Appearance and dynamics of accretion onto black holes

Program:

Tuesday, 5 November, 16:00 (CET)

- Vladimír Karas: Welcome, The origins of strong-gravity lensing projects in Prague and elsewhere
- Maitrayee Gupta: Comparing radio loud Swift/BAT AGN with their radio quiet counterparts
- Michal Dovčiak: Modelling the thermal reverberation in AGN
- Michal Zajaček: How can we utilize the planned small UV space telescope QUVIK for solving unresolved AGN problems?
- Jiří Horák: Misalignment of the Lense-Thirring precession by an accretion torque
- Bozena Czerny: First successful measurement of the Hubble constant from reverberation mapping of NGC 5548

Wednesday, 6 November, 9:30 (CET)

- Henry Best: Reverberation mapping in strongly lensed AGN
- Izzy Garland: Large-scale galactic bars as a secular mechanism for black hole growth
- Amit Kumar Mandal: Discrepancies in AGN Corona Height Measurements: Insights from X-ray and Optical Studies
- Matúš Labaj: Compact star clusters hosting an intermediate mass black hole: 3D magnetohydrodynamic study of inflow-outflow dynamics

  Coffee/Tea

- Václav Pavlík: Dynamics of star associations in an SMBH-IMBH system
- Petra Suková: Quasi-periodic outflows from star-disc interaction
- Sudeb Datta: Investigating the consistency of the shape and flux of X-ray reflection spectra in the hard state with an accretion disk reaching close to the black hole
- Petr Kurfürst: Current state and future developments in star-jet interactions models

  Lunch (Institute cafeteria, or a nearby pub)

- Monika Pikhartová: Young stellar objects across the galaxy: From solar neighborhood to Galactic center
- Jakub Podgorný: X-ray polarization models of AGN
- *Brainstorming discussion (15:00 CET)*

  Joint walk and dinner in the downtown (Café Louvre, or nearby - reservations are not available, menu and funding are individual:)

Thursday, 7 November

- Individual work and discussions
- Optional: Czech Space Week in Villa Lanna (free, registration is required), and QUVIK@VZLU (individual arrangements)
- Sightseeing: Klementinum Libraries or an independent walk through astronomy related places.

Friday, 8 November

- Individual work and discussions

Location: ASU Praha-Spořilov, Room 101 (ground floor), https://astro.cas.cz/contact

Online access: Zoom link

Dates: 5 - 9 November 2024

Abstracts:

Vladimír Karas: Welcome, The origins of strong-gravity lensing projects in Prague and elsewhere

Accreting black holes are believed to emit X-rays, which then mediate information about strong gravity in the vicinity of the emission region. We report on the origin of ray-tracing method for spectra of black-hole accretion disks in Kerr metric. The adopted technique appears to be useful also in the context of future high-angular-resolution (miliarcesond) imaging in X-rays.

Bozena Czerny: First successful measurement of the Hubble constant from reverberation mapping of NGC 5548

Light echo from irradiated accretion disk in active galaxies was proposed as a cosmological tool in 1999, allowing to determine the Hubble constant directly but it was never working in practise. The estimated disk sizes were always too large, and the attempted determination of the Hubble constant in 2007 gave much too low values. Recently, there was a growing understanding that the problem is caused by the contamination of the accretion disk continuum by the continuum produced in the Broad Line Region (BLR). Using our model of the BLR and combining the mean spectrum and the measured time delays from Swift we were able for the first time to disentangle the two effects for the source NGC 5548. Our recent modelling gave the value of 69+18_12 km/s/Mpc.

Maitrayee Gupta: Comparing radio loud Swift/BAT AGN with their radio quiet counterparts

Some AGN are known to be efficient producers of strong, relativistic jets which power the extended radio sources. Most spectacular in respect of powers and sizes are the radio sources associated with AGN hosted by giant elliptical galaxies. However, even among them, the production of powerful jets is a very rare phenomenon and the unanswered question remains why it is so. Since relativistic jets are most likely powered by rotating BHs via the Blandford-Znajek mechanism, one might expect that the parameters deciding about efficient jet production are BH spins and magnetic fluxes. If their values are large, then the innermost portions of accretion flow should be affected by the jet production and this should be imprinted in their radiative properties. In order to verify whether this is the case, we compare the radiative properties of radio-loud (RL) and radio-quiet (RQ) AGN selected from the Swift/BAT catalog with similar BH masses and Eddington ratios. As we have found, the only significant difference concerns the hard X-ray luminosities, which are about two times larger in radio-loud AGN than in radio-quiet AGN. One might speculate that this difference comes from RL AGN having X-ray contribution not only from the innermost, hot portions of the accretion flow but also from a jet. However, this interpretation is challenged by our following findings: (1) hard X-ray spectra of RL AGN have similar slopes and high-energy breaks to those of RQ AGN; (2) hard X-ray radiation is to be in both RQ and RL AGN quasi-isotropic. Hence we argue that the production of hard X-rays in the RL AGN is like in the RQ AGN, dominated by hot, central portions of accretion flows, while larger X-ray production efficiencies in RL AGN can be associated with larger magnetic fields and faster rotating BHs in these objects.

Michal Dovčiak: Modelling the thermal reverberation in AGN

Several AGN have shown UV/optical variability lagging behind the X-ray emission by a few days. The simplest and most straightforward interpretation is that the variable X-ray flux from the corona illuminates the accretion disc below where it is partially reflected and observed as fast X-ray reverberation signal, and partially absorbed and thermalised in the disc, which produces a slow UV and optical reverberation signal. Since the size of the corona is very small compared to the accretion disc, and it is located in the innermost central region of AGN, it first illuminates the hottest inner parts of the accretion disc and later on its colder further out areas. Thus one expects to see the original X-ray fluctuations to be firstly followed by variations in the UV and then in the optical wavebands. To study the thermal reverberation we have improved our X-ray reverberation KYNxilrev model to include the thermalisation of the absorbed (non-reflected) part of the incident flux. In our contribution we will discuss the results of our thermal reverberation modelling in a lamp-post corona geometry and show that the time lags observed in UV and optical wavebands are in agreement with the standard Novikov-Thorne accretion disc.

Michal Zajaček: How can we utilize the planned small UV space telescope QUVIK for solving unresolved AGN problems?

I will give a short overview of the parameters of the two-band UV space telescope QUVIK with the primary mirror diameter of ~30 cm. The advantage of QUVIK over survey telescopes is that it can perform high cadence monitoring of target-of-opportunity sources, potentially reaching the cadence of ~0.1 days. This can be crucial for solving several unresolved problems, such as the origin of the UV light of tidal disruption events, accretion disc

size problem, existence of UV quasiperiodic erupters and more.

Jiří Horák: Misalignment of the Lense-Thirring precession by an accretion torque Type-C QPOs in low-mass X-ray binaries are most commonly explained by a free Lense-Thirring precession of the innermost hot component of the accretion flow. We will discuss how this simple picture changes when accretion torque from the outer cold disk is taken into account.

Henry Best: Reverberation mapping in strongly lensed AGN

In the near future, tens of thousands of strongly lensed AGN are expected to be monitored with the advent of wide-field surveys. These will be closely followed as they are targets of opportunity for caustic-crossing events, which occur when a compact object's micro-caustic crosses over the inner region of the AGN. These events will be carefully observed with high cadence observations across multiple wavelengths in order to probe the AGN's central engine. However, only a few studies have focused on an important aspect of reverberation mapping in strongly lensed systems. This is known as the microlensing time delay and has the ability to affect our understanding of reverberation mapping. In this talk, I will present some preliminary work done on reverberation mapping of strongly lensed AGN with the goal of quantifying our uncertainty in short-term and long-term light curves.

Izzy Garland: Large-scale galactic bars as a secular mechanism for black hole growth

Despite the evidence that supermassive black holes (SMBHs) co-evolve with their host galaxy, and that most of the growth of these SMBHs occurs via merger-free processes, the underlying mechanisms driving this secular co-evolution are poorly understood. I will discuss the role that both strong and weak large-scale galactic bars play in mediating this relationship up to $z = 0.1$ over a range of stellar masses and colours. After controlling for stellar mass and colour, I show to a high statistical significance that strongly barred galaxies have a higher fraction of AGN than weakly barred galaxies, which in turn have a higher fraction than unbarred galaxies. Thus, while bars are not required in order to grow an SMBH in a disc galaxy, large-scale galactic bars appear to facilitate AGN fuelling, and the presence of a strong bar makes a disc galaxy more than twice as likely to host an AGN than an unbarred galaxy at all stellar masses and colours. I will then highlight some preliminary results on this relationship's variation with bulge prominence. I will discuss the effect of bar strength on AGN presence when we disentangle their complex relationship with bulge prominence.

Amit Kumar Mandal: Discrepancies in AGN Corona Height Measurements: Insights from X-ray and Optical Studies

Hard X-ray emission in AGN originates from a compact region known as the hot corona, although its precise geometry remains unclear. It is often modeled as a 'lamp-post,' where the source is compact and either point-like or spherical, positioned along the symmetry axis above the equatorial plane. Spectral and light echo studies, conducted in both the X-ray and optical domains, are commonly used to estimate the height and size of this hot corona. In our analysis, we have compiled a sample of AGN sources with height determinations from both spectral bands. Interestingly, the average height derived from X-ray studies (~13 Rg) is significantly smaller compared to that from optical studies (~32 Rg). This discrepancy could stem from differences in source selection between the two types of studies or from the sensitivity of the methods employed. Investigating this issue further is one of the key projects proposed for the Polish-Czech collaboration.

Matúš Labaj: Compact star clusters hosting an intermediate mass black hole: 3D magnetohydrodynamic study of inflow-outflow dynamics

I will present the current state of my project.

Václav Pavlík: Dynamics of star associations in an SMBH-IMBH system

The existence of intermediate-mass black holes (IMBHs) still poses challenges to theoretical and observational astronomers. Several candidates have been proposed, including the one in the IRS13 cluster in the Galactic centre, where the evidence is based on the velocity dispersion of its members, however, none have been confirmed to date. We aim to gain insights into the presence of an IMBH in the Galactic centre by a numerical study of the dynamical interplay between an IMBH and star clusters (SCs) in the vicinity of a supermassive black hole (SMBH). We use high-precision N-body models of IRS13-like SCs in

the Galactic centre, and of more massive SCs that fall into the centre of the Galaxy from larger distances. We find that at IRS13's physical distance of 0.4 pc, an IRS13-size SC cannot remain gravitationally bound even if it contains an IMBH of thousands $M_\odot$. Thus, IRS13 appears to be an incidental present-day clumping of stars. Furthermore, we show that the velocity dispersion of tidally disrupted SCs (the likely origin of IRS13) can be fully accounted for by the tidal forces of the central SMBH; the IMBH's influence is not essential.

Petra Suková: Quasi-periodic outflows from star-disc interaction

Recently, a previously quiescent nearby galactic nucleus, ASASSN-20qc, went to an outburst during which it has shown quasioperiodic ultra-fast outflows (qUFOs) with changing column density every cca 8 days. Different physical mechanisms have been proposed to explain such behaviour, with the most promising scenario being the smaller, probably intermediate-mass black hole, orbiting the primary supermassive black hole at the distance of about a hundred gravitational radii of the primary. The secondary black hole is punching through the accretion flow launching fast outflowing blobs of gas (~ 0.3c), which are causing repeating absorption events. We will examine the potential launching mechanisms of UFOs and show GRMHD simulation for the SMRI (Small Mass Ratio Inspiral) scenario. We will discuss the importance of observing UFOs and their variability in large sky surveys.

Sudeb Datta: Investigating the consistency of the shape and flux of X-ray reflection spectra in the hard state with an accretion disk reaching close to the black hole

The observed spectra from black hole (BH) X-ray binaries (XRBs) typically consist of two primary components. A multitemperature blackbody originating from the accretion disk in the soft X-ray, and a power law-like component in the hard X-ray, due to the Comptonization of soft photons by the hot corona. The illumination of the disk by the corona gives rise to another key component known as reflection. A fraction of the incident hard X-ray radiation is naturally absorbed and re-emitted as a blackbody at lower energies and referred to as the "reprocessed blackbody". Our fitting of the representative observation of the BH XRB low/hard state suggests that the disk may, in principle, extend very close to the BH, even though the reprocessed thermal emission (due to disk illumination) remains cold (and thus low) enough to be consistent with the data in contrast to the results of a previous study. The inner reflection component is highly ionized and its fit is primarily driven by its contribution to the continuum, rather than by the shape of the relativistic iron line.

Petr Kurfürst: Current state and future developments in star-jet interactions models

In a recently submitted paper, we have completed 3D models of some configurations of interacting red giant stars and past galactic jet, at least during the first 10 star-jet passages. The calculated mass loss due to the ablation of these stars by the relativistic galactic jet corresponds to the order of 10^{-6} M_star/yr during the simulated time. Extrapolating the mass loss from the models, we arrive at an average value of the order of about 10^{-4} M_star/yr, which is the expected lifetime of such a jet. In future work, we want to extend the modeling time to at least the order of 100 - 200 star-jet passages in order to make the extrapolation more credible, and also to include the accompanying effects such as the influence of the jet's magnetic structure and stellar rotation.

Monika Pikhartová: Young stellar objects across the galaxy: From solar neighborhood to Galactic center

The study of young stellar objects (YSOs) and star formation is a dynamic field within astrophysics, driven by observations of nearby star-forming regions across multiple wavelengths (e.g., Pikhartova 2021+). Despite these advancements, our understanding of star formation under extreme conditions—such as strong magnetic fields and intense radiation—remains limited. In this contribution, we will discuss peculiarities of candidate YSOs orbiting the supermassive black hole at the Galactic center.

Jakub Podgorný: X-ray polarization models of AGN

We present a series of numerical models suitable for X-ray polarimetry of accreting systems.