

IV Conference on Active Galactic Nuclei and Gravitational Lensing  
November 12-15, 2019, Banja Ždrelo, Serbia

ABSTRACTS OF INVITED LECTURES AND PROGRAMME

Edited by Saša Simić, Luka Č. Popović and Milan S. Dimitrijević



Faculty of Sciences, University of Kragujevac  
Kragujevac 2019

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## SCIENTIFIC RATIONALE

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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# **ABSTRACTS OF INVITED LECTURES**

**POSSIBILITY TO DO POLARIZATION MONITORING WITH THE 1.4m  
MILANKOVIC TELESCOPE AT VIDOJEVICA**

**Oliver Vince**

*Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia*

The first polarimetric measurements on the 1.4m Milankovic telescope operated at the Astronomical Station Vidojevica is presented. The measurements were obtained with Savart plate (double calcit plate cemented together) which splits the light from the telescope into ordinary ('o') and extraordinary ('eo') beams. Measuring 'o' and 'eo' fluxes for two angles of the Savart plate 45 degrees apart, relative Stokes parameters were determined. Beside observation of blazar (0716+714) as a target, zero-polarization standard star (BDp32\_3739) and high-polarization standard star was performed in order to properly correct relative Stokes parameter to instrumental and sky polarization. Theoretical calculation, which illustrates the capability of the Milankovic telescope to do polarimetric measurements of a target with certain magnitude and given polarimetric precision, is also presented.

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## **LIJIANG 2.4m TELESCOPE AND ITS INSTRUMENTS**

**Pu Du**

*Institute of High Energy Physics, Chinese Academy of Sciences,  
Beijing 100049, China*

We have used the 2.4-meter telescope at the Lijiang station of Yunnan Observatories, Chinese Academy of Sciences, to perform reverberation mapping of super-Eddington accreting massive black holes (SEAMBHs) for more than 7 years, and discovered that the SEAMBHs have shortened time lags by factors of 3-8 with respect to the radius-luminosity relation of the normal AGNs. We will present a brief introduction of the 2.4-meter telescope and the instruments.

## **THE CAPABILITIES FOR AGN MONITORING IN POLARIZED LIGHT**

**Victor Afanasiev, Elena Shablovinskaya**

*Special Astrophysical Observatory of RAS, Russia*

Nowadays, polarimetry is a very useful tool in the AGN investigation as it is able to provide the information about the gas kinematics, spatial structure and supermassive black hole parameters in the optically unresolved central parsec. According to the latest achievements in polarimetry and new offered approaches this talk is devoted to the polarimetric equipment and observational and reduction techniques. The existing polarimetric devices and their capability at 1-m and 2-m class telescopes are discussed.

## **SPATIAL FIELD RECONSTRUCTION WITH INLA**

**Joao Silvestre**

*Centra-Sim, Universidade de Lisboa, Portugal*

An introduction to spatial reconstruction using bayesian inference is presented, along with a walkthrough the integrated nested Laplace approximation (INLA) algorithm and statistical roots (Rue et al. (2009)). Recent implementations of INLA to astronomical data (González-Gaitán et al. (2018), Garcia et al. (2020)) show potential for different strategies in both data acquisition and reconstruction. The possibility of combining INLA with monte carlo radiative transfer (MCRT) methods (Baes et al. (2011)) is explored as way to improve the overall computationat cost of more detailed simulations.

## REVERBERATION MAPPING OF AGNs: THE ROLES IN THE INTERFEROMETRY ERA

**Jian-Min Wang**

*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing  
100049, China*

Reverberation mapping (RM) is a classical but very powerful tool of probing the structure and kinematics of broad-line region (BLR) around the central supermassive black holes. The recent success of GRAVITY/VLTI observations of 3C 273 is opening an exciting avenue of understanding the central engines. In the talk, I suggested that joint analysis of GRAVITY and RM observations provides:

- 1) simultaneous measurements of SMBH mass and cosmological distances (BLR parallax) for cosmology;
- 2) determination of orbital parameters of close binaries of SMBHs for nanon-Hz gravitational waves.

I showed the results of BLR parallax distances of 3C 273 and Hubble constant of  $H_0 = 71.5^{+11.9}_{-10.6}$  km s<sup>-1</sup> Mpc<sup>-1</sup> from the joint analysis. Accuracy of the measurements can be dramatically improved by expanding GRAVITY/RM sample.

## **OSCILLATION PATTERNS IN AGN LIGHT CURVES**

***Andjelka Kovačević<sup>1</sup>, Luka Č. Popović<sup>2</sup>, Jian-Min Wang<sup>3</sup> Dragana Ilić<sup>1</sup>***

*<sup>1</sup>Department of astronomy, Faculty of mathematics, University of Belgrade,  
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Beijing 100049, China*

We formulate and test two types of algorithms: one for echo mapping the emission-line regions near active galactic nuclei and second for detection of oscillatory signals in the light curves of these objects. The echo mapping algorithm can help in detection of binary supermassive black holes on elliptical orbits with elliptical broad line regions. The oscillation detection algorithm successfully classified type 1 objects according to characteristics of oscillatory patterns in their light curves.

## **SPECTRAL VARIABILITY OF AGN: DIFFERENT ASPECTS**

**Edi Bon, Predrag Jovanović**

*Astronomical Observatory, Volgina 7, 11000 Belgrade*

There are various mechanisms that can produce and trigger variability of active galactic nuclei (AGN). Here we explore different mechanisms depending on variability time scales measured from long term spectral monitoring. We focus on several examples with variability time scales that correspond to the orbital time scales and explore orbital parameters of such systems. We model possible orbits, and mass ratios that could explain observed light and radial velocity curves. We calculate whether the observed reverberation lags are in agreement with different observed epochs of their orbits. Also, we calculate observability of such systems in different epochs with GRAVITY.

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## **SUPER-MASSIVE BINARY BLACK HOLES AND POLARIZATION IN LINE**

**Djordje Savić**

*Astronomical Observatory, Volgina 7, 11000 Belgrade*

A considerable number of active galactic nuclei (AGNs) show complex broad lines, most notably with double peaks, highly shifted to the blue or red, and with a strong asymmetry. Some of these AGNs are established as super-massive binary black hole (SMBBH) candidates. Here we explore the polarization characteristics across broad emission lines as well as continuum polarization images for the case where AGN hosts a SMBBH. We used the 3D Monte Carlo radiative transfer code STOKES Goosmann & Gaskell (2007), Marin et al. (2012,2015) to investigate polarized broad line emission. We conducted models for a wide range of system parameters.

## DISCOVERY OF THE NEW CHANGING LOOK EVENTS IN NGC1566

**V. L. Oknyansky<sup>1</sup>, H. Winkler<sup>2</sup>, S. S. Tsygankov<sup>3,4</sup>,  
V. M. Lipunov<sup>1</sup>, E. S. Gorbovskoy<sup>1</sup>, F. van Wyk<sup>2</sup>,  
D. A. H. Buckley<sup>5</sup>, N. V. Tyurina<sup>1</sup>**

<sup>1</sup>SAI Moscow Stat University, Russia

<sup>2</sup>Dept. Physics, University of Johannesbugr, South Africa

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We present a study of optical, UV and X-ray light curves of the nearby changing look active galactic nucleus in the galaxy NGC 1566 obtained with the Neil Gehrels Swift Observatory and the MASTER Global Robotic Network over the period 2007 - 2019. We also report on our optical spectroscopy at the South African Astronomical Observatory with the 1.9-m telescope on the 5 nights: 2018 Aug. 2, Dec. 18, 2019 Jan. 9 and 15, Mar. 27. A substantial increase in X-ray flux by 1.5 orders of magnitude was observed following the brightening in the UV and optical bands during the last year. After a maximum was reached at the beginning of 2018 July the fluxes in all bands decreased with some fluctuations. The remarkable re-brightening in of the light curve following the decline from the bright phase was observed at MJD range 58440-58490. The amplitude of the flux variability is strongest in the X-ray band and decreases with increasing wavelength. Low-resolution spectra (2018 Aug.) reveal a dramatic strengthening of the broad emission as well as high-ionization [FeX]6374 lines. These lines were not detected so strongly in the past published spectra. The change in the type of the optical spectrum was accompanied by a significant change in the X-ray spectrum. At the last 4 spectra (2018 Dec.-2019 Mar.) we see dramatic changes comparative to the first one (2018 Aug.) with fading of broad emission lines during Dec.-Mar. So we were observed 2 changing look (CL) cases with the object: changing to Sy1.2 type and then returning to the low state as Sy 1.8-Sy1,9 type. All these facts confirm NGC~1566 to be a CL Seyfert galaxy. Some possible explanations of the observed dramatic changes are discussed.

## **TYPE 1 AGN REVERBERATION MAPPING IN POLARIZED LIGHT**

**Elena Shablovinskaya, Viktor Afanasiev, Luka Popović**

*Special Astrophysical Observatory of RAS, Russia  
Astronomical Observatory, Volgina 7, 11000 Belgrade*

In this talk, we are going to present a new observational method for measurements of the inner dusty torus radius using variability in the polarized broad lines in Type 1 AGNs. The inner radius of the dusty torus is crucial for the investigations of the physical state in the central parsec of AGNs and, moreover, is needed for the supermassive black hole mass estimation with the spectropolarimetric tools (Afanasiev & Popović 2015). Using the fact that polarization in broad lines of Type 1 AGNs is caused by equatorial scattering, we propose to monitor variability in the polarized line flux and finding the time lag between the non-polarized continuum and polarized broad line variability. The method was applied to the observations of Type 1 AGN Mrk 6, and we found that the dusty torus inner part in this AGN is around 100 light days.

## **LONG-TERM VARIABILITY OF AGN: FUTURE PERSPECTIVES**

**Dragana Ilić**

*Department of Astronomy, Faculty of Mathematics  
University of Belgrade*

In this contribution, a short summary of the importance of long-term monitoring of active galactic nuclei (AGN) has been presented. The three main directions of investigations were discussed: i) the physics of the line-emitting regions and consequently the estimates of the mass of the super-massive black hole (SMBH), ii) the hunt for SMBH binaries from the long-term light curves, and iii) the detection of long-term trends of variability, especially of the changing-look phenomena. Some of the most important monitoring campaigns and their results were presented, and put in the context of future massive spectroscopic campaigns, like Manuakea Spectroscopic Explorer.

## **LSST PROMPT DATA PRODUCTS**

**Darko Jevremović**

*Astronomical Observatory, Volgina 7, 11000 Belgrade*

LSST is the main project in ground based survey astronomy in 2020's. It will scan ~16000 square degrees of sky using 8.4 m telescope on mount Cero Pachon approximately twice a week. There are going to be observations in six filters (ugrizy) and the depth of the single visit is going to be 24.5 and after ten years by coadding will reach 27.5 in r filter. I will review data products which will be released inside 24 hours of observations. Those products consist of alerts which will report any change (flux, position) of detected objects (60 seconds) and update of orbits of solar system objects (within 24 hours). According to the current LSST and funding agencies policies those products should be available to the whole astronomical community.

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## **LSST AND AGN VARIABILITY INVESTIGATION**

**Luka Č. Popović**

*Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia*

In this talk I give a short overview of AGN investigation which will be performed using LSST observations. LSST is going to cover a field of 18000 sq.deg. where is expected to detect more than 300 million AGNs. A huge number of AGN will be observed with a good cadence that will give new possibility to investigate AGN variability. This can be used for exploring of the accretion disc structure. Especially in this talk we discussed the possible detection super-massive binary black holes using LSST data. At the end we give some ideas about in-kind contribution to LSST from Serbian AGN group, especially contributing to the LSST AGN SC.

**SUMMARY OF DISCUSSION SESSION  
LONG-TERM MONITORING OF AGN: PAST AND FUTURE**

**moderator: Dragana Ilić**

*<sup>1</sup>Department of astronomy, Faculty of mathematics, University of Belgrade,  
Studentski trg 16, 1100 Belgrade, Serbia*

During the meeting we had a telecon-meeting on the long-term reverberation mapping (LoTeRM) programme. The participants were: Dragana Ilić, Luka Č. Popović, Anđelka Kovačević, Edi Bon, Saša Simić, Đorđe Savić, Slađana Marčeta-Mandić, Victor Afanasiev, Elena Shablovinskaya, and via Skype: Vahram Chavushyan, Victor Patino Alvarez, and Paola Marziani.

In the first part of the meeting, the campaign of Alla I. Shapovalova was presented and main results were shown, especially the list of objects and used telescopes. It was decided that Dragana Ilic is to continue to coordinate the LoTeRM campaign. In the second part of the meeting, we discussed what spectral data is not yet published, and what are the next step to take, i.e. collecting all log files, analysis, discussion, etc. Also, the future of the campaign was discussed, and it was decided that the objects will be continued to monitor, with maybe setting the list of priorities.

## PROGRAMME

### Tuesday, November 12

9:00 - *Bus departure*

11:00 - 12:00 - *Arrival and registration*

**Chairman: S. Simić**

12:00 - 13:00 - *Welcome cocktail & opening ceremony*

13:15 - 15:00 - *Lunch break*

#### **Talks with discussion - Telescopes and elaboration techniques:**

**Chairman: A.F. Zakharov**

15:00 - 15:30 - **O. Vince** (Serbia): *Possibility to do monitoring (spectral and In polarization) with 1.4m Milankovich telescope at Vidojevica*

15:30 - 16:00 - **P. Du & J.-M. Wang** (China): *Li Jang 2.4m telescope and its instruments (short overview about possibility to monitor in polarization)*

16:00 - 16:30 - **V. Afanasiev** (Russia): *SAO telescopes in observation of AGN and GL polarization*

16:30 - 17:00 - **S. Gonzalez & J. Silvestre** (Portugal): *Spatial field reconstruction with INLA*

17:00 - 19:00 - *Variability in polarization of AGNs - discussion and short talks and opinions of participants*

19:00 - *Dinner time*

### Wednesday, November 13

#### **Talks with discussion - AGNs and SMBBHs:**

**Chairman: M. S. Dimitrijević**

10:00 - 10:30 - **J.-M. Wang & P. Du** (China): *SMBH binaries with GRAVITY*

10:30 - 11:00 - **A. Kovačević** (Serbia): *Oscillation patterns in AGN light curves*

11:00 - 11:30 - **E. Bon** (Serbia): *Spectral variability of AGN: different aspects*

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11:30 - 12:00 - **Dj. Savić** (Serbia): *Super-massive binary black holes and polarization in line*

12:00 - 12:30 - **V. L. Oknyansky** (Russia): *Discovery of the new changing look case in NGC1566*

12:30 - 13:00 - *Discussion*

13:00 - 15:00 – *Lunch break*

15:00 - 19:00 - *Work on mini projects*

15:00 - 17:00 - *Discussion about long term monitoring (Moderator: D. Ilić; Participants all presented at meeting + video conference link with V. Chavushian, P. Marziani, A. Burenkov)*

19:00 - *Dinner time*

**Thursday, November 14**

***Talks with discussion - Perspectives in AGN and GL investigations:***

***Chairman: V L. Afanasiev***

10:00 - 10:30 - **A. F. Zakharov** (Russia): *Polarization measurements for exoplanet searches with gravitational microlensing*

10:30 - 11:00 - **E. Shablovinskaya** (Russia): *Investigation of Type 1 AGN based on reverberation mapping in polarized light.*

11:00 - 11:30 - **D. Ilić** (Serbia): *Long-term and MSE monitoring of AGNs - perspectives*

11:30 - 12:00 - **D. Jevremović**: (Serbia): *LSST prompt data products*

12:00 - 12:30 - **L. Č. Popović**: (Serbia): *LSST and AGN investigation*

12:30 - 13:00 - *Discussion*

13:00 - 15:00 - *Lunch break*

15:00 - 19:00 - *Work on mini projects*

19:30 - *Conference dinner*

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**Friday, November 15**

**Chairman: L. Č. Popović**

10:00 -11:30 - *Round table discussion and summary of the work on mini-projects*

11:30 - 12:00 - *Closing ceremony and check-out*

12:30 - 17:00 - *Thematic excursion with lunch*

17:00 - *Departure to Belgrade*

**MINI-PROJECTS**

**MP1:** Physics of the AGN emitting regions

**MP2:** Strong gravitation and centers of AGNs

**MP3:** AGNs and super-massive binary black hole systems: Spectral Energy Distribution (SED) and microlensing effect

**MP4:** Databases for investigation of the physics of AGNs

**MP5:** SDSS and LSST in AGN and GL investigations

**MP6:** Long-term spectral variability of AGNs

**MP7:** Polarization of the AGN spectra

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# IV CONFERENCE ON ACTIVE GALACTIC NUCLEI AND GRAVITATIONAL LENSING

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ABSTRACTS OF INVITED LECTURES AND PROGRAMME

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Заједничка слика свих учесника конференције. С лева на десно су: Маша Лакићевић, Ђорђе Савић, Јелена Ковачевић Дојчиновић, Слађана Марчета Мандић, Pu Du, Оливер Винце, Jian-Min Wang, Дарко Јевремовић, Милан С. Димитријевић, Влада Срећковић, Victor Oknyansky, Анђелка Ковачевић, Саша Симић, Лука Ч. Поповић, Елена Шабловинскаја, Виктор Афанасјев, Драгана Илић, Вељко Вујчић, Santiago Gonzales, Марко Сталевски, Joao Silvestre, Еди Бон.