven by the success of this model, we launched a campaign to observe this source with several other VLT instruments and in different modes. I will provide an overview of our past, on-going and future efforts in this endeavour, focusing on the MIR and optical polarimetry data.

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SOLITARY VORTEX STRUCTURE IN A CLASS OF SELF-GRAVITATING ACCRETION DISKS

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We consider a class of steady-state self-gravitating accretion disks for which efficient cooling mechanisms are assumed to operate so that the disk is self-regulated at a condition of approximate marginal Jeans stability. We treat the disk in nonlinear regime and we derive conditions for existence of nonlinear stable structure in a shape of twodimensional soliton. We explain why the nonlinear regime is important in accretion disk dynamics.

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A SIMPLE APPROACH OF GRAVITATIONAL LENSING FOR RAR MODEL

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Several year ago Ruffini, Argueles and Rueda (2015) proposed a dark matter model to substitute supermassive black holes in AGNs. Later, these models started to call RAR models of dark matter distributions. Moreover, it was declared that the RAR-model provides a better fits for bright star trajectories near the Galactic Center. We consider a simple approach for gravitational lensing in the framework of RAR-model. When gravitational lens consists of a ball with a constant density (this case corresponds to a central part of core in the RAR-model). We discuss cases when RAR-model could mimic shadows formed by supermassive black hole.

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Programme

Monday, June 13

13:00 - 14:45 - Arrival to hotel Oplenac and Registration

Chairperson: L. Č. Popović

14:45 - 15:00 - Opening ceremony

15:00 - 15:30 - P. Marziani: Peculiar line profiles - looking for secular changes

15:30 - 16:00 - *Coffee break (with discussion)*

16:00 - 19:00 - Discussion and work on miniprojects MP1-MP5

In the frame of MP1 a short talk:
M.S.Dimitrijevic - Rydberg atom colisional processes in the broad line region of AGNs

19:00 - 22:00 - Welcome cocktail with degustation of wines of the winary of hotel Oplenac

Tuesday, June 14

LSST Day

Chairperson: A. Kovačević

LSST Kickstarter project: Regional Storage Support for LSST Related Science

10:00 - 10:30 - S. Simić: Installing, adopting and using storage support in realization of LSST tasks

10:30 - 11:00 - T. Jurkić: Supercomputer BURA as a software processing centre for LSST Vera C. Rubin observatory

11:00 - 11:30 - L. Palavestra: Croatian Rubin LSST in-kind contribution

11:30 - 12:00 - *Coffee break (with discussion)*

Chairperson: S. Simić

LSST Corporation Enabling Science Building Deep Learning Engine (DLE) for AGN light-curves

12:00 - 12:30 - D. Ilić A. Kovačević: Review of DLE project (20min + discussion)

12:30 - 12:50 - N. Andrić Mitrović,D. Ilić, A. Kovačević, Cvorović-Hajdinjak: Pytorch implementation of Conditional neural process (15min notebook presentation + discussion)

13:00 - 15:00 - Lunch break

Chairperson:T. Jurkić

Serbian in-kind contribution to LSST Project

15:00 - 15:30 - D. Jevremović: A brief history of Serbian involvement in LSST

15:30 - 16:00 - A. Kovačević, D. Ilić J. Kovačević Dojčinović: SERSAG in kind contribution to the LSST software and telescope time contribution

16:00 - 17:00 - *Discussion + coffee break*

Chairperson: D. Ilić

Forum - discussion on overlapping interests in periodicity mining in LSST light-curves

17:00 - 19:00 - Open to LSST community - Hybrid format (online + in-person)

Wednesday, June 15

Chairperson: M. Stalevski

10:00 - 10:30 - H. Landt: The first spectroscopic dust reverberation programme on active galactic nuclei (on-line)

10:30 - 11:00 - *Coffee break (with discussion)*

11:00 - 13:00 - ***Discussion on requirements for crunching hybridized data***

13:00 - 15:00 - Lunch break

Chairperson: S. Gonzalez Gaitan

15:00 - 15:30 - I. Liodakis: Microlensing of blazars jets: fact or fiction? (on-line)

15:30 - 16:00 - A. Zakharov: A simple approach of gravitational lensing for RAR model (on-line)

16:00 - 16:30 - Coffee break (with discussion)

16:30 - 19:00 - Work on mini projects: WPs 1-5

17:00 - 19:00 - ***Mini-project #4: Discussion on the long-term monitoring of AGNs within the LoTerm AGN project (hybrid) - moderator D. Ilic***

Thursday, June 16

Chairperson: J. Kovačević-Dojčinović

10:00 - 10:30 - E. Shablovinskaya: New results of the polarimetry of AGN with equatorial scattering

10:30 - 11:00 - E. Malygin: MAGIC for 1-m telescope of SAO RAS

11:00 - 11:30 - *Coffee break (with discussion)*

11:30 - 13:00 - Discussion and work on mini-projects: MPs 1-5

13:00 - 15:00 - Lunch break

15:00 - 18:00 - Visiting the Royal complex Oplenac

18:00 - 20:00 - Work on mini projects MP1-MP5 In the frame of MP1

and MP4, a short talk: M. Vucevic: Solitary vortex structure in a class of self-gravitating accretion disks

20:00 - Conference diner

Friday, June 17

Chairperson: P. Marziani

10:00 - 10:30 - M. Stalevski: Dissecting the active galactic nucleus in Circinus galaxy

10:30 - 11:00 - J. Rino-Silvestre: EmulaRT: Emulating Radiative Transfer with Auto-Encoders

11:00 - 11:30 - *Coffee break (with discussion)*

11:30 - 11:50 - D. Kozlova: Kinematics of extended ionized-gas regions around active galaxies

11:50 - 12:50 - Work on mini projects MP1-MP5

12:50 - 13:00 - Conclusion remarks

13:00 - 14:30 - Lunch break

15:00 - Departure